AN ECONOMIC ANALYSIS OF THE TECHNICAL, ALLOCATIVE, AND EQUITY EFFECTS OF FINANCING MUNICIPAL GOVERNMENT FROM REVENUE OVER COST EARNED BY THE MUNICIPAL ELECTRIC UTILITY: A CASE STUDY OF STILLWATER, OKLAHOMA

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May, 1977

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PREFACE

A case study approach is used to examine two basic questions arising from the tax interest subsidy afforded municipal utilities. The subsidy in question occurs as a result of the municipal utilities' (1) exemption from taxation, (2) tax exempt debt instruments, (3) freedom from debt-equity ratio regulation, and (4) marketing of debt instruments backed solely by the faith and credit of the municipal government. This study examines (1) the technical and allocative effects of the subsidy in offsetting the expected higher costs of small municipal generating units and (2) tax equity questions involved in financing municipal government from revenue over cost derived from operation of the electric utility. Attention should be called to the fact that the analysis is based on 1970 data and reflects 1970 price structure. Since that time, the increase in all prices has intensified the issue of efficiency in production, and this is especially true where fuel is concerned given the skewing of the price relationship by the much more rapid increase in fuel prices.

Appreciation is expressed to the dissertation committee, Drs. Larkin B. Warner, Joseph M. Jadlow, Robert L. Sandmeyer, and William L. Hughes. Appreciation is also expressed to the following individuals for their assistance with specific aspects of the study: Drs. Richard H. Leftwich and Gerald M. Lage provided guidance in analyzing costs and subsidy aspects of the study; Drs. Richard Wallace and Wallace J. Primeaux shared resources and insights into both the cost and tax aspects of the study; Dr. Frank Steindl, Dr. Kenton Ross, Dr. Donald R. Williams, Marilani Shirey,

and Norman A. Shupeck, assisted in acquiring and analyzing financial data; Dr. Daniel D. Lingelbach, Dr. Bennett Basore, Curtis H. Guernsey, Jr., Charles P. Massey, Carl Stover, Tom Hoke, Bill Purvis, Gene Biggerstaff, Norton Savage, and Alexander Gakner shared technical information and general insights regarding the operations of electric utilities; Paul Fry and James Webster shared information and insights regarding municipal electric utilities; Charles Ferguson, Merle King, and Carl Stadler shared insights and provided assistance in identifying and interpreting data relative to the operation of the Stillwater electric utility; the following representatives of the city government graciously contributed time and effort in assisting the study: Lawrence Gish, Ron Owens, David Bretzke, Edna Spaulding, Joan Skaggs, Annette Bloom, Charles Harwood, and Lawrence Christian, and also Martin Dickson who audits the city accounts.

Drs. Keith Harries, Paul Hagel, Anna Coe Crum London, and Richard Watson shared and identified sources of raw data and unpublished work on geographic distribution of city services; Ted Lehman assisted in acquiring aerial photo maps of the city. Dr. Donald Williams, Dr. James Condie, Dr. Steve Taubman, Iris McPherson, William Acola, and Dena Mennen provided technical advice and assistance in analysis of data; Loralie Childers assisted in data collection; Fran Gill's team drafted the figures; Ada Lou Penner, Barbara Wardle, and the secretarial staff of the Board of Governors of the Federal Reserve system typed drafts; Mrs. Wardle prepared a very professional final copy, the printing staff of the Board of Governors of the Federal Reserve System supplied technical advice and printed the paper. A National Science Foundation summer grant helped cover some of the expenses of the project.

Above all, appreciation and recognition are due my family and most especially to my parents, to whom life did not extend opportunities for such luxuries as higher education, but who have willingly made heavy personal sacrifices to guarantee the opportunity of securing the benefits of intensive study for succeeding generations of our family. Not only am I indebted to them for material sustenance during this period of study, but also for the example of personal discipline, patience, and perseverance in pursuit of decent and responsible objectives and for the encouragement of their deep faith in the ultimate success of honest effort and triumph of justice; their wisdom and example have been a source of moral support in times of adversity.

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CHAPTER I

AN INTRODUCTION TO THE PROBLEM

The development of the energy crisis has prompted much recent reexamination of economic policy and practices with respect to energy resources and their use. In keeping with this reexamination an investigation of the economic issues surrounding the practice of municipal electric energy generation and marketing is timely and appropriate.

Significant efforts have been made to conserve fuel. The federal government has urged reduction of the use of electric energy. Both the public and private sectors have financed large scale studies in the interest of discovering techniques for curtailing the growth of demand for electric energy. Investor owned electric utilities have reduced their efforts to gain new customers. However, at the same time, certain state and federal laws have continued to encourage installation and expansion of municipal generating systems.[1] Economic theory regarding costs would raise suspicions as to whether many of these relatively small units are of inefficiently small scale. Some causes and economic effects of this occurrence are considered in this study.

A. Survey of the Problem

A.1 The Historical Aspect

Municipal electric utilities sprang up around the turn of the century as a practical response to technological developments that offered

opportunities for improving the quality of life and working conditions of persons in local communities. When electric energy first came to most cities and towns, the only means of obtaining it was on-the-spot installation of a generating unit. That was before the day of 1200 megawatt generating units capable of serving the diversified needs of several communities, and of alternating current and transmission system transformers which made long distance transmission feasible and efficient.

These two technological developments, (1) increased efficiency of generating units which has principally been associated with increasing unit scale[2] and (2) the development and improved efficiency of long distance transmission, would be expected to result in displacement of the municipal units which are generally small in scale and likely to have low load factors. However, there have been very practical reasons why the municipal systems have not only exhibited a strong staying power but can also claim to be the most rapidly growing sector in the industry.[3]

A.2 Motivation for Continuing the Practice

Certain accepted practices and institutional arrangements are partially responsible for the persistence of the municipal electric utility. Despite the above-mentioned technological advances in generation and transmission of electric energy which suggest significant scale disadvantages for small municipal units, municipal tax-interest subsidies enable many such plants to generate electricity at a lower nominal expense to the "firm" than is possible for the larger privately owned systems which are capable of more efficient use of resources. The tax-interest subsidies arise from four sources. (1) Municipal systems do not pay all the taxes paid by privately owned systems. (2) The interest paid on

municipal bonds is not subject to federal income taxes. (3) Bonds may be backed by the full faith and credit of the municipal government. (4) Most municipal systems are not subject to regulation by state commission and hence are not bound by rules concerning debt-equity ratios, although the market imposes some practical limitation on indebtedness.[4]

Historically, many cities have relied on marketing of utilities as an important source of revenue.[5] While in later years there seems to have been a general trend away from that practice in favor of reduced prices of electric energy,[6] the recent concern over the burden of property taxes and the rapid increase in the price of utility services of investor owned utilities have created a strong incentive for cities to consider raising rates.[7]

Where marketing of utility services has been treated as a prime source of revenue, sales of electric energy have tended to be the most popular area of revenue expansion.[8] In Oklahoma, operation of municipal electric utilities has in the past been particularly encouraged by a long history of stringent statutory limitations on municipal revenue sources which have forced some cities to rely on revenue over cost from the sale of electric utilities as their major source of operating revenue.[9]

Despite statutory changes in 1965 which now permit municipal governments to use most revenue sources available to the legislature,[10] cities have not taken advantage of new opportunities for revenue such as the income tax and have delayed a decade or more in electing to levy the maximum sales tax available, perhaps partly as a matter of lethargy and inertia or as an expression of the old adage that "an old tax is a good tax."[11] Consequently, in Oklahoma and in many other states, the municipally owned electric utility continues to perform two distinct

functions: (1) supplying electric energy to the community, and (2) assessing and collecting revenue for financing operations of the city government via the electric service bill. The electric bill then becomes a combination of two elements, (1) a price for electric service and (2) a tax levy providing revenue for the general fund and financing the provision of municipal services which are not self supporting.

A.3 The Economic Issues

The current concern over capital equipment constraints and fuel shortages in the electric service industry and also taxpayer revolt in the public finance sector heighten the economist's interest in the efficiency of allocating scarce resources among alternative uses, and (2) the equity of assessment of municipal revenue requirements via the tapering block utility rate schedule.[12] For purposes of this study it is hypothesized that the cluster of laws which promote the practice of municipal electric generation:

1. May produce significant departures from technical efficiency in resource allocation by:
   a. encouraging electric energy generation by plants too small to take advantage of economies of scale in the industry, and
   b. encouraging inefficient use of capital capacity by causing installation of generating units which serve small populations with homogeneous demands which consequently create unfavorable load[13] and diversity factors.[14]
2. May redistribute income through distribution of the tax burden in a manner which violates the principles of equity in taxation.

B. Choice of Type of Study

The case study was chosen as a vehicle for evaluating the economic aspects of the arrangement under consideration. This method has the advantages of permitting close detailed study which could enhance the researcher's understanding and appreciation of the practical and institutional aspects of the question as well as revealing the extent, availability, quality, and feasible applications of the data. Such a study would provide a basis for other individual city studies or cross sectional studies of the industry and might aid in detecting and avoiding potential pitfalls in subsequent studies.

The City of Stillwater, Oklahoma, was considered an acceptable choice for the study. Professional engineers have indicated that the City's municipal electric utility is comparable with others across the state with respect to earnings and operations.[15] Stillwater currently provides virtually every ordinary municipal service other than a city cemetery.[16] While the complete set of findings from a study of the Stillwater case will not be directly applicable to other municipalities in general due to some of the unique revenue problems posed by the presence of Oklahoma State University in Stillwater, the design of the study is applicable to any city operating a municipal electric utility.

C. Aspects of the Question to be Studied

A group of interrelated questions is asked concerning the economic effects and consequently the present-day desirability of the institutional arrangements which have promoted the energy supply and taxation roles of the municipal utility. The following procedures were used to examine the technical, allocative and equity aspects of the energy

supply and revenue functions of the Stillwater Municipal Electric Utility.

C.1 Technical Efficiency

C.1.1 The Question

The municipal electric energy generating system is a socially owned and operated "firm."[17] Socialized operations are generally carried on for other than profit motives and are to some extent insulated from the market discipline; however, efficiency in resource use is a relevant economic question. Stillwater's municipal electric system is not totally immune to a market-type discipline because it must compete for resources in the market, and must compete with other municipal objectives in the city budgetary process. Moreover, because its net revenues are the most important single source of funds for other city functions, there is considerable pressure on it to operate profitably. Periodic professional engineering studies of the Stillwater system and its operation appear to have facilitated maintenance of a plant which is technically efficient for its scale and to have made for the most efficient level of capital investment relative to the demands of the population served.[18]

Consequently, within the context of the firm, it seems reasonable to assume that efficient resource management exists.[19] However, viewed from outside the firm, the institutional factors cited earlier would be expected to hinder efficient allocation on the supply side in the following manner. (1) capital is wasted to the extent that distortions in resource prices lead to the construction of generating units whose service is artificially limited to a population with homogeneous demand patterns which result in low load and diversity factors. (2) Both

capital and fuel are wasted to the extent that distortions in resource prices encourage the installation of generating units too small to achieve economies of scale available to the industry.[20] This waste of resources is encouraged by the institutionally induced tax-interest subsidy which produces a divergence between real and nominal costs.

C.1.2 Methodological Approach

Questions of technical efficiency are the topic of Chapter II. The first issue will be examined in terms of the magnitude of the subsidy. Results from empirical studies of the nature and magnitude of scale economies in the electric utility industry will be examined for indications of real cost differences between the Stillwater system and an alternative investor owned energy source, Oklahoma Gas and Electric Company. In addition cost data from Federal Power Commission reports will be used for direct comparison of the operating costs of the two utilities. With respect to the second issue, Federal Power Commission data and operating data from the records of the two systems will be used to determine and compare the load factor as an indicator of efficiency in utilization of capacity.

C.2 Allocative Efficiency

Allocative efficiency refers to the channeling of society's resources into the various competing uses in such proportions that the maximum level of satisfaction attainable is achieved. Optimal allocative efficiency occurs when the conditions of cost minimization and profit maximization by firms on the supply side occur in conjunction with utility maximization by consumers on the demand side. One of the

results is the existence of equality among value of marginal product, marginal revenue product, and resource price on the product side and equality of price, marginal cost, and marginal revenue associated with the product. Questions of technical efficiency or the achievement of minimum cost resource combinations are treated under C.1 of this chapter. Attention is now directed toward the other side of the production problem, the product price and output combination.

The firm under consideration is a monopolist. Pricing above marginal cost and discriminatory pricing[21] to yield economic profits[22] are areas of economic concern in cases of monopoly. Given its revenue function, a municipal utility can be expected to have profit maximization motives on par with those of a private monopolist. While revenue over operating cost cannot be taken as a measure of monopoly profit, comparisons of variations in the percentage of revenue over operating cost may lend a rough first approximation of the extent to which the potential for revenue over cost is exploited by one utility relative to others. The Stillwater electric utility yielded revenues over operating costs equal to 55 percent of its annual revenue during the years 1969-70 and 1970-71.[23]

While this is a fairly typical rate of earnings among municipal electric utilities in Oklahoma,[24] better perspective may be obtained by comparing the Stillwater yield with the average yield of 46 percent for investor owned utilities during the years 1969-71[25] and 40 percent for all municipal utilities during the same period.[26] Exactly how the profit is derived with respect to the relationship between the segments of the rate schedule and the various types of costs of supplying electric energy is not immediately evident; possibilities for profit are inherent in the

discriminatory block rate structure, pricing above marginal cost, or some combination of the two practices.

Two issues are at stake in the matter of how profits are acquired. The first is part of the more general issue, i.e., that under monopolistic production, product price does exceed marginal cost. A welfare loss is imposed upon society when the price of the product is artificially elevated causing the resulting equilibrium quantity demanded to be less than it would be normally.

Another dimension is added to the welfare loss problem for industries where the long run marginal cost is decreasing and less than long run average cost as many studies seem to indicate is true for the electric utility industry.[27] In such cases, one consequence of artificially increasing prices as occurs when the utility serves a tax function would be a lower degree of efficiency in production or a higher cost in terms of the quantities of resources required to produce each unit of the commodity supplied.

Both the problems of welfare loss and decreasing marginal cost are recognized but not included within the scope of the study due in part to the difficulties of applying the welfare loss models to situations where resource prices are artificially controlled at other than the equilibrium price; the development of the energy crisis has confirmed the existence of pricing below equilibrium with respect to fuel for the electric power industry. Even without the problems posed by nonoptimal resource pricing, welfare loss calculations are difficult to interpret in the context of an economic setting in which a considerable amount of production occurs under conditions of imperfect competition.

The second issue involves the reduction in the level of utility of the society when the price paid for a good which serves as a proxy for its marginal utility or valuation relative to other goods is greater than the marginal cost of the good. The implication is that too few resources have been allocated to the production of the monopolistically produced good while too many have been allocated to the production of other goods and that the level of utility of the society could be improved by a reallocation of the resources to restore the optimal marginal conditions. The relationship between the price and marginal cost of electric energy supplied by the Stillwater system is examined in Chapter IV.

C.3 Tax Equity

In addition to the questions of technical and allocative efficiency raised with respect to the supply function of the electric utility the tax or revenue function poses additional questions associated with the allocative and distributive effects of the practice. In particular, it is hypothesized that the pricing arrangement (1) may directly violate the ability to pay criterion[28] of equity in taxation and (2) through its redistribution of real income, may violate the benefits received criterion[29] of equity in taxation.

C.3.1 Ability to Pay

In the pricing of electric energy two classes of charges are involved, (1) the sale of a socially produced commodity, electric energy, and (2) assessment of the tax for the provision of other municipal goods and services from revenue over cost derived from the sale of electric energy. User charges for any normal good are typically regressive in

terms of the ability to pay criterion of tax equity.[30] The graduated block rate structure used in pricing of electric energy would be expected to exacerbate that situation.

The question of the degree to which the municipal electric utility's pricing arrangement for financing the provision of a bundle of municipally supplied goods and services meets the ability to pay criterion of equity is the topic of Chapter IV. Electric utility data on usage and billing for electric energy services are compared with census data on income to determine the relationships between (1) the level of income and the price of the services and (2) level of income and the share of income absorbed by the electric bill.

C.3.2 Benefits Received

The issue of the benefits received criterion of equity is bound up in the redistribution effects of the pricing scheme. Two relationships are involved, (1) the relationship of the price of electric energy to the costs imposed by the various income groups which determines the source of the revenue over cost which subsidizes the provision of other municipal goods and services and (2) the relationship between the residual tax-profit and consumption of the subsidized goods and services.

The relationship between the annual bill paid for electric energy and the costs imposed. Pricing of electric energy is considerably more complex than the simple price-marginal cost allocation issue because the block rate structure subsumes not one commodity but several, e.g., customer service, capacity to meet demand, and energy, into a single price such that a unique average price is associated with each possible quantity of energy consumed. Unless the rate structure is designed to take

account of differences in the costs of providing services to the various income groups and distributes the discrepancy between revenue and cost uniformly over the different segments of the rate structure, a discriminatory pricing scheme may assess the tax burden unequally among different consuming groups. For example, promotional rates appear to have increased the quantity of capital equipment required to meet peak demand. However, such promotional rates have been available predominantly to upper income users while the portion of the block rate schedule designed to recover costs of generating and transmission is paid by all residential customers regardless of their contributions to the peak of demand or their level of income.[31]

The answer to the question of who actually pays the tax or economic profits, then, depends upon which segments of the rate schedule collect revenues in excess of the costs of service provided. The relationship between the annual tax bill and costs of electric service is examined in Chapter V to determine the distribution of tax-profits with respect to income groups. Data on quantities consumed and the median annual electric bill are obtained from electric billing records. Customer costs[32] are assessed on the basis of data from the electric billing records and aerial photo maps of the city. Demand or capacity costs[33] are analyzed on the basis of patterns of demand for electric energy by the various consuming groups during a one-year period as revealed by the electric billing data. Energy costs have been defined as the costs that vary with the quantity of kilowatt hours produced and consequently are similar to the variable cost concept in microeconomic theory. Energy costs are assumed to be the same for all consuming groups, except where high income groups create peak demand pressures requiring

the plant to generate at less efficient levels or requiring the purchase of energy.

The relationship between the residual tax-profit and consumption of subsidized commodities. Revenues in excess of costs derived from operation of the municipal electric utility partially finance the supply of other city services. It is hypothesized that no positive correlation exists between the revenue-over-cost generated by various electric energy consuming groups and their consumption of the municipal services it subsidizes.

Chapter VI uses data on such services as fire protection, police protection, use of park and recreation facilities, and the existence and condition of paved streets to examine the accrual of benefits of these subsidized commodities to the various income groups. Findings with respect to the limited variables for which data are available provide some limited insights into the extent to which the tax conforms to the "benefits received" criterion of equity.

While the sparse assortment of existing data on use of municipal services limits the investigation of the benefits received principle of tax equity to a rather cursory level, it does suffice for this study's purpose of an exploratory inquiry into the mechanism and functioning of the system. Based on the procedures used here, a more definitive study might be undertaken at the expense of a considerable allocation of resources to the collection and development of a more comprehensive set of data; however, such an undertaking is outside the scope and purpose of this study.

FOOTNOTES

[1]In January 1970, there were 1,909 municipal electric utilities. Local publicly owned electric utilities which are usually municipal utilities existed in every state except Hawaii and Montana. Nebraska, the only state in which all electric utility service is consumer-owned or provided by either publicly owned or cooperative systems, had the largest number (174) of local publicly owned utilities. Oklahoma ranked 11th with 71 local publicly owned systems. Of the 1,909 municipal utilities, 619 were engaged in at least some generating activity. The smallest generating system reported had .09 megawatts capacity. The largest generating system had 3,886 megawatts capacity. Public Power, Vol. 28, No. 1 (January 1970), pp. 22-57; Vol. 34, No. 1 (January-February 1976), pp. 31-74. By 1976, the number of municipal utilities had grown to 2,126.

[2]Phoebus J. Dhrymes and Mordecai Kurz, "Technology and Scale in Electricity Generation," Econometrica, Vol. 32, No. 3 (July 1964), pp. 287, 297, 305-312; Ryutaro Komiya, "Technological Progress and the Production Function in the United States Steam Power Industry," Review of Economics and Statistics, Vol. XLIV (May 1962), p. 162, see especially footnote 21; Malcolm Galatin, Economies of Scale and Technological Change in Thermal Power Generation, Contributions to Economic Analysis No. 53, Amsterdam: North-Holland Publishing Company (1968), p. 126.

[3]While municipal utilities serve only about 13% of the population compared to 80% served by privately owned power companies, they are significant for two reasons. (1) They represent more than half the electric utilities in the nation and are the source of electric supply for more than 2100 communities. (2) More significantly, the municipal utilities have in recent years been the most rapidly expanding segment of the industry in terms of average residential consumption, number of customers, growth of operating revenues, and net plant investment. They have followed the REA for a close second place in the percent gain in installed capacity. The percentage of the population served by municipal utilities has about doubled since the mid-thirties. American Public Power Association, Public Power and the APPA, Washington, D. C.: American Public Power Association, pp. 5, 6; Alex Radin, "Municipal Electric Service--Tradition and Opportunity," (speech at Berlin, New Hampshire, October 15, 1969) Washington, D. C.: American Public Power Association, pp. 1-3; and Robert P. Strauss and Kenneth L. Wertz, "The Impact of Municipal Electric Profits on Local Public Finance," National Tax Journal, Vol. 29, No. 1 (March 1976), p. 22.

[4]Richard L. Wallace and Paul E. Junk, "Economic Inefficiency of Small Municipal Electric Generating Systems," Land Economics, Vol. XLIV, No. 1 (February 1970), pp. 98-104; Federal Power Commission, National

Power Survey, 1964, Part I - Advisory Reports, Washington, D. C.: United States Government Printing Office (February 1964), pp. 24, 25.

[5]Strauss and Wertz found that 98.8 percent of the city-operated electric utilities filing statements with the Federal Power Commission during the years 1951 through 1971 reported net incomes and that in many cities these "profits" have been substantial when compared with revenues raised by local taxation. Strauss and Wertz, p. 22.

[6]In private conversation with the researcher, Paul Fry of the American Public Power Association indicated that in recent years the APPA has urged municipal utilities to regard their role as being the provision of low-cost electric energy to their customers. In part, this policy has been urged as a political deterrent to pressures to disband the municipal utility in favor of investor owned utilities which are now capable of serving and interested in acquiring the customers of municipal utilities.

[7]Ronald D. Gilbert, "Municipal Acquisition of Utilities: Some General Equilibrium Considerations," Journal of Economics, Vol. 1 (1975), pp. 61-64.

[8]City managers and other representatives from the municipal electric utility systems attending the Oklahoma Municipal Utilities Conference in Stillwater, Oklahoma, April 7 and 8, 1971, commented at length during informal discussions on the difficulty of increasing revenues from other utilities vis-a-vis the growth of revenue from electricity. The revenue productivity of municipal utilities has been offered as one of their major selling points by the public utilities' own lobby group. American Public Power Association, pp. 5-6; Alex Radin, Municipal Electric Service --Tradition and Opportunity, (Speech at Berlin, New Hampshire, October 15, 1976) mimeo. Washington, D.C.: American Public Power Association (1969).

[9]City managers' comments with regard to electric utility operation, Oklahoma Municipal Utilities Conference, Stillwater, Oklahoma, April 7 and 8, 1971; Robert M. Coffelt, "Financing the Municipal Government in Stillwater, Oklahoma" (unpublished Master's thesis, Oklahoma State University, 1930), p. 3; Stanley Allen Self, "Municipal Electric Utility Systems" (unpublished Ph.D. dissertation, University of Oklahoma, 1958), p. 231; Jack W. Strain, An Outline of Oklahoma Government, Norman, Oklahoma: Rickner's Book Store (1969), pp. 154-157; Robert Warren, Jr., "Taxation: Municipal Operation of Public Utilities: Sources of Municipal Revenue in Oklahoma," Oklahoma Law Review, Vol. I (May 1948), pp. 101-106; and Will T. Wright, "Commentary on Oklahoma Revenue and Taxation," Oklahoma Statutes Annotated, Title 68, St. Paul, Minnesota: West Publishing Company, 1966, pp. xxx, xxxi, lix, lx.

[10]Strain, pp. 154-156; Oklahoma Tax Code, Title 68 Article 27 § 2701.

[11]A recent study of citizen's attitudes toward municipal ownership of electric utilities and their tax function lends support to this

possibility. In the population studied the citizenry strongly approved municipal sales of electric energy on grounds of fairness in taxation despite feelings that it might be more expensive. Some respondents were from cities where revenues from municipal electric sales enabled the government to maintain a budgetary surplus without using the full mill levy allowed. Audie L. Blevins, Jr., "Public Response to Municipally Owned Utilities in Wyoming," Land Economics, Vol. 52, No. 2 (May 1976), pp. 241-245. Similar overtones have been evident in conversations with respect to the tax function of municipal utilities in Oklahoma.

[12]The block meter rate schedule is the most widely used for residential and other small-volume customers. This type of schedule offers successively lower rates per kilowatt hour for all or part of each block (quantity) of energy consumed. The customer's bill is calculated by cumulating the charges incurred for each successive block of energy taken or fraction thereof. Paul A. Garfield and Wallace F. Lovejoy, Public Utility Economics, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., (1964), p. 155.

[13]"The load factor shows the average use of facilities as a percentage of the maximum use. It is defined as the ratio of the average load over a designated period of time to the peak load occurring in that period...The load factor shows how steadily the maximum power requirement has been employed..." Paul A. Garfield and Wallace F. Lovejoy, Public Utility Economics, Englewood Cliffs, New Jersey: Prentice-Hall, Inc. (1964), p. 153.

[14]Diversity refers to the fact that peak demands for the various classes of service do not occur simultaneously. The diversity factor measures the degree of diversity and is defined as "the ratio of the sum of the class peak demands to the system maximum demand...The higher the diversity factor, the less the total plant capacity required to serve a particular market or service area." Garfield and Lovejoy, p. 153.

[15]This statement was verified in discussions between the writer, representatives of C. H. Guernsey and Company, who are consulting engineers to the publicly owned utilities in the area, and representatives of a number of municipal electric utilities present at the Municipal Utilities Conference in Stillwater, Oklahoma on April 7 and 8, 1971.

[16]The variety of municipal services provided by the City of Stillwater is a matter of considerable pride among the members of the city government and the residents as is immediately evident from even a cursory examination of the city budget. Assistant City Manager David Bretzke discussed this in some detail in a personal interview of March, 1968, in which he explained the operation and revenue functions of the municipal utility in the city's financial scheme.

[17]"Firm" as used here refers not to the commonly accepted usage of the privately operated production entity in price theory but to the

socially owned electric generating and marketing system operated by the city.

[18]C. H. Guernsey and Company, Consulting Engineers, Oklahoma City, Oklahoma: Power Source Study, City of Stillwater, Oklahoma (1963); North Central Oklahoma Power Pool, Preliminary Power Cost Study (March 1964); Comparison of Proposed Interconnection Contracts: Grand River Dam Authority and Oklahoma Gas and Electric Company for the City of Stillwater, Oklahoma (May 1965); City of Stillwater, Fourth Street Power Plant Survey (February 1965); Supplemental Power Source Study, City of Stillwater, Oklahoma (April 1965); Electrical System Study, City of Stillwater, Oklahoma (August 1966); Power Source Study, City of Stillwater, Oklahoma (July 1968); Power Source Study, City of Stillwater, Oklahoma (1972).

[19]Other researchers in studies of investor owned utilities have made similar assumptions based on the same rationale, e.g., Marc Nerlove, "Returns to Scale in Electricity Supply," Measurement in Economics, C. Christ, Editor, Stanford, California: Stanford University Press (1963), p. 168.

[20]John B. Lansing, "An Investigation into the Long Run Cost Curves for Steam Central Stations" (unpublished Ph.D. dissertation, Harvard University (1948) cited in Suilin Ling, Economies of Scale in the Steam Electric Power Generating Industry, Amsterdam: North-Holland Publishing Company (1964), p. 15. Lansing found the minimum efficient scale of plant to occur around 75,000 KW capacity as did J. Johnston, Statistical Cost Analysis, New York: McGraw-Hill Book Company, Inc. (1960), p. 72-73. Minimum efficient scale was reported to occur at 100,000 KW according to findings of Charles E. Olson, Cost Considerations for Efficient Electricity Supply, East Lansing, Michigan: Institute of Public Affairs of the Michigan State University (1970), pp. 30-42. The study by the Twentieth Century Fund indicated that maximum economies occur in plants of about 150,000 KW capacity, The Twentieth Century Fund, Electric Power and Government Policy, New York: The Twentieth Century Fund (1948), p. 357. Despite continuing scale economies beyond 75,000 KW, the tendency of plants to become more elaborate results in almost constant investment per kilowatt past that level; Walter Isard and John B. Lansing, "Comparison of Power Costs for Atomic and Conventional Steam Stations," The Review of Economics and Statistics, Vol. XXXI (1949), p. 219.

[21]The term "discrimination" carries several different meanings in the economic literature. The concept implied here is that of third degree price discrimination which Pigou describes as existing "if a monopolist were able to distinguish among his customers or different groups separated from one another more or less by some practicable mark and could charge a separate monopoly price to the members of each group." Simply stated, the monopolist would maximize his profit among markets having differing demand elasticities for his product by pricing the product such that the quantity demanded in each market would result in the equality of marginal revenues in each of the markets. A. C. Pigou, The Economics of Welfare, second edition, London: MacMillan and Company, Limited (1924), pp. 247-251; and Richard H. Leftwich, The Price System and Resource Allocation, fourth edition, Hinsdale, Illinois (1970), pp. 221-224.

[22]The concept of economic profit differs from the accounting concept of profit. Both concepts treat profit as revenue in excess of costs; the differences are to be found in the cost concepts. The economic concept of cost embodies not only the explicit costs which the accountant lists as the firm's expenses but also such implicit costs as the opportunity costs of investment or a return to the owner "on his investment [which is] equal to what he could have earned had he invested the same amount elsewhere in the economy..." Any return above that opportunity cost may be regarded as an economic profit. Leftwich, pp. 144-146, 190-191.

[23]Federal Power Commission, Statistics of Publicly Owned Utilities in the United States, 1970, FPC S-219, Washington, D.C.: United States Government Printing Office (February 1972), p. 46, and Statistics of Publicly Owned Utilities in the United States, 1971, FPC S-228, Washington, D.C.: United States Government Printing Office (December 1972), p. 48. The cost concept referred to here is the difference of operating revenues minus operating costs divided by operating revenues.

[24]In informal discussion at the Oklahoma Municipal Utilities Conference in Stillwater, Oklahoma, April 7 and 8, 1971, city managers, representatives of the municipal utilities, and representatives of C. H. Guernsey and Company, consulting engineers for most of the publicly owned utilities in the surrounding five state area, confirmed that earnings of the Stillwater utility are similar to those of other publicly owned utilities in the same geographic area. These findings are supported by the Federal Power Commission data.

[25]Moody's Investors Service, Inc., Moody's Public Utility Manual, 1972, New York: Moody's Investors Service, Inc., p. a27.

[26]Federal Power Commission, p. XXI.

[27]Galatin, p. 162.

[28]Simply stated the ability to pay principle says that individuals possessing the greater capacity for paying should bear the greater share of the burden of supplying public goods. In its earlier form this criterion for assessing the burden for the provision of public services was supported as a concept of justice. Later it evolved through the welfare rationalizations involving the equal sacrifice principles of taxation and finally resulted in formulations of maximum-welfare principles of budget determination. Bernard P. Herber, Modern Public Finance, Homewood, Illinois: Richard D. Irwin, Inc. (1967), pp. 53-59; and Richard A. Musgrave, The Theory of Public Finance, New York: McGraw-Hill Book Company (1959), pp. 90-115. In this study income is selected as a proxy for ability to pay and the ability to pay principle is treated in its simplest form, i.e., that at the very least, the poor should not be required to pay more.

[29]The benefits received criterion of equity involves a quid pro quo relationship. An individual is willing to pay in accordance with the benefits received from the commodity. Earlier proponents of this principle endorsed it on grounds of justice. Later writers have viewed its

merits in terms of optimal allocation within the public sector and between the private and public sectors; this view of the benefits criterion has been refined into the voluntary exchange theory which holds that an individual buys public goods through taxes much the same as he buys private goods in the market. In voluntarily paying taxes for public goods according to the benefits he receives the taxpayer is "equating the ratios of the marginal utilities to the tax prices of the public goods as well as equating the ratios between public goods and private goods." Herber, pp. 49-53; and Musgrave, pp. 61-89.

[30]Herber, p. 275; and Harold M. Groves, Financing Government (3rd ed.), New York: Henry Holt and Co. (1950), pp. 287-288.

[31]The problem one would suspect here is that high income users have a poorer load factor and consequently create demands for peaking capacity much greater than their average demand whereas lower income people are less likely to own and operate appliances and equipment which contribute significantly more to peak demand than off-peak demand. If this is the case, then assessing both income groups the same charges for providing capacity amounts to a regressive rate of charge for a service which is typically regressive by nature even in the presence of proportional charges for service.

[32]"The total of customer costs varies directly with the number of customers served. Customer costs include the expenses of meter reading, billing, collecting, and accounting. Also included are the expenses associated with the capital investment in the general distribution system. If administrative and general expenses are spread on the basis of investment, part of that expense total may be included in customer costs." See Garfield and Lovejoy, p. 158.

[33]"Demand or capacity costs vary in total with the quantity of plant and equipment. Such costs consist of return on rate base, taxes and depreciation expenses, with the exception of that part thereof which is assigned to customer goods...part of administrative and general expenses, those operating and maintenance expenses which do not vary with the quantity of service supplied...[and]...some portion of the fuel expense ...included...in recognition of the fact that part of the fuel consumed, perhaps 20 percent, may be required to keep the plant in readiness to serve." Garfield and Lovejoy, p. 158.

CHAPTER II

THE SUPPLY FUNCTION OF THE MUNICIPAL ELECTRIC UTILITY

A. Introduction

As noted in Chapter I, the Stillwater Municipal Electric Utility serves two functions: (1) supplying electric energy to the community and (2) providing revenue for operation of the municipal government. The purpose of this chapter is to investigate the economic aspects of the supply function. Concern at this point of the study is with technical efficiency or whether the municipal generating system represents a least-cost source of electric energy for the community.

During fiscal year 1969-70, operating cost for the generating system of the Stillwater Municipal Electric Utility as reported to the Federal Power Commission averaged .0055 dollars per kilowatt hour; during fiscal year 1970-71 reported operating costs for the Stillwater generating system averaged .0059 dollars per kilowatt hour. For calendar year 1970, the Oklahoma Gas and Electric Company (OG&E) experienced generating costs averaging .0025 dollars per kilowatt hour based on reports to the Federal Power Commission.[1] Operating costs for self-generation of Stillwater's electric supply averaged from 220 to 236 percent greater than the generating costs for electric energy available to the Stillwater system for purchase through an existing interchange with OG&E. In overall terms, this cost discrepancy amounted to $336,333 for the 112,111,000

kilowatt hours of electric energy consumed by patrons of the Stillwater system during fiscal year 1969-70 or $402,604 for the 118,413,000 kilowatt hours they consumed during fiscal year 1970-71.

Capital costs for the two generating systems appear to be equally disparate. In 1971 the 22,650 kilowatt generating capacity of the Stillwater system was valued at $4,138,332 or $182.71 per kilowatt of capacity.[2] The Oklahoma Gas and Electric Company's 1,919,247 kilowatts of generating capacity were reported to have a value of $183,244,322 or $95.48 per kilowatt of capacity.[3] The smaller equipment of the Stillwater plant cost 91 percent more per kilowatt of capacity than the larger units used by Oklahoma Gas and Electric Company. While comparison of operating costs and book value per kilowatt capacity represents a cursory approach to the assessment of technical efficiency in the municipal-vs.-investor owned setting in that no attention is given to use economies and the influence of institutional differences with respect to financing costs, these dramatic results are indicative of some of the concerns to be further investigated in the pages that follow.

B. Defining the Problem

B.1 Scope of the Study

The immediate issue investigated in this chapter is the question of whether residents of Stillwater are enjoying a least-cost supply of electric energy in terms of resources absorbed. However, the findings have implications for a broader question not researched here, i.e., whether organization of the nation's electric utility industry under current institutional arrangements which encourage the existence of many small municipal systems is suboptimal as statistical studies would seem to indicate.[4]

B.1.1 Conceptual Framework

The problem to be researched may be illustrated conceptually as in Figure 1.

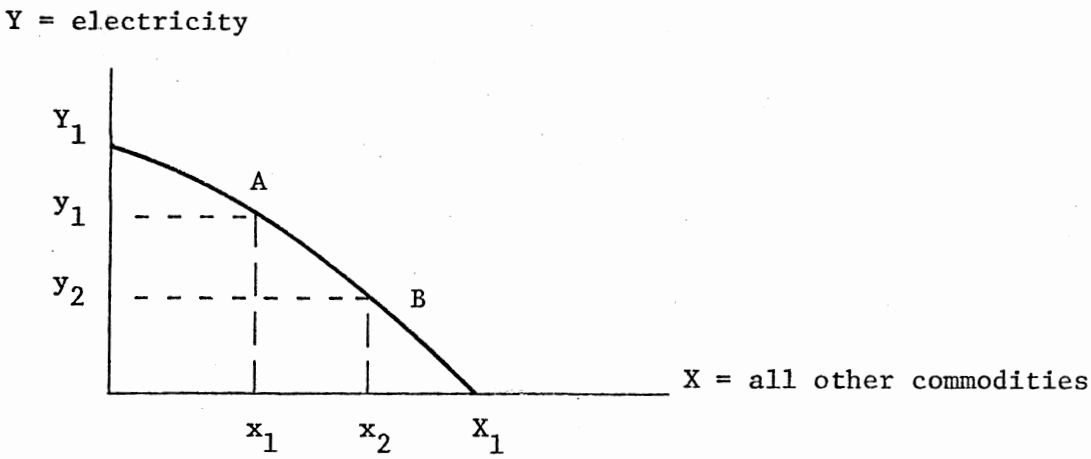


Figure 1. Hypothetical Production Possibilities Boundary

Let curve Y_1X_1 represent the locus of possible output combinations for electric energy and all other goods attainable by the most efficient employment of all resources available. Then an inefficient or non-least cost employment of resources in any industry would result in a level of production somewhere to the left of the production possibilities boundary Y_1X_1. If operation were to occur such that some hypothetical quantity x_1 of X and y_2 of Y were produced at (x_1,y_2) in commodity space by employing current production techniques, then other things equal, the welfare of society would be reduced by the amount of its valuation of any possible quantity (x,y) along the segment AB which would be yielded by efficient employment of the resources minus society's valuation of (x_1,y_2).

Results of empirical investigation would suggest that alternative sources of electric energy supplied by producers having larger plants would have greater technical efficiency than local generation as a

consequence of economies of scale and utilization available to the larger units, or that continued employment of small municipal generating systems to produce the electric energy supply places the total bundle of goods available at some point (x_1, y_2) behind the production possibilities boundary. However, engineering studies of the Stillwater system have consistently over several decades indicated that in nominal terms the local municipal electric utility does represent the least cost source of energy for the city of Stillwater.

This is not to say that the results of economic analysis and findings of engineers are in conflict; rather it reflects the significance of the differences between the two cost concepts employed. It was noted in Chapter I that the tax-interest subsidy to municipal utilities would tend to produce a divergence of the resource costs examined by economists and nominal costs which are the basis for the engineering studies. One of the questions to be investigated then is whether this element results in sufficient influence over nominal costs to offset any economies gained by production in technically more efficient plants. Such suspicions seem to be substantiated by the fact that in nominal terms the city of Stillwater finds it less expensive to generate than to purchase electric energy produced at double OG&E's operating costs while the Stillwater system also earns over 55 percent revenue over operating cost compared to approximately 26 percent for OG&E.

The situation may be illustrated diagramatically as in Figure 2 and Figure 3 which follow. Figure 2 depicts the reduction of nominal costs as experienced by the local municipal generating system as a result of the tax interest subsidy. Figure 3 carries the analysis to the broader level of firms operating in the industry and indicates the real resource

costs to society of subsidizing the supply of electric energy via a less efficient alternative technical arrangement.

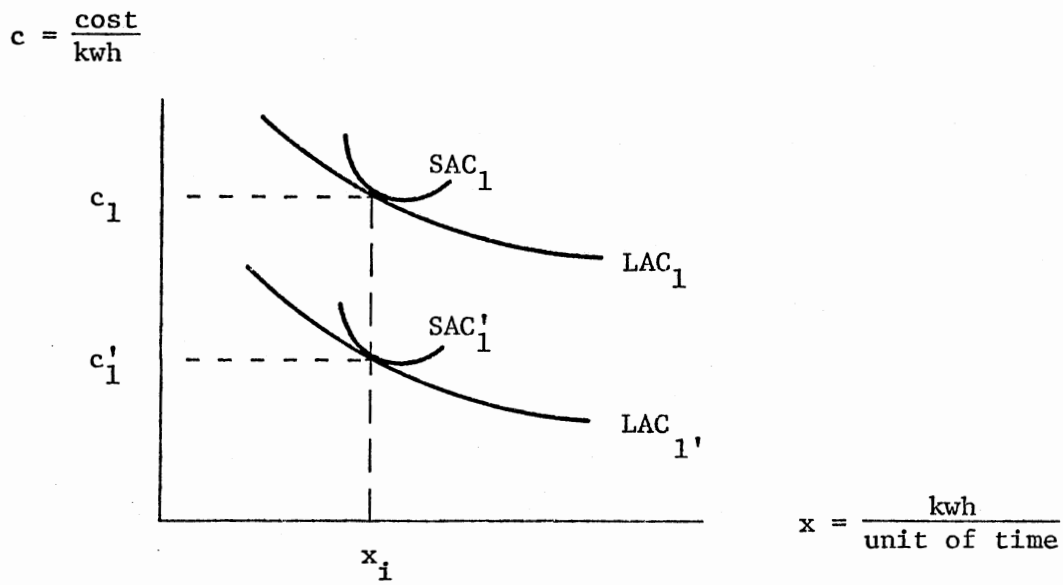


Figure 2. Hypothetical Cost Curves for a Municipal Utility and an Identical Investor Owned Firm in the Electric Power Industry

Let LAC_1 represent the observed long run average cost curve for a firm in the investor owned segment of the electric power industry, and LAC_1' represent the observed long run average cost curve for an identical "firm" in the municipally owned segment of the industry. The assumption that the firms are identical is required to hold the load factor constant. Let SAC_1 and SAC_1' represent the firms' respective short run average cost curves. Then the difference between nominal unit costs of production of the two firms for any capacity x_i will be measured by the vertical distance between the two curves, LAC_1 and LAC_1'. This difference represents the amount of the subsidy provided to municipally owned utilities by their tax interest advantage vis-a-vis the investor owned utilities or alternatively, depending upon one's point of view, the burden in taxes borne by the investor owned utility vis-a-vis the tax exempt municipal utilities.[5]

In terms of real resource costs,[6] i.e., the value of resources used, the Stillwater municipal utility's short run average cost curve may be represented by SAC_1 on LAC_1, but it is observed in nominal cost terms as SAC_1' on LAC_1'; the difference between the real cost c_1 and the nominal cost c_1' represents a hidden resource cost obscured by the institutionally induced tax interest subsidy. The problem is to determine the location of point c_1 on LAC_1 in order to estimate the portion of the real cost of Stillwater's operation which is obscured by the subsidy. The difference in resource costs of the two firms estimates the effects of the subsidy. It is hypothesized that this subsidy enables the Stillwater utility to operate a plant which may be suboptimal in the technical least-cost sense within the context of the industry rather than purchasing electric energy from OG&E. This problem is discussed below.

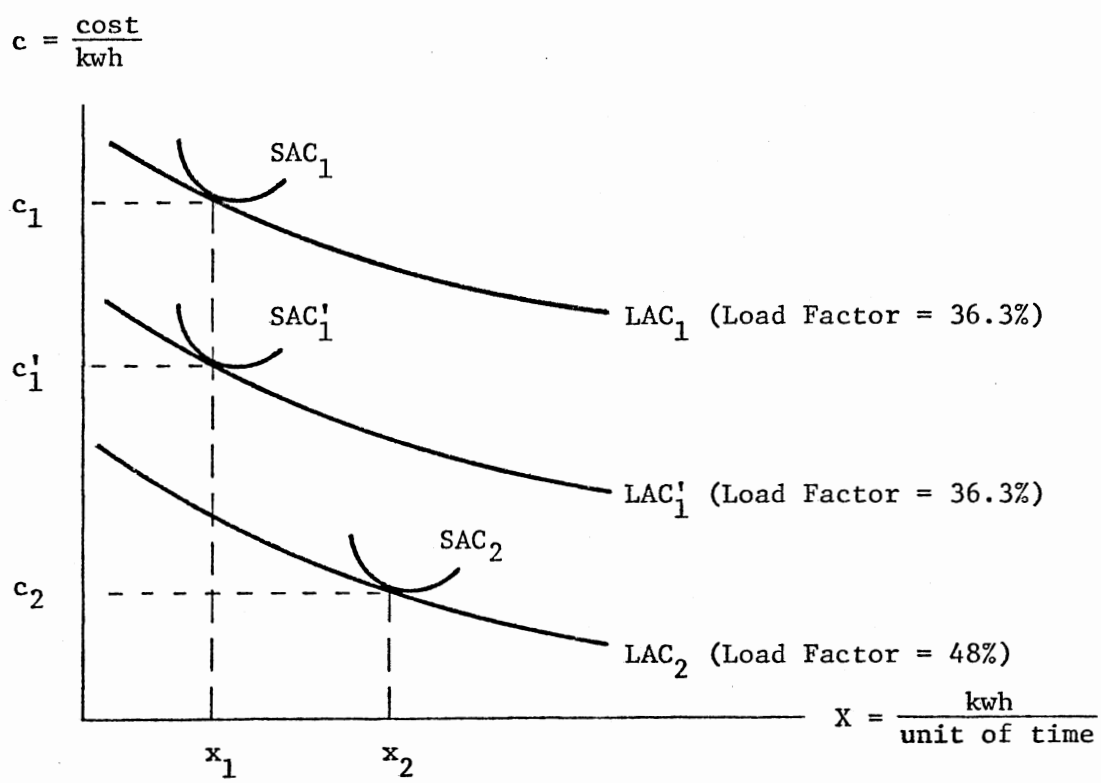


Figure 3. Hypothetical Cost Curves for Firms in the Electric Power Industry

B.1.2 The Test Case

Figure 3 illustrates conceptually the real resource cost to society of the choice of the less technically efficient alternative arrangement for the supply of electric energy. For purposes of this study it is reasonable to make a comparison of the Stillwater utility with the investor owned Oklahoma Gas and Electric Company (OG&E) as a primary alternative source of supply. The two utilities have an existing interconnection through which the Stillwater utility purchases peaking power. Also, since both are located in the same geographic area they face the same general market and climatic conditions such that it seems reasonable to assume that all factors influencing costs may be regarded as constant between the two utilities with the exception of the load factor differences associated with size of market and those associated with the subsidy. Consequently, it seems that OG&E's costs may reasonably be applied to the Stillwater municipal utility's production conditions to estimate the nominal cost reductions enjoyed by the latter as a result of the subsidy.[7] It should be recalled that the advantages associated with the subsidy are not reflected in the cost data cited in the introductory remarks of this chapter.

In reference to Figure 3 let SAC_1' on LAC_1' represent the observed cost conditions for the 22.65 megawatt Stillwater utility and let SAC_1 on LAC_1 represent the real cost conditions in terms of resources absorbed. Both SAC_1 and SAC_1' reflect Stillwater's load factor of approximately 36 percent during fiscal year 1970-71. The observed or nominal average cost to Stillwater for producing x_1 kilowatt hours per year with the subsidy is c_1' per kilowatt hour, but the market value of the resources absorbed is c_1 in the absence of the subsidy. The OG&E system with total capacity

of 1919.25 megawatts and a load factor of 48 percent in 1970 can be represented by SAC_2 on LAC_2 producing x_2 kilowatt hours per year at an average cost of c_2 per kilowatt hour. Both c_1' and c_2 represent costs for which data series are available; c_1 can only be estimated.

B.2 Methods of Study

Two approaches were considered for assessing the institutional effects and technical efficiencies involved in municipal electric energy generation vis-a-vis the investor owned alternative. Economies associated with variations in unit size in electric energy generation, i.e., the real technical relationships depicted by the shape of the LAC curve, might be studied to determine the nature and magnitude of advantages to be gained from size along the relevant portion of the long run average cost curve in question. Discovery of the relationship between real costs and size would then permit c_1 to be determined and the effects of the subsidy measured on the basis of the discrepancy between c_1 and c_1', which reveals the hidden cost of the Stillwater utility due to the subsidy, and between c_1 and c_2, which indicate the resource costs to society of choosing that alternative supply arrangement.

Another approach to discovering the differences in technical efficiency is direct comparison of nominal costs of the two firms and an estimation of the subsidy based on accounting data pertaining to the tax interest subsidy. The difference between c_1' and the estimated c_1 would reveal the size of the hidden resource costs of the Stillwater plant and the difference between c_1 and c_2 would indicate the effects of differences in technical efficiency or the social cost of having

chosen that alternative. Feasibility of both approaches was investigated and the results follow.

C. Cost Curves as a Tool for Estimating the Subsidy

C.1 Empirical Studies of Scale Economies in the Generation of Electric Energy

Production theory embodies a well developed framework of hypotheses regarding behavior of costs as quantity of output is varied. Many empirical studies have been conducted in a great variety of industries in the industrialized countries in attempts to verify, refute, or measure the hypothesized cost relationships. Since electric energy generation has been the object of a great deal of this type attention in the last three decades, these studies were evaluated as possible means for estimating c_1. The studies were examined first to determine whether a general concensus regarding existence and size of scale economies could be found among them and second to determine which, if any, of the studies had been designed such that the findings could be applied directly to the questions investigated in this study.

C.1.1 Search for a General Concensus

Table I summarizes the major studies of the relationship between costs and quantities of output in electric energy generation. As is evident from Table I, synthesis or comparison of results of the studies of cost and production relationships in the electric power industry is made difficult by the great variety of approaches, assumptions, data sources,

TABLE I

SUMMARY OF STUDIES OF SCALE ECONOMIES IN THE ELECTRIC UTILITY INDUSTRY

	Characteristics of Unit of Analysis					Characteristics of the Analytic Model					
Researcher	Unit of analysis	Differentiation by machine size mix	Differentiation between single and multi unit operations	Differentiation by fuel type	Differentiation by vintage (or level of technology)	Ex post or ex ante	Functional relation	Static or dynamic	Assumptions regarding least-cost production	Adjustment Adjustment use economies	Adjustment to remove use economies and interaction effects
Barzel[1]	Plant	No	No	No	Yes; attempts to remove effects	Ex post statistical	Production function	Dynamic	Yes; implicit	Yes	No
Dhrymes and Kurz[2]	Plant	No	No	No	Yes; attempt to remove effects	Ex post statistical	Production function	Static	Yes; subject to regulatory effects	Yes	Not indicated
Galatin[3]	Machine	Yes	Yes	Yes	Yes; attempts to remove effects	Ex post statistical	Production function	Dynamic	Yes; subject to regulatory effects	Yes	No; not explicit
Isard and Lansing[4]	Plant	Not stated	Not stated	Yes; fossil fuel vs. atomic	No	Ex post statistical	Cost function	Static	Not stated	No	No
Iulo[5]	Firm	No	Yes	No; specified steam electric	Yes	Ex post statistical	Multiple regression of costs	Static	Yes; implicit	Yes	No
Johnston[6]	Firm	No	No	No; specified steam electric	No	Ex post statistical	Cost function	Static	Yes	No	No
Komiya[7]	Machine	No	No	Yes	Yes	Ex post statistical	Production function	Dynamic	Yes; explicit	No	No
Lansing[8]	Plant	Unknown	Unknown	Unknown	Yes; attempts to remove effects	Ex post statistical	Cost function	Unknown	Yes; implicit	Yes; with caution	Yes, with caution
Ling[9]	Firm	Specified plant has an optimal machine mix	No	No; specified steam electric	No	Ex ante engineering project analysis	Cost function	Dynamic	Yes; explicit	Yes	No
Lomax[10]	Machine	No	No	No	No	Ex post statistical	Cost function	Static	Yes; implicit	Yes; with caution	No
Nerlove[11]	Firm	No	No	No	No	Ex post statistical	Cost function	Static	Yes; explicit	No	No
Olson[12]	Machine	No	No	Yes	Yes; attempts to remove effects	Ex post statistical	Cost function	Static	Yes; implicit	Yes	No
Twentieth Century Fund[13]	Plant	Not indicated	Not indicated	Not indicated	Not indicated	Not indicated	Not indicated	Not indicated	Not indicated	Not indicated	Not indicated

[1] Yoram Barzel, "The Production Function and Technical Change in the Steam-Power Industry," Journal of Political Economy, Vol. 72 (April 1964), pp. 133-150.

[2] Phoebus J. Dhrymes and Mordecai Kurz, "Technology and Scale in Electric Generation," Econometrica, Vol. 32, No. 3 (July 1964), pp. 287-315.

[3] Malcolm Galatin, Economies of Scale and Technological Change in Thermal Power Generation, Amsterdam: North-Holland Publishing Company (1968).

[4] Walter Isard and John B. Lansing, "Comparisons of Power Cost for Atomic and Conventional Steam Stations," The Review of Economics and Statistics, Vol. XXXI, No. 3 (August 1949), pp. 217-228.

[5] William Iulo, Electric Utilities--Cost and Performance, Pullman, Washington: Washington State University Press (1961).

[6] J. Johnston, Statistical Cost Analysis, New York: McGraw Hill Book Company, Inc. (1960).

[7] Ryutaro Komiya, "Technological Progress and the Production Function in the United States Steam Power Industry," The Review of Economics and Statistics, XLIV (May 1962), pp. 156-166.

[8] John B. Lansing, "An Investigation into the Long Run Cost Curves for Steam Central Stations," (unpublished Ph.D. dissertation, Harvard University, 1948).

TABLE I, Continued

Characteristics of the Data							
Date	Cross section or time series	Geographic region	Factor prices adjusted	Extraordinary items included in cost data	Differentiation between generation only or generation purchase	Existence scale economies	Upper limit for which scale economies were detected[14]
1941-1959	Both	United States	Yes	None	Generation only	Yes	Not specified
1937-1959	Cross section	United States	No, used physical quantities	Land, improvements, structures	No; probably	Yes	Above 1400 MW
1938-1953	Both	United States	No, used physical quantities	Land, improvements, structures	Generation only	Yes	Above 100 MW
1945	Cross section	United States	Not stated	Not stated	No, probably included both	Yes	100 MW for conventional steam, beyond 375 MW for atomic
1952-1957	Both	United States	Yes; over time	Operating expense and some capital items[15]	Yes; explicit	Yes	Not specified
1927-1947	Both	United States & Great Britain	Capital cost only over time	British work cost, U.S. capital cost	No, probably included both	Yes	75 MW
1930-1956	Cross section	United States	Yes, for equipment. Used physical units for fuel	Omitted the construction component of capital and land	No; probably included both	Yes	Not reported
1945	Cross section	United States	Unknown	Unknown	No, probably included both	Yes	75 MW
1905-1959	Both	United States	No	Land, improvements, structures	No, probably included both	Yes	Throughout 20,000 MW
1947-1948	Cross section	Great Britain	Yes; Geographically	Works costs only	Generation only	Yes	Throughout 300 MW
1955	Cross section	44 states of the United States	Capital prices adjusted by Handy-Whitman Index	All costs reported to FPC	Generation only	Yes	Over the entire rante, largest is Commonwealth Edison
1956-1965	Cross section	United States	Used current fuel price for all periods	Limited capital to generating equipment	No, probably included both	Yes	Above 200 MW
pre-1949	Not indicated	United States	Not indicated	Not Indicated	Not Indicated	Yes	150 MW

[9] Suilin Ling, Economies of Scale in the Steam Electric Power Generating Industry, Amsterdam: North-Holland Publishing Company (1964).

[10] K. S. Lomax, "Cost Curves for Electricity Generation," Economica, Vol. XIX, No. 74 (May 1952), pp. 193-197.

[11] Marc Nerlove, Estimation and Identification of Cobb-Douglas Production Functions, Chicago: Rand McNally and Company (1965), pp. 167-198.

[12] Charles E. Olson, Cost Considerations for Efficient Electricity Supply, East Lansing, Michigan: Institute of Public Affairs of the Michigan State University (1970).

[13] The Twentieth Century Fund, Electric Power and Government Policy, New York: The Twentieth Century Fund (1948), pp. 30-37, 355-359.

[14] Figures given may represent the largest firm in the sample rather than an actual upper limit.

[15] Capital items included are depreciation, amortization, taxation, and some income deductions. Returns to equity capital are not included.

degree of aggregation of units of analysis, degree of refinement, and inclusiveness of the various models.

Characteristics of models. Both the *ex post* statistical approach and *ex ante* engineering project analysis have been employed.[8] The question of economies associated with size have been approached from the position of both cost functions and input relationships in production.[9] Both static and dynamic analysis have been employed.[10] Data sources have been both time series and cross section.[11] Some studies have specifically assumed optimal behavior, some have specifically assumed optimal behavior subject to a regulatory constraint, and others have employed models which implicitly indicate optimal or cost minimizing behavior[12] although no direct recognition of this assumption, or its appropriateness in light of criticisms of the assumptions for the regulated power industry,[13] have been made.

Unit of analysis. Depending upon the objectives of the study, the machine, plant, and firm have been chosen as the unit of analysis.[14] Studies using the plant as the unit of analysis may disaggregate the sample on the basis of machine mix,[15] fuel type,[16] and vintage taken as a measure of the level of technology,[17] while others do not. Studies using the firm as a unit of analysis may or may not give attention to the above items,[18] in addition to considerations of whether the firm operates more than one plant,[19] and whether the firm generates all its power or includes power purchases.[20] Likewise, there are variations in the attention given to fuel[21] and level of technology[22] when the machine is the unit of analysis.

Concepts of size variables. Depending, again, upon the objectives of the study, there were variations in the degree of refinement of the variables estimated. At issue here is the question of what shall be subsumed in the long run average cost curve which many of the studies were attempting to estimate. Some studies subsumed all variations in technical efficiency associated with changes in size under the heading of economies of scale.[23]

Other researchers distinguished between scale economies which are due strictly to changes in size and utilization economies which are associated with load factor.[24] Some of the latter pointed out the presence of interaction effects between scale and utilization economies associated with the smoothing out of the demand pattern as larger more diverse populations are served.[25] Those who made the distinction between scale and utilization economies regarded the economies as representing a shift in the long run average cost curve as opposed to a movement along such a curve. Observations of two units of different size would then reflect not movements along a true average cost curve but units on two different average cost curves as illustrated in Figure 3.

Technology considered. Some studies move one step further in separating out the effects of variations in levels of technology.[26] Since technological improvements in generating systems seem to be positively associated with increases in size of units installed, the reasoning concerning influence of technological improvements on the long run average cost curve is analogous to that regarding utilization economies.[27]

Data considerations. Difficulties in locating adequate data and problems in interpreting data to fit into the theoretical framework have

resulted in individual studies being based on differing cost components or differing combinations of cost components. Where nominal costs are used, changes in factor prices produce shifts in the curve similar to those caused by differing load factor, as illustrated by Figure 3. Johnston and Barzel[28] used a price index to deflate costs over time. Some studies were based on works costs alone.[29] Johnston analyzed working costs for British industry and capital costs for the United States industry.[30] Barzel's final results[31] excluded structures and improvements, and land from capital costs while others included these costs in their calculations.[32]

Findings regarding concensus. The complications discussed above along with the variety of models employed in estimating cost and input relationships make meaningful direct comparison of the various research findings regarding economies associated with size impossible. Part of the diversity problem arises from difficulties in moving from the theoretical concepts of costs to an operational model compatible with available data; the result is individual interpretations for the derived relationships in each study.

While this situation precludes any synthesis of the results of the studies to yield a basis for a precise estimation of the economic effect of the subsidy with respect to municipal electric utilities, this collection of studies does provide strong support for the effects hypothesized. Regardless of the structure of the study, results were consistent in finding an association between improved technical efficiency and size at least up to sizes well above that of the 22.65 megawatt Stillwater plant.

C.1.2 Appropriateness of Individual Studies

Only the study by Nerlove encompassed data sets and a model which might permit successful direct application of the results to the case examined in this chapter. However, attempts to use Nerlove's findings for estimating the subsidy were regarded as unsuccessful due to the inaccuracies yielded by the Cobb-Douglas model for extreme values of the function.[33]

D. Estimation of Effects of the Subsidy and Inefficiency in Resource Use Based on Direct Application of Accounting Data

D.1 Previous Studies Examined

Earlier researchers' findings regarding size economies in generation of electric energy were examined in the preceding section of this chapter as one possible approach to estimation of the subsidy effects of the tax-interest advantages allowed publicly owned utilities. Wallace and Junk[34] and Olson[35] estimated the amount of resource waste by direct applications of engineering estimates and accounting data without statistical treatment to estimate cost or production functions.

Olson compared the advantages enjoyed by the tax-free electric cooperatives against the position of investor owned utilities for which taxes average about 20 percent of operating revenues.[36] He also noted the 2 percent federal loans repaid over 35 years by the cooperatives as compared to an average capital cost of 7 percent faced by privately owned utilities at the time of his study. Assuming a 25 percent capital turnover, Olson estimated that the lower interest rate amounted to an

advantage of approximately 20 percent of utility operating costs for the cooperatives. Consequently Olson infers that the cooperative segment of the publicly owned sector of the electric utility industry receives a subsidy of around 5.57 percent of capital when the tax and interest effects are combined.[37] Olson's estimate addresses strictly differences in nominal interest rates and gives no attention to additional cost differences associated with size of equipment and scale and use economies which tend to vary with system size.

Wallace and Junk's study comparing two operating utilities, one a municipally owned utility and the other a private system, found capital costs 23 percent greater for the private system as a result of the tax-interest subsidy. Lack of the tax-interest subsidy for the private firm resulted in around 18 percent higher overall costs per kilowatt hour of energy. The Wallace and Junk study which involves a more comprehensive assessment of the sources of cost differences was chosen as the model for this study.

Wallace and Junk used engineering estimates of cost per kilowatt of generating capacity adjusted by system load factor to determine capital cost per kilowatt hour. The capital cost was added to engineering estimates of production costs per kilowatt hour to obtain estimated total costs per kilowatt hour. These costs were estimated for a municipal utility of a given size and an investor owned utility of a given size. Their estimates were calculated by the following formula.[38]

$$c_t = c_v + c_f$$

where

c_t = total cost per kilowatt hour

c_v = operating or variable cost per kilowatt hour

c_f = annual capacity cost or fixed cost per kilowatt hour

$$c_v = \frac{\text{total production expense}}{\text{net energy generated}} \tag{2}$$

and

$$\text{Annual capacity costs} = c = C_o \left[\frac{i(1 + i)^n}{(1 + i)^n - 1}\right] \tag{3}$$

where

C_o = the value of the initial investment, i.e., the cost of the generating unit per kilowatt capacity

i = annual interest rate

n = life of the investment in years

Then

$$c_f = \frac{\text{annual capacity cost}}{\text{(load factor)(hours in year)}} \tag{4}$$

where

$$\text{Load factor} = \frac{\text{average kilowatt hours per time period}}{\text{peak kilowatt hours per time period}} \tag{5}$$

and

$$\text{Average kilowatt hours} = \frac{\text{total annual kilowatt hours generated}}{\text{number of hours in the year}} \tag{6}$$

Wallace and Junk assumed an interest rate of 4 percent for the municipal utility and a discount rate of 11 percent for the private investor owned utility. The discount rate for the investor owned utility was based on an assumption of average required earnings of 6 percent after taxes on the debt and equity instruments plus an assumption of a total tax bill equivalent to 5 percent of the private utility's investment.

As an alternative method for estimating the costs of the municipal utility vis-a-vis those of the investor owned utility, Wallace and Junk

suggest ignoring the taxes for both systems and using an interest rate which reflects the market evaluation of the risks involved in the investment.[39] The second suggested approach is less useful than the first because there is no one market rate of interest; rather, lenders assess the risk for each firm individually on the basis of such factors as leverage, growth expectations, and capitalized earnings or assets currently held.[40] Consequently, using actual data for each firm should yield more plausible results, given the sharply divergent institutional circumstances under which financing is arranged for the two types of utilities. The approach used by Wallace and Junk is used in this study in an attempt to reconstruct the costs of the Stillwater Municipal Electric Utility on the same basis as those of OG&E in order to estimate the amount of subsidy accruing to the municipal utility.

D.2 Reconstruction of Costs Following Wallace and Junk

Reconstructing the costs of the Stillwater Municipal Electric Utility according to the procedure used by Wallace and Junk requires computation of the production costs per kilowatt hour of each system when production costs per kilowatt hour are defined as the sum of operating costs per kilowatt hour plus annual capacity costs per kilowatt hour. The computation and data sources follow.

D.2.1 Operating Costs, c_v

The "operating costs" referred to in Wallace and Junk's study correspond to the variable costs of price theory. The computations of these costs and the data sources appear in Table II.

TABLE II

CALCULATION OF COSTS PER KILOWATT HOUR OF ELECTRIC ENERGY

System	c_v					c_f							c_t
	Total production expense[a]	Purchased power	Total production expense of own plant[b]	Net energy generated in thousands of kwh	Operating cost per kwh (c_v)[c]	Total production plant in dollars	Total production plant in kw	C_o[d]	i	n	Load factor (lf)	$c_f = \frac{\left(C_o \frac{i(1+i)^n}{(1+i)^n-1}\right)}{lf \cdot 24 \cdot 365}$	
OG&E, 1970	$31,563,962[e]	$5,418,795[f]	$26,145,176	10,472,134[g]	$.0025	$183,244,322[h]	1,919,247[i]	$ 95.48	.147	35 yr.	.48	.0034	.0059
Stillwater 1969-70	707,378[j]	88,823[k]	618,553	112,111[m]	.0055	3,703,117[n]	22,650[l]	157.00					
Stillwater 1970-71	826,518[p]	124,926[q]	701,592	113,413[r]	.0059	4,138,332[s]	22,650[t]	182.71	.097	35 yr.	.363	.0056	.0115
Stillwater 1970-71 adjusted for OG&E capital costs					.0059			182.71	.1514	35 yr.	.363	.0088	.0147

[a]Production expense in the Federal Power Commission data are defined as "operating costs" in this study.

[b]Total production expense of own plant is equal to total production expense minus purchased power in dollars.

[c]Operating cost per kilowatt hour is equal to total production expense in own plant divided by net energy generated in kilowatt hours.

[d]C_o = Total production plant in dollars divided by total production plant in kilowatts.

[e]Federal Power Commission, Statistics of Privately Owned Utilities in the United States - 1970, S-214, Washington, D.C.: United States Government Printing Office (December 1971), Table 519, Line 64.

[f]Ibid., Table 519, Line 60. [g]Ibid., Table 719, Line 33. [h]Ibid., Table 619, Line 71. [i]Ibid., Table 719, Line 78.

[j]Federal Power Commission, Statistics of Publicly Owned Electric Utilities in the United States, 1970, S-219, Washington, D.C.: United States Government Printing Office (February 1972). Data contained herein corresponds to data reported in the 1969-70 City of Stillwater Utility Department Financial Report. Table 46A, Line 6.

[k]Ibid., Table 46A, Line 4. [m]Ibid., Table 46A, Line 35. [n]Ibid., Table 46, Line 72. [o]Ibid., Table 46A, Line 53.

[p]Federal Power Commission, Statistics of Publicly Owned Electric Utilities in the United States, 1971, S-228, Washington, D.C.: United States Government Printing Office (December 1972). Data contained herein corresponds to data reported in the 1970-71 City of Stillwater Utility Department Financial Report. Table 48A, Line 6.

[q]Ibid., Table 48A, Line 4. [r]Ibid., Table 48A, Line 35. [s]Ibid., Table 48, Line 72. [t]Ibid., Table 48A, Line 53.

OG&E reported operating costs of $.0025 per kilowatt hour of energy produced during the calendar year 1970. Data for the Stillwater Municipal Utility are reported on a fiscal year basis; the Stillwater generating system experienced generating costs of $.0055 during the fiscal year ending July 30, 1970, and $.0059 for the fiscal year ending June 30, 1971. Comparison of these operating cost figures for OG&E and the Stillwater system provide some indication of the difference in technical efficiency of the two production systems in the use of variable resources. Three factors are subsumed in the calculations: (1) the greater mechanical efficiency of the larger equipment used by OG&E, (2) OG&E's better load factor, and (3) the perhaps greater efficiency of OG&E in the resource market which may be accounted for by lower costs per unit of resource as a consequence of purchasing in large quantities and/or economic power through a better bargaining position associated with the size of the firm.

It is this operating cost differential which must be offset by the subsidies received by the municipal utilities which enable them to generate their own electric energy for a lower nominal cost than the price at which they can purchase it from a private utility even when the private utility offers terms consistent with regulations governing the rate of return. The subsidy appears mainly in its influence over what Wallace and Junk have referred to as capacity costs which correspond to the fixed costs of price theory and are examined below.

D.2.2 Capacity Costs, c_f

Capacity costs are fixed costs; such costs must be allotted to production over time to discover the total unit costs of production. In

Wallace and Junk's calculation of capacity costs "C_o" is the value of the initial investment and the remaining term represents the capital recovery factor which takes account of interest and depreciation. It should be noted that the value ultimately desired is c_f which is the annual capacity cost or c divided by the hours of generation time per year. Computation and data sources for capacity costs appear in Table II. Selection of data sources is discussed below.

Estimating C_o. The conventional practice is to use Federal Power Commission data on the value of the generating plant as the basis for C_o. That convention has been followed here, as is reflected in Table II. Basing calculations on 1969-70 data for the Stillwater plant yields a capacity cost of $157.00 per kilowatt installed capacity with a cost of $94.48 per kilowatt of installed capacity for OG&E for calendar year 1970. These figures are in line with Wallace and Junk's findings of average investment costs per kilowatt hour of $94 for private utilities and $157 for municipal utilities in Federal Power Commission Region V in 1964.[41] However, if the calculations are based on 1970-71 data for the Stillwater plant, a reported increase in the value of the production plant of $425,215.00 with no change in generating capacity raises the cost per kilowatt hour to $182.73. Data for 1970-71 are used in this study as discussed below. On the basis of 1970-71 data, C_o for the Stillwater plant was estimated to be 91 percent greater than for the OG&E plant while c_f for the Stillwater plant was 159 percent greater than for the OG&E plant reflecting the influence of scale and use economies and differing financing costs.

Estimating i. Selection of the interest rate "i" is a more complex matter due to the great variety of different indexes and data series which have been employed as proxies for capital costs in empirical studies of investment behavior.[42] Even in the various studies of the costs of electric utilities a number of different measures and techniques for estimating the cost of capital have been employed, as is indicated in Table III.

A measure of "i" similar to that suggested by Miller and Modigliani is used for purposes of this study. A weighted average cost of capital was computed based on the actual market value of the financial instruments of both the Oklahoma Gas and Electric Company generating system and the Stillwater Municipal Electric Utility generating system during the period to which this study applies. Following the procedure recommended by Levy and Sarnat the market value of each issue of each type of financial capital-gathering instrument was estimated as a relationship between the return paid on the debt or equity instrument and the behavior of its price over time. Actual market price, coupon, and dividend data for debt and equity were substituted into the following model recommended by Levy and Sarnat.[43]

$$i_t = \frac{C_t + P_t}{P_{t-1}} - 1 \qquad (7)$$

where

i_t = the rate of return in the year under study

C_t = the rate of return on the debt or equity instrument in the year under study

P_t = the market price of the financial instrument in the year under study

TABLE III

ESTIMATORS OF "i" USED IN SELECTED STUDIES OF ELECTRIC UTILITY COSTS

Researcher	Objective of the Study	Estimator Used	Desirability of Estimator for Purposes of this Study
Galatin[1]	Separation and quantification of the effects of scale and technological change in the production process.	Did not estimate "i"; used the book value of the original investment as reported to the Federal Power Commission as the estimate of capital cost.	Not acceptable; does not consider financial costs wherein rest a sizeable portion of the subsidy to municipal utilities vis-a-vis investor-owned utilities.
Komiya[2]	Analysis of technological change in the United States steam power industry in terms of the production function to determine the relationship between the decline in input requirements and (1) economies of scale, (2) factor substitution, and (3) shifts in the production function.	Did not estimate "i"; based estimated capital cost on the price of equipment in constant (1947) dollars per generating unit. Costs of construction and land were excluded.	Not acceptable; does not consider financial costs wherein rest a sizeable portion of the subsidy to municipal utilities vis-a-vis investor-owned utilities.
Wallace and Junk[3]	Comparison of costs of a specific municipal utility and an investor owned utility located near-by.	Assumed an interest rate of 4 percent for municipal utilities and a discount rate of 11 percent composed of a tax of 5 percent of investment and a required yield of 6 percent to attract funds for investor owned utilities.	Technique is acceptable but some accepted source of data on the rates of taxation interest, and yields are necessary; Wallace and Junk indicated no such source
Dhrymes and Kurz[4]	Econometric investigation of the impact of technology and size on the characteristics of production in the steam electric generating industry.	Treated "i" as a return to capital, i.e., as the residual of total revenue after payments has been made for all other factors.	Not acceptable; the cost differentials associated with the subsidy remain obscured by this technique.
Ling[5]	Construction and analysis of cost functions for steam electric power generating systems based on an analytical model which simulates a typical large utility in the United States. A specific set of engineering cost estimates and assumptions as to technological relations and development patterns for the utility are used.	Based capital costs on price-deflated annual costs per kilowatt of capacity as reported to the Federal Power Commission. Assumed a fixed charge of 12 percent on investment cost.	Not acceptable; the 12 percent estimate is out of date and is a general industry-wide estimate which does not consider the peculiarities associated with the individual firm and geographic region in which it operates.
Olson[6]	Empirical determination of the behavior of electricity generation costs to determine an optimal market structure for the industry and evaluation of the electric power industry with respect to cost minimization behavior.	Uses Federal Power Commission data to calculate the original investment cost per kilowatt of capacity and generating equipment. Annual capacity cost was derived by assuming fixed charges of 12 percent to cover depreciation, financial cost of capital, insurance, and taxes. The 12 percent figure was based on Federal Power Commission estimates of fixed charges for conventional steam generation equipment.	Not acceptable; the 12 percent estimate is out of date and is a general industry-wide estimate which does not consider the peculiarities associated with the individual firm and the geographic region in which it operates.

TABLE III, Continued

Researcher	Objective of the Study	Estimator Used	Desirability of Estimator for Purposes of this Study
Nerlove[7]	Estimation of the existence and relevant range of returns to scale in the electric utility dustry.	Used cost of debt financing; used the long term rate at which firms could borrow adjusted by the Handy-Whitman Index.	The technique is appropriate; the firm is the unit of analysis, capacity costs include interest, depreciation, maintenance, yield on long term debt, but the data are out of date.
Iulo[8]	Investigation of the nature of the quantitative relationships among the factors that are believed to affect unit costs of providing electric energy.	Used cost of debt financing; used the weighted average of the interest rates on all outstanding long term debt of the individual utility and the face value of the interest rate is specified on the debt instrument.	The technique is appropriate; the data are out of date and consequently inappropriate.
Miller and Modigliani[9]	Development of effective methods for inferring the cost of capital to facilitate optimal investment decisions based on the market value of securities.	Weighted average of debt and equity capital price and yield.	The technique is appropriate. Data used are out of date.

[1]Malcolm Galatin, Economies of Scale and Technological Change in Thermal Power Generation. Contributions to Economic Analysis, No. 53, 1968.

[2]Ryutaro Komiya, "Technological Progress and the Production Function in the United States Steam Power Industry." Review of Economics and Statistics, XLIV (May 1962), 156-166.

[3]Richard L. Wallace and Paul E. Junk, "Economic Inefficiency of Small Municipal Electric Generating Systems," Land Economics, XLIV, No. 1 (February 1970), pp. 98-104.

[4]Phoebus J. Dhrymes and Mordecai Kurz, "Technology and Scale in Electricity Generation," Econometrica, 32, No. 3 (July 1964), pp. 287-315.

[5]Suilin Ling, Economies of Scale in the Steam Electric Power Generating Industry, 1964.

[6]Charles E. Olson, Cost Considerations for Efficient Electricity Supply, 1970.

[7]Marc Nerlove, "Returns to Scale in Electricity Supply," Measurement in Economics, C. Christ, Editor, 1963, 167-193.

[8]William Iulo, Electric Utilities - Cost and Performance, 1961.

[9]Merton H. Miller and Franco Modigliani, "Some Estimates of the Cost of Capital to the Electric Utility Industry," The American Economic Review, LVI, No. 3 (June 1966), 333-391.

P_{t-1} = the market price of the financial instrument in the preceding year.

Values for fiscal year 1970-71 were selected for the Stillwater study in preference to fiscal year 1969-70 in an effort to avoid irregularities introduced by the erratic behavior of the financial markets in the early months of 1970. A weighted average cost of capital of 9.71 percent was found for the Stillwater utility for fiscal year 1970-71 compared with a weighted average cost of capital of 14.7 percent for OG&E for calendar year 1970. Computation and data sources appear in Tables XV through XX (Appendix A).

Since the bonded debt of the Stillwater utility is marketed with A ratings while OG&E's debt instruments have earned Aa ratings, the interest rates determined above must be adjusted to compensate for risk differences before a direct assessment of the effect of the subsidy on cost differences can be made. A two-step process was used as follows.

To arrive at an index of the difference between A and Aa rated bonds, the composite yields for A and Aa public utility bonds was compared for the seven year period 1967-73. During that period the higher risk associated with A rated bonds was found to increase the yield on debt instruments or the cost of borrowing for the issuing public utility by an average of three percent of yield. Consequently an index of 1.03 may be used for converting public utility A bond yields to Aa yields (Table XXI, Appendix A). This indicates that the appropriate cost of capital to use in estimating c_1 is 1.03 times .147, or .1514.

Since Stillwater municipal bonds are marketed unsecured while OG&E public utility bonds are marketed secured, the index could not be applied to data for estimating the effect of the subsidy until tests had been made to evaluate possible differing costs of debt induced by that

difference. Since Stillwater and OG&E had no debt instruments of the same date of issue, data on all unsecured public utility issues from January 1, 1945 through December 31, 1970 were collected from Moody's Public Utility Manual (Table XXII, Appendix A). These dates were chosen since both utilities had debt instruments outstanding which had been issued over that time span. The set of data on unsecured bond issues was then matched with that of all secured public utility issues of identical dates of issue. Since statistical tests indicated no significant difference in yield for the two series there was no need for further adjustment of the index before applying it to the OG&E-Stillwater cost of capital estimates, i.e., i was taken as 14.7 percent for estimation of OG&E's costs and 15.14 percent for estimating Stillwater's costs.

Estimates of n. The term "n" refers to the life of the investment. Estimates for the life of electric generating plants vary between 30 and 40 years. Federal Power Commission findings indicate that the variance is determined by load factor and heat rates.[44] Since both plants studied experience relatively low load factor and heat rates and use equipment of pre-1955 technological vintage, 35 years was regarded as a reasonable estimate of life of the investment.

Load factor. Load factor is used in estimating the hours the plant operated during the year under study in order to determine annual capacity costs per kilowatt hour. The Stillwater plant had a load factor of 36.3 percent during fiscal year 1970-71.[45] OG&E maintained a load factor of 48 percent in 1970.[46]

Estimates of c_f. Substituting the values of C_o, i, n, and the load factor into the capital cost formula yields an estimate of the annual

capital cost per kilowatt hour, i.e., per unit of output, c_f. The amount is estimated as \$.0034 for OG&E in 1970. The nominal cost estimate of c_f for the Stillwater system based on figures reported to the Federal Power Commission and on existing market conditions is \$.0056 per kilowatt hour. When the value of the subsidy is removed from Stillwater's costs by substituting OG&E's interest rate adjusted to include Stillwater's higher risk into the cost formula, the cost of capital is estimated at an annual rate of \$.0088 per kilowatt hour, or 159 percent greater than that for OG&E.

D.2.3 Estimates of c_t

Total cost per kilowatt hour, c_t, is the sum of operating cost per kilowatt hour, c_v, and capacity or capital costs per kilowatt hour, c_f. The calculations of total costs are shown in Table II. OG&E's total cost per kilowatt hour is estimated to be \$.0059. This corresponds to point (x_2,c_2) on LAC_2 in the geometric schema of Figure 3. When the effects of the subsidy are removed from Stillwater's operations by substituting OG&E's interest rate adjusted for risk in the capital cost equation, Stillwater's resource cost of generation is calculated to be \$.0147. This value corresponds to point (x_1,c_1) on SAC_1 in Figure 3. Stillwater's nominal cost for 1970-71 before adjustment for the subsidy is estimated to be \$.0115. This value corresponds to point (x_1,c_1') in Figure 3.

D.3 Estimate of Inefficiency in Resource Use

In Section B.1.1 of Chapter II, the difference between the nominal cost and the cost in terms of the value of resources used in generating

electric energy by the city of Stillwater, or the difference between c_1 and c_1' in Figure 3 was defined as the hidden cost of generation for the Stillwater plant. This difference is estimated to be $.0032 per kilowatt hour or 22 percent of the real resource cost per kilowatt hour.

The amount by which Stillwater's nominal costs are reduced by the subsidy is not the full cost to society of Stillwater's decision to generate its own supply of electric energy. The social cost is the value of resources wasted due to differences in efficiency, i.e., the Stillwater plant's real resource cost of $.0147 per kilowatt hour compared to $.0059 for OG&E, a difference of $.0088 per kilowatt hour or 150 percent higher total costs. A reasonable assessment of the difference in costs must include OG&E's transmission costs in supplying electric energy to Stillwater. Transmission costs have been estimated to be $.00225 per kilowatt hour[47] bringing the cost of energy generated by OG&E and delivered to Stillwater to $.00815 per kilowatt hour. Then in terms of demands on society's scarce resources these results would indicate that it costs $.0065 or 80.4 percent more per kilowatt hour for Stillwater to exercise its option of self generation of electric energy, i.e., the resource costs for Stillwater's production of electric energy are 180.4 percent above the costs of having the energy supplied by OG&E. Stated differently, these figures suggest that Stillwater's option for self generation absorbed an unnecessary $775,605.15 worth of resources during fiscal 1970-71.

While the findings seem high compared to the results of Olson's work and of Wallace and Junk's study, several reasons may account for the differences. Differences in scale are much greater for the Stillwater and OG&E systems than for the two plants compared in the study by Wallace

and Junk. Further, the difference in cost per kilowatt of generating capacity is much larger for Stillwater and OG&E systems than was true for the Wallace and Junk study. The Olson study does not give attention to the costs of holding capital and makes no allowance for differences in scale, level of utilization, or cost per kilowatt capacity. The Olson study would consequently be expected to yield a lower cost estimate than studies which specifically consider those differences. The reliability of the estimate depends upon the accuracy of the assumptions embodied in the model.

A word of caution is in order at this point in calling the reader's attention to the cost concept employed in the estimates presented here. It should be recalled that the estimates embody a concept similar to the traditional average cost concept and embody a proration of capital costs over the life of the equipment. Under the opportunity cost concept, including such sunk capital costs is inappropriate; i.e., once capital investment is in place, only the variable costs, c_v, are relevant. It will be recalled from the introductory discussion that operating costs for the Stillwater utility are over 100 percent greater than those for OG&E, the alternative source of energy. When transmission costs are added to OG&E's cost of generation, the discrepancy is reduced such that Stillwater's costs are 25 percent greater; however, this still indicates a sizable inefficiency in resource employment.

FOOTNOTES

[1]These figures were determined by subtracting purchased power in dollars from total production expense in dollars and dividing the difference by net energy generated. Data were derived from the following sources: Federal Power Commission, Statistics of Publicly Owned Electric Utilities in the United States, 1970, FPC S-219, Washington, D.C.: United States Government Printing Office (February 1972), Table 46A, lines 6, 4, 35; Statistics of Publicly Owned Electric Utilities in the United States, 1971, FPC S-228, Washington, D.C.: United States Government Printing Office (December 1972), Table 48A, lines 6, 4, 35; and Statistics of Privately Owned Electric Utilities in the United States - 1970, FPC S-214, Washington, D.C.: United States Government Printing Office (December 1971) Table 519, lines 64 and 60 and Table 719, line 33.

[2]Federal Power Commission, Statistics of Publicly Owned Electric Utilities in the United States, 1971, FPC S-228, Washington, D.C.: United States Government Printing Office (December 1972) Table 48, line 72 and Table 48 A, line 53.

[3]Federal Power Commission, Statistics of Privately Owned Electric Utilities in the United States - 1970, FPC S-214, Washington, D.C.: United States Government Printing Office (December 1971) Table 619, line 71 and Table 719, line 28.

[4]Despite the combining of many municipal utilities into power pools, the number has continued to grow as new systems come into existence. The number of systems increased from 1,909 in January 1970 to 2,126 in January 1976. Public Power, Vol. 28, No. 1 (January 1970), pp. 20-56 and Vol. 34, No. 1 (January-February 1976), pp. 32-74.

[5]It should be borne in mind that if there are significant departures from efficient operation of firms inherent in the investor owned segment of the industry which are not common to the socially owned segment of the industry such as, for example, a significant Averch-Johnson effect, then the subsidy will be overstated by the measure of c_1 minus c_1'. However, Moore's study comparing public and private electricity generation found private firms to have less excess capacity and lower operating costs than public firms. Such a finding would suggest that any discrepancy would be more likely to understate than to overstate the true subsidy estimated by c_1 minus c_1'. Thomas G. Moore, "The Effectiveness of Regulation of Electricity Prices." Southern Economic Journal, Vol. 36 (April 1970), p. 365-375; Harvey Averch and Leland L. Johnson, "Behavior of the Firm Under Regulatory Constraint." American Economic Review, 52 (December 1962), 1053-1069.

[6]The concept of resource costs under study in this chapter departs somewhat from the traditional opportunity cost concept. Under the traditional concept of opportunity cost, sunk costs are irrelevant; once an article of capital has been cast into a particular form, society has foregone the utility which might have been yielded by its potential alternative forms; the value of that utility foregone constitutes the opportunity cost of the item. See Richard H. Leftwich, The Price System and Resource Allocations (fourth edition), Hinesdale, Illinois: The Dryden Press, Inc. 1970, p. 144; Paul A. Samuelson, Economics (ninth edition), New York: McGraw-Hill Book Company, 1973, p. 472, 473, 562; Campbell R. McConnell, Economics, New York: McGraw-Hill Book Company, 1966, p. 25, 26, 445; Donald S. Watson, Price Theory and Its Uses (third edition), Boston: Houghton Mifflin Company, 1972, p. 171; Ray J. Sampson and Thomas W. Calmus, Economics, Boston: Houghton Mifflin Company, 1974, p. 42.

However, acquisition of capital is prefaced on the assumption of recovery over time of the cost of the investment including not only the price of tangible materials but also the financing costs or rewards for someone's consumption foregone in the present. Further, inasmuch as electric service bills are designed to achieve the objective of recovery, the consumer of electric energy faces on a monthly basis, some proration of those costs of capital equipment essential to the operation of the municipal electric utility; sunk costs and financial costs remain an item to be dealt with either in the consumer's day-to-day budgetary decisions or as losses sustained by the investor. Consequently, the values of all resources are included in the cost analysis in this study. In this sense, the cost concept used here resembles the opportunity cost of the investment at the time of decision for the investment, but it does not represent opportunity cost once the plant is in place.

[7]It should be noted that to the extent that the larger OG&E is better known in the financial market, it may possess a higher degree of liquidity. Such liquidity advantages may result in more favorable terms of debt financing for the investor owned firm than for the municipality. To the degree that such an influence exists, using the investor owned utility's costs of debt financing as a proxy for the real cost of capital for the municipal utility would underestimate the effects of the subsidy and the estimate of inefficiency in resource use.

[8]Statistical studies have been undertaken by the following researchers: Charles E. Olson, Cost Considerations for Efficient Electricity Supply, East Lansing, Michigan: Institute of Public Utilities of the Michigan State University (1970); J. Johnston, Statistical Cost Analysis, New York: McGraw Hill Book Company, Inc. (1960); John B. Lansing, "An Investigation into the Long Run Cost Curves for Steam Central Stations" (unpublished Ph.D. dissertation, Harvard University, 1948); Phoebus J. Dhrymus and Mordecai Kurz, "Technology and Scale in Electricity Generation,: Econometrica, Vol. 32, No. 3 (July 1964), pp. 287-315; William Iulo, Electric Utilities--Cost and Performance, Pullman, Washington: Washington State University Press (1961); Malcolm Galatin, Economies of Scale and Technological Change in Thermal Power Generation, Amsterdam: North-Holland Publishing Company (1968); Yoram Barzel, "The

Production Function and Technological Change in the Steam-Power Industry," Journal of Political Economy, Vol. 72 (April 1964), pp. 133-150; Marc Nerlove, Estimation and Identification of Cobb-Douglas Production Functions, Chicago: Rand McNally and Company (1965), pp. 101-131; Ryutaro Komiya, "Technological Progress and the Production Function in the United States Steam Power Industry," The Review of Economics and Statistics, XLIV (May 1962), pp. 156-166; J. A. Nordin, "Note on a Light Plant's Cost Curves," Econometrica, Vol. XV (July 1947), pp. 231-235; K. S. Lomax, "Cost Curves for Electricity Generation," Economica, Vol. XIX (May 1952); and Laurits R. Christensen and William H. Green, "Economies of Scale in U.S. Electric Power Generation," Journal of Political Economy, 48 (Number 4, Part 1, August, 1976), pp. 667-678. Ling employed an engineering project approach; Suilin Ling, Economies of Scale in the Steam Electric Power Generating Industry, Amsterdam: North-Holland Publishing Company (1964).

[9]Cost functions were estimated by Lomax, Nordin, Johnston, Ling, Lansing, and Olson. The production function and input relationships were the basis for research by Komiya, Nerlove, Dhrymes and Kurz, Galatin, Barzel, and Christensen and Green.

[10]Static analysis was used by Olson, Nordin, Lomax, Nerlove, and Christensen whereas the effects of time were incorporated into the models employed by Dhrymes and Kurz, Galatin, Ling, Komiya, Barzel, Olson, and Johnston.

[11]Nordin used time series data. Cross section data were used by Dhrymes and Kurz, Olson, Komiya, Nerlove, Lomax, and Christensen. Combinations of time series and cross section data were used by Iulo, Barzel, Johnston, and Galatin.

[12]Ling explicitly assumed cost minimizing behavior. Dhrymes and Kurz, Galatin, and Nerlove explicitly assumed cost minimizing behavior subject to regulatory constraints. Cost minimizing assumptions appear to be implicit in the work of Nordin, Lansing, Lomax, Johnston, Komiya, Barzel, Iulo, and Olson although no explicit statement was made. Christensen and Green explicitly avoided such an assumption.

[13]Overinvestment in the electric power industry is suspected. Two prominent motivations for such behavior exist. In an industry characterized by increasing returns to scale and growing demand, firms may find it more profitable to add more capacity than they expect to use in the immediate future, Nerlove, p. 102; H. B. Chenery, "Overcapacity and the Acceleration Principle," Econometrica, Vol. 20 (1952), p. 1-28. A second motivation is the familiar Averch-Johnson response to a regulatory policy which allows a rate of return greater than the cost of capital but less than that which the firm could obtain if free of regulatory constraints. Under such conditions a utility can be expected to substitute capital for other factors of production and operate at an output level where cost is not minimized; Elizabeth E. Bailey and John C. Malone, "Resource Allocation and the Regulated Firm," The Bell Journal of Economics and Management Science, Vol. 1, No. 1 (Spring, 1970), p. 137-139; Harvey Averch and Leland L. Johnson, "Behavior of the Firm Under Regulatory Constraint," American Economic Review, Vol. 52 (December 1962), p. 1053; Robert M.

Spann, "Rate of Return Regulation and Efficiency in Production: An Empirical Test of the Averch-Johnson Thesis," The Bell Journal of Economics and Management Science, Vol. 5, No. 1 (Spring 1974), p. 38-52.

[14]The machine was the unit of analysis in studies by Lomax, Komiya, Galatin, and Olson. Nordin, Lansing, Dhrymes and Kurz, and Barzel based their analysis on the plant. The firm was the unit analyzed by Johnston, Iulo, Nerlove, Ling, Hulbert, and Christensen and Green.

[15]Nordin studied one plant having one generating unit and consequently machine-mix was not a relevant factor. Neither Barzel nor Dhrymes and Kurz gave attention to variations in machine sizes within plants.

[16]Nordin analyzed only one plant having one generator. Barzel and Dhrymes and Kurz did not differentiate plants by fuel types.

[17]Since Nordin considered only one plant, differences in vintage or technology did not apply. However, Dhrymes and Kurz divided plants in their study into four periods in the following manner according to date of construction: 1937-45, 1946-50, 1951-54, and 1955-59. Barzel entered plants in his study on a year-by-year basis through inclusion of dummy variables in the regression equation. Christensen examined costs for 1955 and for 1970.

[18]No attention was given to variations in machine mix of firms in studies by Johnston, Iulo, Nerlove, and Christensen. However, in his *ex ante* model Ling specified an optimal firm with the plant mix resulting from an optimal expansion pattern in terms of technical efficiency. Johnston, Iulo, Nerlove, and Ling made no distinctions for types of fuel aside from specifying steam-electric generation. Iulo gave specific consideration to vintage of plants. This was not the case in studies by Johnston, Nerlove, and Ling.

[19]Johnston and Nerlove gave no indication of distinguishing between multi- or single-plant firms. Ling's hypothetical basic generating system could be of either type. Iulo made a definite distinction and studied the resulting effects on cost.

[20]Only Iulo's study specifically distinguished between firms relying totally on self generation and those making power purchases although it would appear that studies by Olson, Lomax, and Johnston would surely involve both types of firms and the situation seems highly likely for all other studies except that of Nordin.

[21]Lomax and Olson made no differentiation between machines on the basis of fuel used. Komiya distinguished between coal and non-coal machines. Galatin disaggregated machines into coal, non-coal, and mixed machines or those equipped to use both types of fuel.

[22]While Lomax made no distinction between machines on the basis of vintage, this distinction was the major focus of studies by Komiya and Galatin whose objectives were the measurement of the effects of technological change on costs. Olson too distinguished between vintage of machines.

[23]Nordin and Nerlove made gross comparisons of size and costs which involve no adjustments for or attention to such factors as degree of utilization, changes in factor prices, and level of technology which may produce shifts in the function. Johnston removed the effects of time and price variations but gave no attention to degree of utilization.

[24]The studies by Olson, Lomax, Ling, Iulo, and Lansing gave specific attention to the shifting effects of utilization economies or economies associated with improved load factor on the functional relationship between size and costs. They attempted to separate out those effects to yield a result more in line with the theoretical concept of the long run average cost curve.

[25]Lansing and Lomax, p. 196, were careful to point out the dangers of trying to remove all effects of utilization economies from formulation of the long run average cost curve given the very close relationship between increasing size and improvement in the load factors.

[26]Effects of technological change on costs and production produce shifts in the long run average cost function. Studies by Dhrymes and Kurz, Olson, Galatin, Barzel, Lansing, and Johnston involved efforts to measure or remove such effects.

[27]The studies of Dhrymes and Kurz, p. 308, Komiya, p. 162, and Galatin, p. 126, indicated that technological improvements have had a bias toward increases in size and consequently interaction effects exist which again produce difficulty in realistically separating the effects of the two to arrive at a conceptually pure long run average cost relationship.

[28]Barzel, p. 142, used a price index to remove geographic differences in costs of fuel and labor costs but made no adjustments for any temporal price variations. Johnston, p. 47, applied a price index to deflate temporal variations in works costs. Iulo used a price index to deflate capital costs, pp. 45-50, but made no such adjustments in fuel and labor costs, pp. 66-77. Olson avoided the problem of price variations by assuming current fuel prices for all periods, p. 32. Dhrymes and Kurz, and Ling made no factor price adjustments.

[29]The Johnston and Lomax studies relied on working costs as reported by British Ministry of Fuel and Power. Works costs were divided into costs of (1) fuel which includes delivered cost of the fuel and handling charges at the station, (2) salaries and wages which pertain to staff engaged in operation, and (3) repairs and maintenance, oil, water, and stores which include salaries and wages of men engaged in repairs and maintenance in addition to materials.

[30]Johnston, pp. 44, 45, 68.

[31]Barzel found that excluding structures, improvements and land from capital costs made little difference in finding of scale economies for capital.

[32]Studies which included in the analysis and explicitly gave consideration to land, improvements and structures include those of Dhrymus and Kurz, p. 313; Ling; Iulo; Galatin, pp. 130-131; and Barzel, p. 145. Olson limited capital considerations to generating equipment, p. 32.

[33]Marc Nerlove, Estimation and Identification of Cobb-Douglas Productions Functions, Chicago: Rand McNally and Company (1965), p. 112-122.

[34]Richard L. Wallace and Paul E. Junk, "Economic Inefficiency of Small Municipal Electric Generating Systems," Land Economics, Vol. XLVI, No. 1 (February 1970), p. 98-104.

[35]Olson, Charles E., Cost Considerations for Efficient Electricity Supply, East Lansing, Michigan: Institute of Public Utilities of the Michigan State University (1970), p. 61.

[36]Olson, p. 16.

[37]Applying Olson's estimate to 1970 aggregate data for investor owned electric utilities, the following procedure was used to determine the share of the subsidy relative to the cost of capital. Olson estimated that the lower interest rate produced a cost advantage equal to 20 percent of utility operating costs for the cooperatives. In 1970 total operating expenses for investor owned utilities as reported to the Federal Power Commission were $9,659,000,000; 20 percent of operating expenses amounts to $1,931,800,000. Investor owned electric utility plants were valued at $102,277,036,000. $1,931,800,000 represents 1.88 percent of $102,277,036,000. Olson estimated that the tax-free status of the publicly owned utility produced a cost advantage equal to 20 percent of operating revenue. In 1970, investor owned utilities had operating revenue of $18,830,000,000; 20 percent of operating revenue amounts to $3,766,000,000. $3,766,000,000 represents 3.682 percent of utility plant. In total, the two advantages represent a subsidy of around 5.57 percent of capital.

[38]For derivation and general discussion of the formula used by Wallace and Junk see Eugene L. Grant, Principles of Engineering Economy, 3rd ed., New York: The Ronald Press (1950), p. 99. Application of the formula in estimating capital costs is discussed by Jack Hirschleifer, James C. DeHaven, and Jerome W. Milliman, Water Supply: Economics, Technology, and Policy, Chicago, Ill.: The University of Chicago Press (1960), p. 152-54, 156-57.

[39]Wallace and Junk, p. 101, footnote 11.

[40]Merton H. Miller and Franco Modigliani, "Some Estimates of the Cost of Capital to the Electric Utility Industry, 1954-57," The American Economic Review, Vol. LVI, No. 3 (June 1966), p. 333-334, 339-348, 373-386.

[41]Federal Power Commission Region V includes utilities in Kansas, Oklahoma, Arkansas, Louisiana, Texas and New Mexico. Wallace and Junk, p. 102, footnote 17.

[42]Some empirical studies of investment behavior have used standard indexes of current nominal yields on high grade corporate bonds in measuring the cost of capital. Other studies have used both a current bond series yield as a proxy for debt capital and current profit series as a measure of availability and cost of equity capital. Some other studies have employed indexes of share prices, current dividend yields or current earnings yields alone or in weighted or unweighted averages along with bond yields. Miller and Modigliani, p. 333-334.

[43]Haim Levy and Marshall Sarnat, Investment and Portfolio Analysis, New York: John Wiley and Sons, Inc. (1972), p. 80-81, 99-100.

[44]Federal Power Commission, National Power Survey, 1964, Part II Washington, D.C.: United States Government Printing Office (October 1964), p. 27-28; National Power Survey, 1970, Part IV (August 1971) p. IV-1-29, IV-1-30.

[45]C. H. Guernsey and Company, Power Source Study, City of Stillwater, Oklahoma, 1972, Oklahoma City: C. H. Guernsey and Company (1972), p. 9 Table 4.

[46]Moody's Investors Service, Inc., Moody's Public Utility Manual, 1972, New York: Moody's Investors Service, Inc. (1972), p. 1436.

[47]Since service to Stillwater originates from any one of OG&E's generating facilities or pool interconnections, the overall average system cost is regarded as an approximate estimate of cost of transmission of energy to Stillwater. The Federal Power Commission estimated in 1964 that on the average it cost about $.00125 per kilowatt hour to transmit electric energy over 345 KV lines similar to those of OG&E which are operated at a 50 percent load factor. Members of OG&E design and engineering departments indicate that their costs of constructing transmission facilities increased from approximately $40,000 per mile for 1965 construction to $110,000 per mile for 1971 construction, an increase of 275 percent. Federal Power Commission figures indicate that OG&E was able to reduce its transmission and maintenance costs per kilowatt hour by 18 percent during that period. Using the Federal Power Commission's 1964 estimates which assumed annual fixed expenses of 11 percent of total investment and annual operating and maintenance expense of one percent of total investment indicates a weighted average increase in costs was 2.50 times the 1965 costs. This indicates a national average cost of 2.50 times the 1964 costs or $.0031 in 1970. However, since costs in South Central Region Advisory Reports where OG&E and Stillwater are located were 72.5 percent of those for the country as a whole in 1970, the cost figure was adjusted downward by 27.5 percent for an estimated transmission cost for OG&E in 1970 of $.00225. Data were drawn from the following sources: National Power Survey, 1964, Part I, Washington, D.C.: United States Government Printing Office (October 1964), pp. 191-194; The 1970 National Power Survey, Part I, Washington, D.C.: United States Government Printing Office (December 1971), I-13-7; Statistics of Privately Owned Electric Utilities in the United States - 1970, FPC S-214, Washington, D.C.: United States Government Printing Office (December 1971), 519, 519A, 719; Statistics of Electric Utilities in the United

States - 1964 (Class A and B Privately Owned), FPC S-175, Washington, D.C.: United States Government Printing Office (March 1966), 419, 419A, 619.

CHAPTER III

SELECTION AND TREATMENT OF DATA FOR ANALYZING TAX EQUITY

A. Introduction

Chapters III through VI examine questions related to the tax equity associated with the redistribution of real income resulting from the revenue function of the municipal utility. The purpose of Chapter III is to identify and treat problems involved in collection and treatment of the data. This clears the way for discussion of the findings regarding tax equity in the following chapters and indicates some limitations due to some incongruities in data sets.

The purpose of Chapter IV is to analyze the data in terms of the ability to pay approach; Chapters V and VI apply the benefits received criterion.

A.1 Concepts to be Tested by the Data

Choices with respect to data employed in a study depend upon both the data obtainable and the definition of the concepts to be tested. For purposes of this study the ability to pay criterion is interpreted in the popularly accepted terms of progression in taxation. The definition and reasons underlying its choice are discussed further in Chapter IV which is devoted to the question of the ability to pay criterion.

Examination of the question of ability to pay requires comparison of the welfare or ability to pay of housing units[1] relative to the tax burden, in this case a user charge for electric energy, combined with a revenue contribution to the general fund. Income data from the 1970 Census of the Population were chosen as the measure of welfare. Records on usage of electric energy and the associated charges and costs are drawn from the city's electric energy accounts. This analysis is based on the tax impact and does not address the issue of shifting and incidence since the study is limited to residential consumption and most consuming units are billed directly rather than through rental payments such that the tax is not passed forward by the rental property owner.

The benefits criterion which is the subject of Chapters V and VI involves examination of the extent to which a quid pro quo exists between taxes paid and publicly supplied commodities consumed. The benefits portion of the study depends upon the same usage and cost data used in assessing the ability to pay approach and upon data on the consumption of goods and services which the city finances from the revenue over cost obtained from operation of the electric utility. The latter data are obtained from studies made by other individuals in assessing the use of the city's services. The following sections of this chapter consist of an evaluation of the data available and its applications to the tax equity questions.

A.2 Organization of Chapter III

Chapter III surveys the resources available for analyzing the redistribution or equity questions and explains the choices made. The following sections consist of an examination of the characteristics of

the data as they relate to the questions of tax equity under study. Sections B, C, and D are related to the data used for assessing the ability to pay question.

Data for the first through the fourth counts of the 1970 U. S. Census of the Population and Housing were available in the printed form and/or on computer tapes for printout; Section B discusses the types of census data available and their formats. Section C deals with electric utility data and their formats.

Section D explains the considerations involved in coordinating the two types of data. A description of the findings regarding compatibility of the various data sets and the procedures used for transforming the data into compatible geographic configurations follows in Sections E through G. Characteristics of the two types of data are compared in a search for pairs of specific data subsets from each data source which correspond sufficiently well to yield meaningful comparisons; two specific problems are faced, (1) geocoding the data into a common system of geographic units, and (2) reconciling the incongruities between the units of classification of data on income as a proxy for ability to pay and the data on electric energy consumption as a measure of contributions to tax revenues.

Section H deals with sources of data pertaining to accrual of benefits from municipal services. It surveys additional data from the electric utility accounts and from studies of use of city services sponsored by the city government and by individuals acting on their own initiative.

B. Census Data

One concern in coordinating census data on income with data on

consumption of electricity, costs of providing electric service, and accrual of benefits from city services involved assembling the data into identical geographic subsets, i.e., discovery of a system for assigning data on city services to census areas.[2] A second problem involved reconciling differences between the social units for which income data were reported in the census and the consumption units for electric energy and other municipal services. Sections B and C describe the data characteristics which were responsible for the problem and Sections D and E explain how the difficulties were resolved.

B.1 Geographic Reporting Levels

B.1.1 Geographic Format of Census Data

Census data are collected for small geographic units which may be progressively aggregated into larger units for analysis. Geographic partitioning is based largely on considerations of homogeneity of the characteristics of the population included within an area. The smallest units are blocks which generally correspond to city blocks. Blocks may be aggregated into enumeration districts and enumeration districts may be aggregated into tracts. In general, a smaller unit will fall entirely within the boundaries of a larger unit; although exceptions may occur, they are infrequent with respect to the city of Stillwater and were easily resolved.

B.1.2. Data Suppression[3] Considerations

With respect to the availability of census data to the public, the researcher faces a tradeoff between (1) the refinement of data as it is

influenced by the sampling level from which the data were derived and (2) problems of increasing data suppression for progressively smaller geographic reporting units. Data reported for blocks and enumeration districts are based on a full count of the population, whereas data reported for tracts include in addition items sampled at the 5, 15, and 80 percent levels. Use of data from the more refined levels might yield greater precision in testing due to increased homogeneity of population characteristics and the higher sampling level. However, for smaller geographic levels, there is greater frequency of data suppression to protect confidentiality. Final choice of the level of refinement then must be made simultaneously with the choice of data to be used.

B.2 Social Unit Classification of Census Data

B.2.1 Availability of Data to be Used as a Proxy for Ability to Pay

Socio-economic variables considered. Several socio-economic variables commonly associated with the level of well being were examined as proxies for ability to pay. Included among these were age, race, occupation, education, housing value, family composition, and income.[4]

Proxy data and geographic reporting level. The census tract was the level of greatest refinement for which sufficient nonsuppressed data with respect to any of these indicators could be obtained in a form suitable to the purposes of this study. Block, enumeration district, and tract data all existed for the city of Stillwater which was divided in the 1970 census into 243 blocks, 39 enumeration districts, and 10 tracts (Figure 4). Tracts were chosen as the level for analysis.[5] Only Tracts 1, 2,

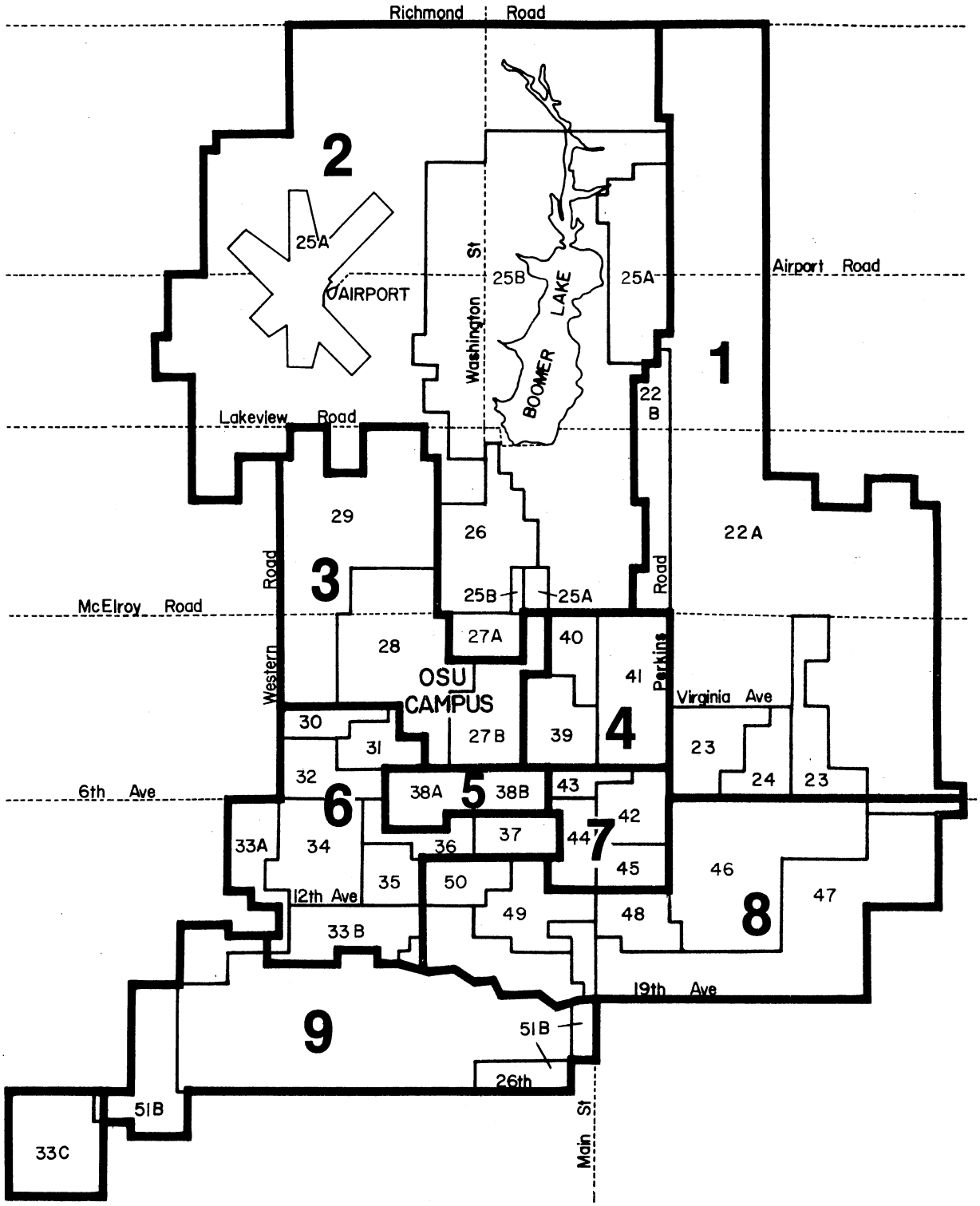


Figure 4. Census Enumeration Districts and Tracts, Stillwater, Oklahoma, 1970

Source: Department of Geography and Arts and Sciences Extension, Oklahoma State University, Stillwater, Oklahoma

4, 5, 6, 8, and 9 were used since the others were not residential areas.

Choice of income as the appropriate variable. Since the census data were equally available at the same minimal level of geographic refinement for each of the variables considered, the choice rested on the desirability of the variable itself. Several factors led to selection of annual income as both the most satisfactory and a sufficient measure of ability to pay for purposes of this study. The other six variables considered tend to move with the level of the income in the city of Stillwater as in other locales[6] and hence reveal very little additional information regarding ability. Furthermore, income is less difficult to handle in a quantitatively concise and yet meaningful manner. Income also has been more commonly used in studies of welfare yielding advantages in comparability and inference.

Having chosen income as an appropriate variable to be used in analysis, the researcher is faced with two further choices regarding which specific income data to use. A choice must be made (1) among the social structure classifications for which the data are reported, and (2) between mean and median income data. The following sections discuss the manner in which both choices were resolved.

B.2.2 Problems Raised by Incongruence Between Social Structure Classification of Census Income Data and Electric Energy Consuming Units

Census data reflecting characteristics of the population are reported under two different social classification schemes, (1) living arrangements and (2) family structure. Living arrangements are

classified as (1) households and (2) group quarters. Family structure refers to (1) families, (2) unrelated individuals, and (3) inmates in institutions. As is demonstrated conceptually by Figure 5, neither of these two classifications can be brought into congruence with the electric account classifications of consumers of electricity. This created problems in comparing ability to pay which is based on income data with contributions to the general fund which are based on consumption of electric energy. The following sections analyze the problem and indicate the choices made in resolving it. As is discussed in Section D, neither the living arrangement nor family structure classification scheme for reporting demographic data corresponds perfectly to the units served by electric accounts which are the basic unit for drawing the sample from which tax contribution data are derived.

C. Electric Utility Data

Data on consumption and pricing of electric energy were used for examining the equity of the tax function served by the electric utility. Billing for utility services by the city of Stillwater is handled by computer. Approximately 9,000 accounts were in service during the 1970-71 fiscal year. A data card containing information pertinent to that month's usage and billing is prepared for each account each month. The set of data cards for the month of July, 1970, were made available for the purpose of selecting a sample of accounts.

C.1 Geographic Coding of Electric Utility Data

Since July, 1970, the city has used a nine-digit number coded by a system based on the United States Geological Survey to uniquely

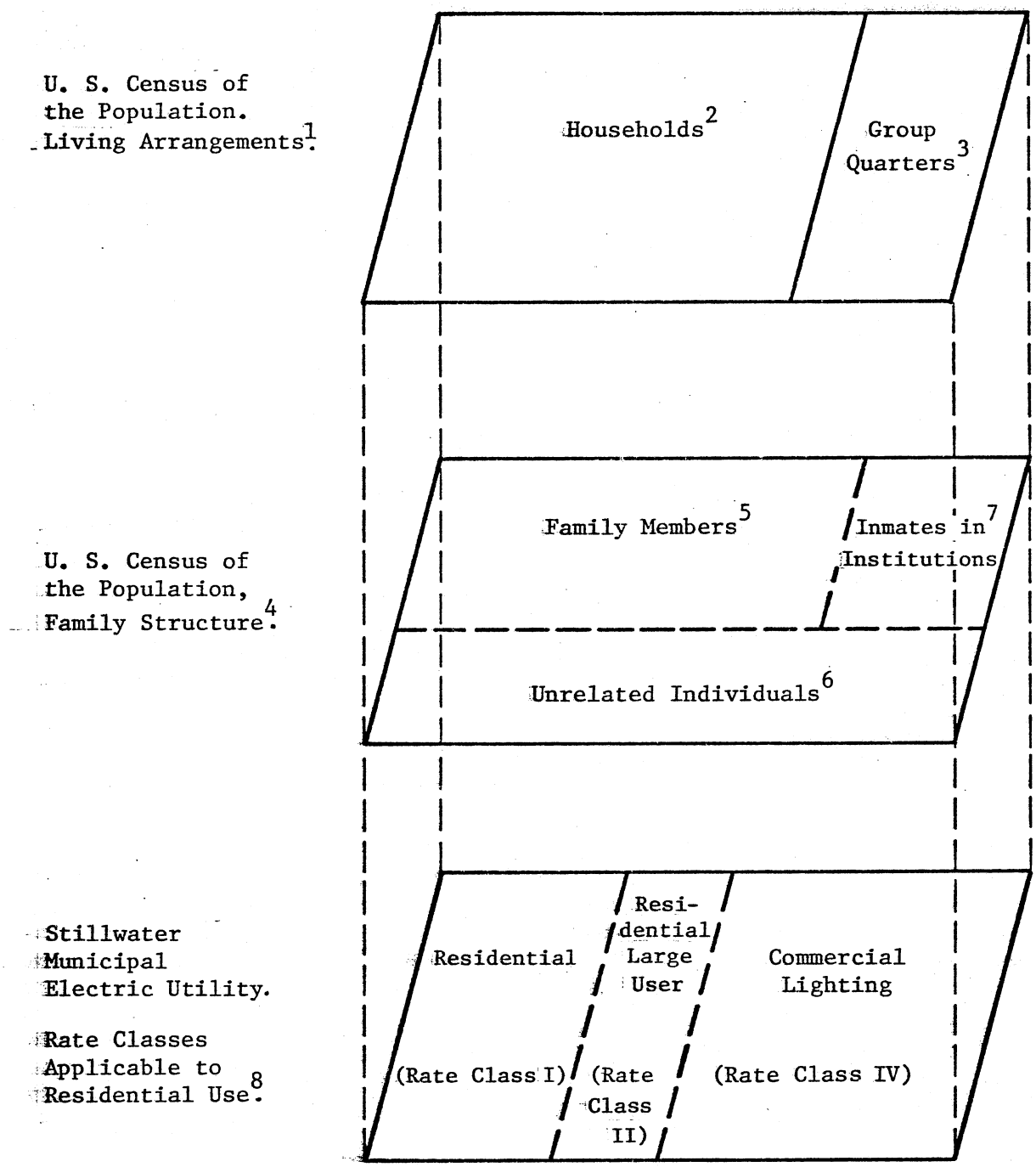


Figure 5. Comparison of Conceptual Relationships of Three Different Systems for Partitioning the Residential Electric Energy Consuming Population of the City of Stillwater, Oklahoma

Source: United States Department of Commerce, Bureau of the Census, 1970 Census Users' Guide, Vol. I, Washington, D.C.: United States Government Printing Office, pp. 99-115; Federal Power Commission, Federal Commission National Electric Rate Book, Oklahoma, Washington, D.C.: United States Government Printing Office, August 1, 1964, p. 171.

Figure 5, continued

[1]All persons enumerated are classified as living in either households or group quarters. All structures occupied or intended for occupancy as living quarters are classified as housing units when (1) the occupants live and eat separately from any other persons in the structure and (2) there is either direct access to the unit from the outside or through a common hall, or (3) when there are complete kitchen facilities for the occupants' exclusive use.

[2]The occupants of any single housing unit are classified as a household.

[3]Group quarters are living arrangements for other than ordinary household life. Group quarters include institutions such as mental hospitals and homes for the aged plus other quarters containing six or more persons where five or more are not related to the head of the household. The latter category would include such living arrangements as dormitories and houses or apartments used as rooming houses or occupied on a partnership basis where five or more of the occupants are unrelated to the head.

[4]All persons counted in the census are classified as family members, unrelated individuals or inmates of institutions.

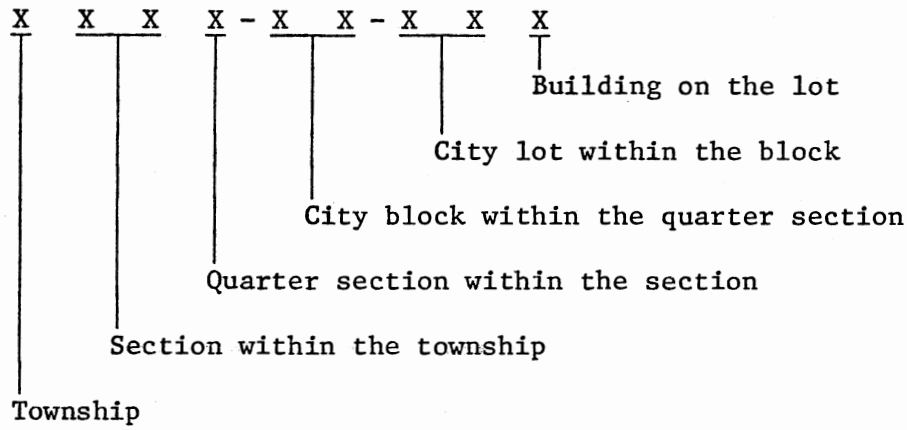
[5]A family is defined as two or more persons living in the same household who are related by blood, marriage, or adoption. No families are recognized in group quarters, and all persons living in a household related to each other are regarded as one family regardless of the degree of closeness of relationship. The number of families does not equal the number of households since not all households include families.

[6]An unrelated individual is a person not living with relatives but living in a household either entirely alone or with one or more persons not related to him or living in group quarters with the exception of inmates of institutions.

[7]Inmates of institutions include all unrelated individuals living in group quarters who are not classified as secondary individuals. Secondary individuals include persons in rooming houses, college dormitories, rest homes, or hospitals.

[8]Electric accounts serve what the census has defined as (1) housing units whose occupants constitute a household eligible for Residential or Residential Large User rates or (2) groups of housing units ranging in number from two through 86 households whose energy consumption is metered under one account to which Commercial rates apply, or group quarters composed of unrelated individuals, lacking facilities generally available to those in a household and served under commercial rates.

identify each electric meter and its exact geographical location in the following manner.



Data on accounts are also coded to identify whether meters are located within the city limits.

C.2 Rate Classes

C.2.1 Three Rate Classes

The city employs three rate classes applicable to residential consumption of electric energy. These are Classes I, II, and IV; rates applicable to the three classes are detailed in Appendix B. The rate classes require attention because they were part of a problem in identifying a unit of analysis common to all data sets.

C.2.2 Relationship Between Rate Classes and Census Data Classifications for Reporting Income

The incongruity of the census classification of the population by family structure for which income data are reported and the division of the population into electric service consuming units applies for each of the electric rate classes as discussed below. Rate Class I, Residential

Lighting, includes single family residences, i.e., households, either owner occupied or rented, which may be occupied by a family, an individual, or several unrelated individuals (Figure 5). There is no means of distinguishing the number or family structure of occupants on the basis of either census data or electric account data. Rate Class II, Residential Service, Large User, applies to single family residences, i.e., households, using electricity for water heating. Residences falling in this rate class will in all other respects encompass the same range of living arrangement and family structure characteristics as those in Rate Class I. Rate Class IV, Commercial Lighting, encompasses certain multi-unit residential consuming units in addition to a varied assortment of retail stores, repair shops, oil well pumps, food markets, etc.

The population of Rate Class IV accounts which represent residential consumption subsume the consumption of a number of families and/or unrelated individuals whose consumption is metered as a single unit. Customers served by these accounts fall into the following two groups: (1) occupants of group quarters serving unrelated individuals, i.e., sorority and fraternity houses, rest homes, rooming houses, rooms in commercial buildings, and old residences converted into rooms; and (2) residents in housing units which may be occupied by one or more unrelated individuals and/or families. Available data provide no means of distinguishing between the type of family structure of occupants of an old residence converted to apartments, an apartment complex, a mobil home park, or an apartment in a commercial building. Later in the study it will be seen that the inability to distinguish the family structure represented by Rate Class I and II and the second category of Rate Class

IV accounts creates some problems, although it does not preclude use of the data in examination of tax equity.

D. Selection of the Specific Subset of Income Data to be Used in Analysis

D.1 Social Classification Considerations

Although living arrangement classifications parallel the consuming units for electric energy more closely than family structure classifications do, complete income data are not available for all living arrangement classifications. Both mean and median income are reported for each of the family structure classifications. Family structure is then the obvious choice; however, two further choices remain in the selection of a specific subset of income data to be used in analysis, (1) choice of family structure and (2) choice between mean and median income.

D.1.1 Choice of Family Structure Subset

Data units from the electric service accounts correspond fairly closely with the census classification of the population on the basis of living arrangements (Figure 5). However, most of the indicators of welfare found in the census data, including income data, are reported along lines of family structure, i.e., for (1) families, (2) families and unrelated individuals, and (3) unrelated individuals.

This incongruity among the classification schemes introduced two constraints into the choice of income data and method of drawing the electric account sample. (1) Inability to sort electric accounts by family structure was a determining factor in the choice of income of families and unrelated individuals over that of either families or

unrelated individuals. (2) The choice of income of families and unrelated individuals then led to the dilemma of how to assure a proportionate representation of single individuals in the sample of energy consumption data similar to their representation in the income data. Both issues are treated in the following sections.

D.1.2 Choice Between Mean and Median Income

The choice of median in preference to mean income was made by default. Census data are reported in discrete intervals and truncated for the upper and lower ranges. Consequently, it is not amenable to parametric testing; the median is the appropriate measure of cental tendency for nonparametric analysis.

D.2 Inability to Sort Electric Accounts by Family Structure

Since it was not possible to disaggregate electric accounts along lines of family structure as the Census Bureau does for income, the logical solution to the problem of mismatched data sets was to select the family structure classification which conforms most closely to the family structure characteristics encompassed by the electric accounts; i.e., income of families and unrelated individuals.

To determine whether any adverse consequences might arise from selecting income of families and unrelated individuals in preference to income of unrelated individuals or of families, these data sets were examined by tract (Appendix C). The results indicated that for purposes of nonparametric analysis, it makes little difference whether income data of families or of families and unrelated individuals are used.[7]

However, the presence of some minor changes in ranking promoted a preference for income of families and unrelated individuals. It is obvious that data for unrelated individuals could not be considered representative for the entire population.

E. Preparation of the Data and Drawing the Sample Accounts

E.1 Coordination of Geographic Boundaries

In general, census enumeration district boundaries were either within and identical with the boundaries of the city limits or covered largely nonresidential farm land outside the city limits. This was in harmony with the definition of electric service rates and identification of electric meters as being either within or outside city limit boundaries. The next task was to arrive at a means of geocoding the electric accounts to census geographic units.

E.1.1 Geocoding Electric Accounts into Census Enumeration Districts

Census tract and enumeration district boundaries and the Geological Survey's township, section, and quarter-section boundaries were color coded onto a large detailed city street map. Referring to the map, the researcher listed in numeric order all quarter sections completely or partially included within the city limits. With the aid of the Meter Reader's Quarter Section Book, used by electric utility personnel for locating meters, the researcher assigned the range of meter numbers in in each city block of each quarter section to the enumeration districts which fell within that quarter section.

As a precaution against missing account numbers by oversight, a second list was prepared listing account numbers within enumeration districts. The second listing was checked against the first to be sure that all blocks had been taken into account and that all enumeration districts in each quarter section had been included in the count. This information became the basis for a computer program designed to assign electric account numbers into enumeration districts and enumeration districts to tracts.

E.1.2 Representation of Unrelated Individuals in the Sample

The main concern over treatment of unrelated individuals with respect to energy consumption had to do with those represented by Rate Class IV accounts. Rate Class IV accounts include (1) groups of housing units whose consumption of electric energy is metered and billed collectively under one account and (2) group quarters. Proportional representation of housing units represented by Rate Class IV accounts consistent with the housing units represented by residential accounts was an easily dispensed matter; replications of the account number equal to the quantity of housing units represented were entered into the set of account numbers. Arriving at a means of achieving proportional representation of the occupants of group quarters in the sample involved a more complex set of issues.

Location of unrelated individuals in the population of electric service accounts. Unrelated individuals may appear in the housing units served by Residential Rate Class accounts and those served by the Commercial Rate Class accounts. They may appear living alone in a housing

unit or in a housing unit serving a group composed of as many as six unrelated individuals. There is no practical means for determining whether such an account for a housing unit serves a family, an unrelated individual, or a group of unrelated individuals. Accounts involving unrelated individuals tend to be located in census areas where the college population and the elderly are concentrated.[8] The elderly unrelated individuals are more likely to live alone whereas students tend to share housing units.

However, not all unrelated individuals live in housing units as those described above. A heavy concentration of unrelated individuals occupy sorority and fraternity houses and make up a sizable portion of the population in Tracts 4 and 5. A dilemma arises over how these individuals should be treated, i.e., how the sample should be drawn to assure the correct proportional representation of unrelated individuals.

Treatment of unrelated individuals in group quarters for purposes of drawing the sample. It is inappropriate to allow only one entry representing one account in the population to represent 100 individuals served by that account. On the other hand, allowing a replication of the account number for every individual would align the proportional group of individuals in the electric energy data with their representation in the census data. However, it would also over-represent the unrelated individuals in group quarters relative to the unrelated individuals in housing units. Further, the bias in their over-representation would be greater in some tracts than in others. Especially to minimize the problem of variation in bias, it was important to represent the unrelated individuals in group quarters in the same way as unrelated individuals in housing units as far as possible.

The following procedure was followed in adjusting group quarters occupancy for drawing the sample. Census data were used to determine the average household size in each enumeration district containing group quarters. The number of occupants of group quarters in 1970 was determined on the basis of records maintained in the office of the Dean of Students at Oklahoma State University and from records of the organizations operating the group quarters. The number of occupants in each group quarters was divided by the average household size in that enumeration district to indicate the number of times each group quarters' electric account should appear in the population from which the sample was drawn. To obtain a proportionate representation of the population in group quarters consistent with that for other enumeration districts with large populations of unrelated individuals, replications of the single account number for the group quarters equal to the number of households represented by it were entered into the population of account numbers from which the sample would be drawn.

E.2 Drawing the Sample of Electric Service Accounts

E.2.1 Preparation of the Card File

The file of data cards for accounts active during the month of July 1970 were made available for use in selecting the sample. A computer program was designed for geocoding account numbers to enumeration districts. A statement was included for eliminating enumeration districts which were not residential areas. Those Rate Class IV accounts which did not serve living quarters were eliminated. In cases where the account represented residential consumption, an attempt was made to determine

the number of households served by the account in 1970. Since some units are not fully occupied during the summer months, information was also obtained for summer occupancy. When such information was not obtainable, it was estimated on the basis of census vacancy rates in the enumeration district. When this process had been completed, new data cards were prepared containing the meter number and number of units served by the commercial accounts representing residential consumption.

E.2.2 Drawing the Sample Accounts

Instructions were added to the computer program for including in the population of account numbers the proper multiples of any account number serving more than one household. Account numbers were set up in an array for each enumeration district; a separate set of random numbers was generated for drawing a 10 percent sample of all accounts in the enumeration district. The new set of data cards for Rate Class IV accounts was combined with those for the two types of residential accounts, and the sample was drawn. The account numbers appearing in the sample were printed out in numeric order within billing cycles. The print-out sheet was designed to serve as a form for collecting one year's monthly electric usage and billing data for each account in the sample.

F. Collection of Sample Data on Consumption of Electric Energy

The ledger of electric accounts was used to draw data on kilowatt hours of electric energy consumed and the total electric bill for each account for each month of the fiscal year beginning July, 1970, through June, 1971.

Two types of data irregularities were encountered for which adjustments were necessary, (1) credited usage due to meter reading mistakes and (2) missing data. These problems were handled as follows.

F.1 Credited Usage

Occasionally in the ledger accounts are credited with energy usage and bills paid due to mistakes in meter reading. In such cases the misread quantity was apportioned over the following months on the basis of that customer's usual usage. For such cases the bill was entered in the data for the apportioned consumption.

F.2 Adjustments for Missing Data

F.2.1 Non-Random Cases

Where a meter had been installed but was not in use either as the result of a new housing unit not yet having been occupied or due to turnover of occupancy, no data were available. This problem became particularly acute in enumeration districts where new housing additions and apartment complexes were under construction and became occupied after the beginning of the period for which the data were collected. Because the meters had been installed, the accounts appeared in the data cards; since the area was previously very sparsely populated and largely undeveloped the huge new complexes overwhelmed the existing housing and swamped the sample. However, there was no electric energy usage by any of the units for the first part of the period so there was neither available data nor a means of generating replacement data. For many of these accounts data were missing for the first five or more months of the study period.

Since examination of the data indicated that other cases of missing data were random, a decision was made to discard those accounts for which four or more months data were missing. In an attempt to replace the data a survey of two problem enumeration districts was made and a statement added to the computer program to eliminate all accounts in areas which were known to have involved totally new construction in the summer of 1970. The machine was then instructed to determine the number of accounts required to bring the remaining portion of the original sample to 10 percent of the adjusted population and draw that number of accounts by a random sample technique.

An additional random sample of the same quantity of acounts was drawn at the same time as insurance against recurrence of the problem. These latter account numbers were printed out in the order drawn and intended to be used in that order if needed. Collection of sample data again resulted in such quantities of missing data that the second set of new random samples drawn were not sufficient to supply all the accounts which had been assumed to be needed after eliminating the major housing developments. At this point it was concluded that the remaining accounts in the original sample probably represented a true sample of the existing housing in the area and the decision was made to accept that sample without further alteration.

F.2.2 Random Cases

A number of generally accepted techniques of varying degrees of sophistication for replacing missing data were examined. It was decided that for the quantity of data involved and for the purposes of this study, a simple average of electric energy consumption in the enumeration

district in question for the month in which the data were missing would be sufficiently reliable. The existing data were processed to determine the averages of existing consumption rates for each enumeration district for each month of the fiscal year. The new information was printed out in a n x 12 array in numeric order for enumeration districts and the chart used to fill in missing data on the original data form. Bills for the amounts of usage were calculated manually. When this process had been completed, the data were keypunched onto the existing cards to complete the sample data set.

G. Determination of Measures of Central Tendency for Electric Energy Consumption

G.1 Determination of Median Values Related to Consumption of Electric Energy

Two median values were found for each tract for each month and for the entire year, (1) median kilowatt hour and (2) median values of kilowatt hours consumption. The electric bill associated with each account's quantity consumed each month was included in the original data set; such values for the year as well as the average price per kilowatt hour for the year and for each month were computed in the mechanical processing of the data.

G.2 Treatment of Inactive Rate Class IV Accounts in Determination of Median Values

The method used for handling the consumption data for Commercial Lighting, Rate Class IV, accounts, when combined with the sharp variance of occupancy rates between the academic year and the summer months,

resulted in the presence of inactive Rate Class IV accounts in the final data set. In drawing the median values, the inactive accounts were treated in three different ways, (1) the zero values for the inactive Rate Class IV accounts were included in the count to determine the median, (2) zero values in the inactive Rate Class IV accounts were excluded from the count to determine the median, and (3) the average values used for active accounts designated by that Rate Class IV account number were substituted for the zeros. Since only two tracts were widely affected, the choice of median had minor influence over test results. Seriousness of the problem is examined in Appendix D.

Tests of the hypothesis were conducted with respect to each of the three methods of drawing the median. Analysis of data based on medians determined with zero values included is included in the text; analysis of data based on the other two procedures for determining the median are reported in the appendixes.

H. Data Pertaining to Accrual of Benefits and Costs of Municipal Services

Since the revenue over cost yielded by the electric utility serves in lieu of the more traditional taxes as a source of revenue for financing the provision of other municipal services, any appraisal of the equity of the tax on the basis of the benefits criterion requires insight into the costs and benefits of such services and consumption of subsidized services. Several sources of information were available for testing these relationships.

H.1 The City Budget and Annual Reports

The City Budget and annual reports provide audited information on the inflow of revenues and expenditures which reveals the extent to which the electric utility's revenues represent a subsidy to other services which are not self supporting. These documents also reveal the spectrum of city services available.

H.2 The Neighborhood Analysis[9]

A neighborhood analysis financed by a Housing and Urban Development grant and carried out under the auspices of the Oklahoma Industrial Development and Park Department was completed in 1971. The study directed by James M. Mayo, Research Planner, involved careful collection of much data including such services as police protection, fire protection, and street conditions. Data collected include the years 1969 through 1971. Since the data were reported on the basis of census enumeration districts, they were compatible with the data used in this study. Comparing the relationship between the use of such city services and the costs to serve as well as the price of electric energy which yields a subsidy to such services provides insights into the extent to which the contribution of revenue by the various consuming groups covers the cost of services enjoyed and consequently the extent to which the benefits criterion of equity in taxation is met.

H.3 The Crum Studies

A Master's thesis and graduate class project by Anna Coe Crum supplied further information for the study of costs and benefits of city

services subsidized by electric utility revenues. These studies too were based on the enumeration district as the geographic unit of analysis.

H.3.1 Study of Urban Parks

Data on use of city parks and the residence of users was collected in the summer of 1972.[10] Information gathered included nature of use of the park, age of users, and estimated frequency of use.

H.3.2 Open Space in Stillwater, Oklahoma

Crum used an aerial photo map to assess three different types of open space in the city of Stillwater.[11] Open space was assessed on the basis of census tracts. Open space within a tract indicates housing density and the degree to which a tract is developed. Variance in levels of housing density and development influence the costs of some types of services such as customer services for the electric utility. While the results of Crum's study were not directly applicable to this study, the techniques used for estimating levels of development were adaptable to this study.

H.4 Aerial Photo Map

Since tract areas vary sharply in size and degree of development, comparison of tract characteristics for many items must be made in terms of units of service per unit of geographic area. An aerial photo map of the city of Stillwater prepared by the United States Geological Survey was used to determine overall area and the developed area within tracts. To determine area within a tract, tract boundaries were first indicated

on the aerial photo map. A transparent grid laid over the aerial photo map permitted the researcher to count the amount of space within a tract and also to determine the amount of space within the tract which had not been developed.

I. Summary

Data were sought for testing hypotheses pertaining to the ability to pay and benefits received principles of tax equity with respect to the current arrangement for financing the supply of municipal services from monopoly profits yielded by the municipal electric utility. The census tract was selected as the geographic unit for testing. Census data on median annual income were chosen as the measure of ability to pay. Use of census data resulted in the choice of nonparametric analysis and the use of the median as the measure of central tendency.

A 10 percent sample of electric service accounts was drawn for each tract and data on monthly kilowatt hours of energy consumed and the associated bill for the fiscal year 1970-1971 were collected. In measurement with respect to the ability to pay criterion, the specific tax is defined as the total electricity bill.

Testing relative to the benefits criterion of equity requires knowledge of how the revenue over cost of electric energy which flows into the general fund is correlated with costs of electric services and benefits of other municipal services. Data to be used in this type of analysis include tract data on total annual bills for electric service and information on customer, capacity, and demand costs associated with provision of the electric energy.

FOOTNOTES

[1]A housing unit is defined here as the population served (1) by an electric meter where the Residential or Rate Class I is in effect or where Residential Water Heating or Rate Class II is in effect, (2) the occupants of a housing unit such as an apartment or mobil home where Commercial or Rate Class IV applies, or (3) in group quarters as defined by the Bureau of Census, a number of occupants equivalent to the average size of households in that geographic area.

[2]The process of assembling the data into identical geographic subsets, i.e., assigning data on city services to census areas, will henceforth be referred to as geocoding.

[3]Data suppression refers to the Census Bureau's practice of not providing information to the public where there are so few units reporting that individual units might be identified from the data.

[4]James N. Morgan, David H. Martin, William J. Cohen, and Harvey E. Brazer, Income and Welfare in the United States, 1st edition, New York: McGraw Hill Book Company, Inc. (1962); Herman P. Miller, Income of the American People, New York: John Wiley and Sons, Inc. (1955); Herman P. Miller, Rich Man, Poor Man, New York: Thomas Y. Crowell Co. (1964).

[5]Enumeration districts were chosen as the optimal unit of refinement for geocoding electric accounts into census geographic units as is explained below. Block data involved such problems of data suppression that there seemed to be little likelihood of a call for analysis of data at the block level. Examination of the boundaries of enumeration districts confirmed intuitively the known fact that in general census boundaries are drawn such that areas within census enumeration districts are relatively homogeneous in terms of demographic variables. Further, there is much greater economy in time and expense required for the geocoding process when enumeration districts are used in preference to blocks with little to be gained in the way of sharpening the analysis by using the smaller unit. Enumeration districts were preferred to tracts for several reasons, the strongest being that once the sample was drawn, it was possible to aggregate data to the tract level without violating the assumptions of randomness of the sample required for some types of statistical analysis whereas the converse was not true. While a greater variety of census data are available at the tract level and fewer suppression problems develop there, much city data is also being collected and tabulated for the enumeration district level. It was believed that refinements or extensions of this study or other studies requiring enumeration district data might eventually prove desirable. In such a case provision in the original sampling program for capability of assessing the population in

a manner which would permit sampling of enumeration district data as well as tract data would economize on the use of resources in follow-up studies. Within that frame of reference, the value of long run returns from increased flexibility of the program appeared to offset the short run economies of a less versatile instrument.

[6]Department of Geography and Arts and Sciences Extension, "Stillwater, Oklahoma--A Computer Generated Atlas." (Keith D. Harries, editor), Stillwater, Oklahoma: Department of Arts and Sciences Extension, Oklahoma State University, 1971.

[7]For every tract, regardless of family income structure, mean income exceeded median income and frequently by substantial amounts (Table XXV). This reflects the fact that the incomes above the mean are sufficiently large to offset the higher concentration of low incomes below the mean. The consistent relationship between mean and median income prompts other questions such as the distribution of income between families and unrelated individuals. Incomes of families are substantially higher. Since the data were to be employed in nonparametric analysis, ordinal values or rankings within the data sets were of greater concern than cardinal values. Comparison of the count of families with that of unrelated individuals reveals the disproportionate concentration of unrelated individuals in Tracts 2, 4, and 5. To determine whether this concentration of unrelated individuals was sufficiently weighty to reorder the rankings of income by tracts, the mean and median incomes of the three family structure classifications were compared as in Table XXVI. Rankings of income of unrelated individuals switched about considerably (1) with respect to mean and median income and also (2) in relation to the rankings for families and for families and unrelated individuals. However, rankings of income by tracts for families and for families and unrelated individuals remain quite stable with respect to both the rankings of mean and median income within and across classes.

[8]A careful analysis of age distribution, percent rental units, and housing unit occupancy can be found in the following source: Department of Geography and Arts and Sciences Extension, Stillwater, Oklahoma--A Computer Generated Atlas, Keith D. Harries, editor, Stillwater, Oklahoma: Department of Geography and Arts and Sciences Extension, Oklahoma State University (1971), pp. 10-28. Familiarity with the sections of the city would indicate intuitively that the area adjacent to the university which has a large number of apartments and rooming houses is heavily populated with students while Tract 8 which is the older original section of town is populated by lower income families and the elderly. A visual survey of the area supports such reasoning as does the census data which indicates that 30.5% of the persons living in Tract 8 are age 65 or older while that segment of the population represent only 9.9% of persons in Tract 4. See United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P-4.

[9]Neighborhood Analysis for the City of Stillwater, Oklahoma, City of Stillwater, Oklahoma (September 1971).

[10]Anna Coe Crum, "Urban Park Planning: A Case Study of Stillwater, Oklahoma," unpublished Master's thesis, Oklahoma State University, (May 1973).

[11]Coe Crum, "An Empirical Study of Open Space in Stillwater, Oklahoma," unpublished paper, Oklahoma State University (May 1972).

CHAPTER IV

THE QUESTION OF EQUITY IN TAXATION: ABILITY TO PAY

A. Introduction

A.1 The Revenue Function of the Municipal Electric Utility

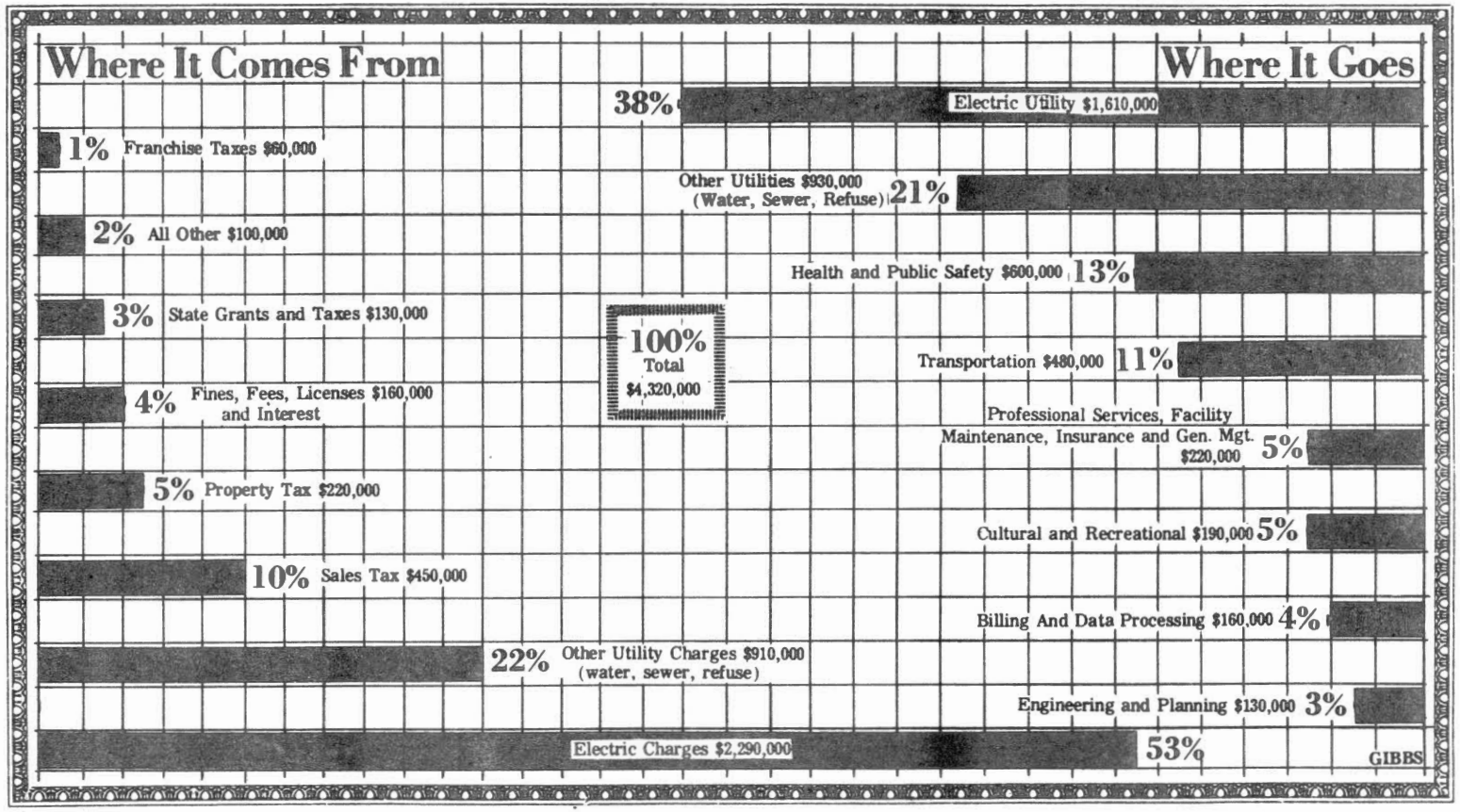
This study focuses upon the dual functions of the electric utility operated by the city of Stillwater, Oklahoma. Chapter II examined technical and allocative aspects of the problem of electric energy supply. Chapters IV, V, and VI deal with allocative and distributional effects of the revenue function. Table IV demonstrates the importance of the revenue gathering function of the electric utility in financing operations of the city government.

A.2 The Economic Consequences

The existence of the revenue function rests upon the ability of the utility to collect monopoly profits and direct those profits which serve in lieu of the more traditional types of tax levies into the provision of other municipal services which are not self-supporting. As explained in Chapter II, the collecting of monopoly profits produces distortions of resource allocation by virtue of the fact that the price exceeds the marginal cost of the product. Segregation of customer classes in

TABLE IV

BUDGET, CITY OF STILLWATER, OKLAHOMA, 1970-71



Source: Stillwater News-Press

pricing compounds the allocation problem by introducing greater discrepancies between price and cost of service for some classes than for others.

Further, in addition to the allocation problem posed by the profit taken, to the extent that there is not a positive correlation between the consumption of electric services and other services whose provision is subsidized by revenues from sales of electric energy, redistribution of real income occurs. The income redistribution produces additional allocative effects and introduces the questions of tax equity examined in the following chapters.

A.3 Organizational Approach to the Problem

The relationship of the median annual average price of electric services and median annual income is examined in Section B.3.1 to test for regressiveness of the tax rate with respect to income. The relationship between income and the share of income absorbed by the total electric bill is examined in Section B.3.2 to test regressiveness of the total tax with respect to income.

B. Tax Equity Under the Ability to Pay Criterion

B.1 Economic Concerns

Concerning the revenue function of the municipal electric utility, two questions need to be asked, (1) whether the practice is neutral with respect to income distribution, and if not, (2) whether it meets the criteria of equity in taxation.

B.2 Concepts of Equity in Taxation

Two differing concepts of equity in taxation exist within the economics discipline. The ability to pay approach to tax equity loosely interpreted indicates that those who have greater wealth[1] should bear a larger share of the tax burden necessary for supplying public services. Equity or neutrality assessed on the basis of benefits received implies a quid pro quo arrangement whereby the person who creates demand or gives rise to costs pays.[2]

B.2.1 The Ability to Pay Criterion

In terms of the ability to pay criterion it is hypothesized that the tax bill is regressive. This prediction follows from previous research and theoretical work which has tended to find user charges for basic consumption items to represent a larger share of the income of low income consumers than of high income consumers.[3] Given the declining block rate structure and the assumption that electric energy is a normal good[4] with respect to demand, it would seem reasonable to expect the bill for electric energy to be both a regressive tax and regressive with respect to the tax rate.[5]

Testing for the ability to pay criterion. Both the question of the regressiveness of the tax and the regressiveness of the tax rate are tested. Regressiveness of the tax is tested by comparing the electric service bill as a share of median annual income to the income of differing income groups. Regressiveness of the tax rate is tested by comparing the per unit charge for electric energy to median annual income for differing income groups. Findings will initiate the first step toward an

answer to the first question posed, i.e., whether the tax is neutral with respect to income or represents a case of income redistribution. They will partially answer the question of tax equity, i.e., whether the ability to pay criterion has been served.

B.2.2 Definition of Tax Concepts

The municipal electric utility of the city of Stillwater, Oklahoma serves the dual functions of providing a basic commodity, electric service, to the community and of collecting monopoly revenues used in lieu of the more traditional tax instruments as a source of funds for financing the municipal operations. Two distinct concepts of the electric bill as an instrument of taxation are recognized in this study. (1) The entire electric bill may be treated as a tax flowing into the general fund; the fund is then used to finance a bundle of municipal goods and services including electric services. This conception of the bill will be identified as B_1.

In assessing the regressiveness of the tax, it is the total annual tax bill or electric bill which is of interest, i.e., B_1. However, in testing regressiveness of the tax rate the charge per unit is the appropriate datum; the per unit charge or the price paid to purchase electric services is defined as follows:

$$b_1 = \frac{B_1}{e} \tag{8}$$

where e is the number of kilowatt hours of electric service provided. (2) The tax may also be treated as a price covering the specific cost of electricity plus a tax covering a bundle of all other municipally provided commodities. Algebraically this concept may be identified as B_2

defined below:

$$B_2 = p_e \cdot e + Tx \tag{9}$$

where $p_e \cdot e$ = the average cost of providing e kilowatt hours of electric service

or $$Tx = B_2 - p_e \cdot e = \text{the residual accruing to other municipally provided services} \tag{10}$$

and $$B_2 = B_1 \tag{11}$$

B_1, the concept of the entire bill as one tax levy for a variety of services, is used in examining the degree to which the revenue function meets the ability to pay criterion of equity. This approach makes use of the sample data on total and per unit electric bill expenses of Stillwater residents. However, if the benefits criterion of equity is under study, it is necessary to separate the portion of the bill required to cover the cost of electric service from the portion of the bill which flows into the general fund and subsidizes other municipal services. Hence the B_2 conception of the bill is used in the discussion of the benefits criterion. As will be seen in Chapter V, the absence of hard data on per unit costs of supplying electricity to various customers means this approach requires a set of rough estimates.

B.3 Assessment of the Tax in Terms of the Ability to Pay Criterion of Equity

The test of the ability to pay criterion assesses two things: (1) the neutrality of the tax with respect to income distribution and (2) in the absence of neutrality, the extent to which the tax burden is borne most heavily by those who are most able. Two hypotheses are tested. (1) It is hypothesized that the tax rate is regressive with respect to income, and (2) it is hypothesized that the tax bill is regressive with respect

to income. To test these hypotheses the Kendall rank correlation test is applied to median annual income for census tracts and median values for electric energy consumption.

B.3.1 Testing for Regressive Rate Structure

The tax rate is said to be regressive if the rate varies with income such that those in a lower income bracket are assessed at a higher rate than those in a higher bracket. In this study the tax rate may be regarded as the average price per kilowatt hour for electricity consumed,

$$b_1 = \frac{B_1}{e}$$

To obtain the average price per kilowatt hour, b_1, the monthly quantities of electric energy consumed and the monthly electric bills were summed to produce the annual bill, B_1, for the annual kilowatt hours, e, of electric energy consumed by each housing unit in the sample. The total electric bill for the housing unit, B_1, was divided by the total number of kilowatt hours of energy consumed to obtain b_1, an average price per kilowatt hour for all energy consumed during the year. The set of annual average prices for housing units was arrayed in numeric order within each tract and the median value was selected. The raw data and results of the Kendall test of rank correlation[6] between median annual income and median price per kilowatt hour, b_1, are summarized in Table V and Appendix E.

A negative correlation coefficient of -.4286 was found between income and annual average price per kilowatt hour, b_1, of electric energy. The correlation coefficient is significant at the .119 level. The correlation coefficient is probably lower than it would otherwise be due in part to the incongrueties in the data sets discussed in Chapter III.

TABLE V

RELATIONSHIP OF TAX TO INCOME
(ZERO VALUES INCLUDED)

Tract[1]	Independent variable: Median annual income of families & unrelated individuals	Dependent variable: Cost of electric energy (Median values where zero values in inactive Rate Class IV accounts were included in the count to determine the median): Median annual kwh	Total bill for median annual kwh	Electric energy cost as a percent of income: Percent	Rank	Median annual average price per kwh[2]: Price	Rank
1	$9,591	7768	$215.19	2.2437	7	$.02770	6
2	4,918	8132	227.98	4.6356	3	.02783	5
4	2,862	4490	149.54	5.2250	2	.03331	2
5	1,237	3495	103.67	8.3808	1	.02966	3
6	7,385	7094	204.78	2.7729	6	.02887	4
8	4,474	3314	129.38	2.8918	5	.03904	1
9	7,087	9774	255.62	3.1836	4	.02615	7
Kendall rank correlation test for the relationship between tax and income:			S	-17		-9	
			p(S)	.0054		.119	
			τ	-.8095		-.4286	

[1]Tracts 3, 7, and 10 were eliminated because they were not residential areas.

[2]Median annual average price = Total bill for median annual kwh divided by median annual kwh.

Source: Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71, and United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P-4.

Income of households which would correspond more closely to electric energy consumption units, i.e., accounts or meters, would probably fall somewhere between the median values for families and for families and unrelated individuals. The exact relationship would vary from tract to tract. This is because some households are composed of families, some of unrelated individuals, and some of groups of unrelated individuals, the categories for which income data are reported. Income of households would be expected to produce a more accurate and more highly correlated measure of the income-consumption relationship and consequently the income-price relationship; however, as indicated earlier, income data are not reported for households.

The small number of values involved in the test cause the results to be highly sensitive to minor shifts in the rankings. Examination of the data in Tables V and VI seems to indicate a strong overall inverse relationship between income and price per kilowatt hour, b_1, despite minor shifting of ranks within the structure.

TABLE VI

COMPARISON OF RANKINGS BY INCOME AND PRICE

	high						low
Rank	1	2	3	4	5	6	7
Tracts ranked by income	1	6	9	2	8	4	5
Tracts ranked by price, b_1	8	4	5	6	2	1	9

Table VI reveals clustering of Tracts 1, 2, 6, and 9 and Tracts 8, 4, and 5 with respect to both price and income. Table V reveals some clustering of income within Tracts 1, 2, 6, 8, and 9 and within Tracts 4 and 5. With respect to consumption of energy, there is clustering of Tracts 1, 2, 6, and 9; Tract 8 falls with Tracts 4 and 5. Tracts 8, 4, and 5 are demographically different from the others. Tracts 4 and 5 have a high concentration of university students. Tract 8 has a heavy concentration of the elderly and retired as well as low income families. The racial minority contingent of the population is concentrated in Tract 8.[7]

The relationship between income and price, b_1, behaves as expected for the clusters although there is some switching among the ranks within the high income cluster which reduces the values of the test results. Within that cluster Tracts 1 and 9 behave as expected. Tracts 6 and 2 do not behave as expected. Tract 6 has a fairly high concentration of persons in the latter stages of the family life cycle and university students renting rooms in private homes. Its behavior is analogous to that of Tract 8 with respect to consumption of electric energy and consequently price, b_1.

It therefore appears that other demographic factors may exert an overwhelming influence in some cases. However, the data still seem to support the hypothesized regressive relationship between income and the price of electric energy, b_1; this indicates that the tax rate is regressive; it tends to fall most heavily on the racial minority population, the young university students, and also the elderly. Persons within these age and income groups are identified as the poor of the society having the lowest ability to pay due to their lower earning power and consequent lower income status.[8]

B.3.2 Testing for Regressiveness of the Tax

A tax is classified as being regressive when it represents a larger share of the income of lower income groups than of higher income groups. To test the null hypothesis that there is no difference among income groups with respect to the share of income represented by expenditures for electric energy, the expenditures as a percent of income were compared with income by tracts.

In preparation for the test the monthly electric bills for fiscal year 1970-71 were summed for each housing unit in the sample to obtain a median annual electric bill, B_1, for each tract. The median annual electric Bill, B_1, as a percent of median annual income was calculated for each tract. Results of the Kendall rank correlation test appear in Table V.

A negative correlation coefficient of -.8095 is found for the relationship between income and the total utility bill as a percent of income. The data do not support the null hypothesis that there is no relationship between annual income and the portion of income represented by the annual electric bill. The result is significant at the .0054 level and negative in sign.

On the basis of the data it must be concluded that the electric bill as a tax, i.e., B_1, is regressive with respect to income. This finding indicates a violation of the ability to pay principle in taxation. It also establishes the first approximation with respect to tax neutrality. The neutrality issue becomes a highly important question at this point, for under the benefits criterion of equity a regressive tax may be called for if the benefits from expenditures of the tax revenue accrue more

heavily to persons in the lower income brackets. This issue is the topic of Chapter VI where the benefits criterion of equity is tested.

C. Summary and Conclusions Regarding Tax Equity Under the Ability to Pay Criterion

The B_1 concept was examined with respect to the ability to pay criterion of equity in taxation. The median annual average price, b_1, was found to be significantly negatively correlated with median annual income. A significantly negative correlation was found between income and the share of income absorbed by the electric bill, B_1. Both results support the hypothesis that the tax is regressive and consequently in violation of the ability to pay criterion of equity.

FOOTNOTES

[1]Despite its many shortcomings, for operational purposes, current personal income is commonly taken as a proxy for wealth. Good discussions appear in Musgrave, pp. 160-183; James N. Morgan, David H. Martin, William J. Cohen and Harvey E. Brazer, Income and Welfare in the United States (first edition), New York: McGraw Hill Book Company, Inc. (1962); Herman P. Miller, Income of the American People, New York: John Wiley and Sons, Inc. (1955); and Herman P. Miller, Rich Man, Poor Man, New York: Thomas Y. Crowell Company (1964).

[2]The literal interpretation of the Latin expression quid pro quo is "this for that" or "something for something." It carries a connotation of equal worth of the items exchanged. Consequently in the public finance literature it has been used to convey the idea that the individual exhibits a willingness to pay for a publicly provided commodity when his benefits are in accordance with the sacrifice.

[3]Bernard P. Herber, Modern Public Finance, Homewood, Illinois: Richard D. Irwin, Inc. (1967), p. 275; and Harold M. Groves, Financing Government (3rd edition), New York: Henry Holt and Co. (1950), pp. 287, 288.

[4]A commodity is said to be a normal good when its consumption is positively related to income. Richard H. Leftwich, The Price System and Resource Allocation (fourth edition), Hinsdale, Illinois (1950), p. 94.

[5]A tax is said to be regressive with respect to income when it represents a larger proportion of the income of lower income taxpayers than of higher income taxpayers. A tax rate is said to be regressive when lower income taxpayers are assessed at a higher rate of taxation than higher income taxpayers. A proportional tax rate wherein the taxpayers at all income levels are assessed at the same rate against the tax base may be a regressive tax if the taxed item represents a larger share in the income of lower income taxpayers compared to higher income taxpayers. A classic case is a sales tax on food which is levied at the same rate for all consumers; however, since food purchases typically represent a much larger share of the income of lower income consumers, the tax is regressive. In the case of electric energy it is likely that the tax would be regressive even if levied at a proportional rate because electric energy is a basic consumption item; however, the rates charged for electric service are themselves regressive.

[6]Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences, New York: McGraw-Hill Book Company, Inc. (1956), pp. 213-229.

[7]Department of Geography and Arts and Sciences Extension, Oklahoma State University, Stillwater, Oklahoma - A Computer Generated Atlas, (Keith D. Harries, editor), Stillwater, Oklahoma: Department of Geography and Arts and Sciences Extension, Oklahoma State University, 1971.

[8]Morgan, et al; Miller (1955); Miller (1964).

CHAPTER V

DISTRIBUTION OF THE PAYMENT OF REVENUE OVER COST AMONG INCOME GROUPS

A. Introduction

Who pays the "tax", Tx, or produces the monopoly profits is an integral part of the allocation and redistribution question and a crucial element in the evaluation of tax equity under the ability to pay criterion. The question will be assessed in terms of the costs imposed upon the system by different income groups, as represented by different Stillwater census tracts compared to their contributions to revenue through the bill for electric services; the examination is in terms of the annual electric bill, and selected service characteristics are used as indicators of annual costs imposed.

A related question concerns the ability of the various income groups to reach the lowest marginal price range of the graduated rate structure and the relationship between that step of the rate structure and marginal cost. These questions are examined in Section C.

A.1 Theoretical Context

As stated in Chapter IV, the total electric bill, $B_2 = B_1$, is composed of Tx, the monopoly profit, and $p_e \cdot e$, the cost of providing electric service. Section B investigates the relationship between the

electric bill, B_2, which is the consuming unit's contribution to revenue vis-a-vis its contribution to costs, $p_e \cdot e$, which are imposed upon the electric system by the various income groups' demands for electric energy services. It is hypothesized that the graduated block rate schedule produces a negative relationship between costs of service and the tax bill paid by the different income groups.

A.2 Classification of Costs

In the provision of electric services, three different classifications of costs are recognized, (1) customer costs which include such items as meter reading, billing, and accounting, (2) capacity or demand costs which include the cost of capital items such as generating, transmission, and distribution facilities, and (3) energy costs which parallel the major portion of the variable costs of microeconomic theory and include the costs of fuel, labor, and purchased power for meeting peak demand.[1] Table VII indicates the importance of the classes of costs relative to the overall costs of the electric utility. The annual contributions to costs will be compared to the annual contribution to revenue by census tracts, with census tracts representing differing income groups.

A.3 Methodological Approach

The objective of Chapter V is to test the hypothesized relationship between cost of service, $p_e \cdot e$, and contribution to revenue through the electric bill, B_2, in order to determine the relationship between B_2 and Tx, the residual of the electric bill flowing into the general fund after the costs of electric service have been met.

TABLE VII

CUSTOMER, DEMAND, AND ENERGY COSTS, STILLWATER MUNICIPAL ELECTRIC UTILITY, FISCAL YEAR 1970-71

(1) Customer Cost			
Meter Reading:		$ 22,018	
Accounting, Billing and Collecting:			
City Clerk's Office	$26,835		
IBM Tabulating	25,323		
Accounting	450		
Telephone Expense	1,163		
Office Equipment Rental Expense	485		
Bad Debt Expense	25,187		
Office Supplies	1,393		
Total Billing and Collecting Cost		80,836	
Total Customer Cost			$102,854
(2) Demand or Capacity Cost			
Interest Expense		$ 99,151	
Depreciation Expense		294,886	
Total Demand or Capacity Cost			394,037
(3) Energy Cost			
Personal Services:			
Administration		$ 17,000	
Generation		156,818	
Distribution		115,851	
Maintenance and Operations:			
Administration		1,308	
Generation		28,234	
Distribution		25,207	
Fuel		373,306	
Electricity Purchased		124,926	
Vehicle Repairs and Maintenance		8,565	
Gasoline Expense		3,594	
Pole Hardware Expense		12,679	
Total Energy Expense			867,488
(4) Other Cost			
City Manager		$ 13,065	
City Commissioners' Expense		162	
Chamber of Commerce Dues		500	
Street Lighting Expense		405	
Total Other Cost			14,132
Total Cost			$1,378,511

Source: Utility Department, City of Stillwater, Oklahoma, Financial Report for fiscal year 1970-71.

In Chapter III, the technique for identifying the median annual electric bill for each tract from the electric utility billing records was described. Data on service requirements of the different tracts are used as indicators of cost imposed on the electric system, i.e., $p_e \cdot e$. If the relationship between B_2 and $p_e \cdot e$ can be found, the relationship between B_2 and Tx can be determined.

Since $B_2 = p_e \cdot e + Tx$, if B_2 and $p_e \cdot e$ are negatively related, it follows that B_2 and Tx are positively related. If B_2 and $p_e \cdot e$ are positively related then as B_2 increases, Tx may increase, decrease, or remain constant depending upon whether the change in $p_e \cdot e$ is less than, equal to, or greater than the change in B_2. To test this relationship between the change in B_2 and $p_e \cdot e$ when B_2 and $p_e \cdot e$ are positively related, the elasticity of $p_e \cdot e$ with respect to B_2 will be tested using the following formula:

$$\varepsilon = \frac{\dfrac{\delta(p_e \cdot e)}{p_e \cdot e}}{\dfrac{\delta B_2}{B_2}} = \frac{\text{Percent change in cost from the lowest bill to the highest bill tract}}{\text{Percent change in revenue from the lowest bill to the highest bill tract}} \qquad (12)$$

The calculations are made as follows. B_2 is the dollar amount of the lowest electric bill; $p_e \cdot e$ is represented by the corresponding quantity of the cost surrogate. δB_2 is the dollar amount of the highest minus the lowest electric bill and $\delta(p_e \cdot e)$ is the corresponding quantity for the cost surrogate. Where the elasticity is greater than unity, it may be concluded that an increase in the quantity of energy consumed will cause $p_e \cdot e$, the contribution to cost of electric service imposed on the electric system, to increase by an amount greater than the increase in B_2; the contribution to revenue, and thus Tx, will decrease or be negatively

related to B_2. If the elasticity is unity, a change in the quantity of energy consumed will result in B_2 and $p_e \cdot e$ changing by the same absolute amounts and Tx will remain constant for all levels of energy consumption. If the elasticity is less than unity, the indication is that B_2 and $p_e \cdot e$ are positively related; Tx increases as B_2 increases. Since cost data per se for the various cost elements are not directly available, the changes in the quantities of the items representing cost will be taken as indicative of changes in cost and will be employed in computing the elasticity measures.

B. Costs of Electric Service by Income Group

B.1 Customer Costs

The Kendall rank correlation test was used to test the relationship between the median annual electric bill for electric energy, B_2, and customer costs of supplying it to the various income groups, $p_e \cdot e$, represented by the populations of the different tracts. Customer costs which account for approximately 7 percent of total costs were regarded as costs associated with (1) meter reading and (2) billing, collecting, and accounting. Results of tests for the relationship between the electric bill, B_2, and variables treated as surrogates for customer costs by tracts are reported below.

B.1.1 Meter Reading Costs

Meters per unit of space. Costs of meter reading which represent about 2 percent of the utility's total costs might be expected to vary considerably for income groups given the fact that low income areas of

the city tend to be centrally located, more densely populated areas, whereas the higher income areas tend to be the peripheral sparsely populated suburban areas. Costs in terms of time and transportation would be expected to vary with the extent of dispersion of meters to be read. Since there is no perfect measure of the degree of density or dispersion of meters over geographic areas, three alternative measures were used in the tests, (1) meters per acre based on total square acres in the tract, (2) meters per developed acre based on total square acres of developed area in the tract, and (3) meters per linear feet of streets.

Results of the test are reported in Table VIII and Appendix F. The Kendall rank correlation coefficient for the relationship between the electric bill, B_2, and electric meters per developed acre, $\tau = -.7143$ is significant at the .015 level compared to the results for meters per total acres where $\tau = .6190$ significant at the .035 level. Of the two measures, meters per developed acre is regarded as the more representative measure because some tracts reflect a fairly high density of residences in a small portion of the tract, with the remainder of the tract being unoccupied open space. The test of electric meters per linear feet of streets yielded $\tau = -.6190$ significant at the .035 level.

Relationship of meters and housing units. As a result of the treatment of consumption of Rate Class IV accounts, the number of meters does not correspond to the number of housing units. A consuming unit may be defined as the population served by one electric meter; however, one consuming unit may represent several housing units when that consuming unit represents a Rate Class IV Commercial Lighting Account. These

TABLE VIII

CUSTOMER COSTS
(ZERO VALUES INCLUDED)

	Independent Variables				Tract Characteristics					
	Median annual income of families & unrelated individuals		Median annual[1] electric bill							
Tract	Income	Rank	Bill	Rank	Total number of electric meters in tract	Total[2] number of housing units in tract	Total acres in tract	Total developed acres in tract	Total linear feet of streets	Electric utility cut-off notices
1	$9,591	1	$215.19	3	1110	1110	252	67	121,985	64
2	4,918	4	227.98	2	1350	1440	376	166	145,250	75
4	2,862	6	149.54	5	590	620	35	29	39,990	51
5	1,237	7	103.67	7	470	910	17	17	32,090	31
6	7,385	2	204.78	4	1350	1390	66	46	115,020	64
8	4,474	5	129.38	6	880	880	85	20	79,990	107
9	7,087	3	255.62	1	130	130	123	39	16,480	3

Kendall rank correlation test for the relationship between median annual electric bill and customer cost for electric service: S, $p(S)$, τ

$$\varepsilon = \frac{\dfrac{\delta(p_c \cdot e)}{p_e \cdot e}}{\dfrac{\delta B_2}{B_2}}$$

[1]Median values where zero values in inactive Rate Class IV accounts were included in the count to determine the median.

[2]Total housing units is based on the adjustment of group quarters reported in the census to housing units by using an index of household size for that tract.

TABLE VIII, Continued

Dependent Variables															
Meter Reading Costs														Accounting, Billing, and Collecting Costs	
Electric meters per total square acre		Electric meters per developed square acre		Housing units per electric meter		Housing units per total square acre		Housing units per developed square acre		Electric meters per linear foot of streets		Housing units per linear foot of streets		Electric utility cut-off notices per meter per year	
Quantity	Rank	Quantity	Rank	Quantity	Rank	Quantity	Rank	Quantity	Rank	Quantity	Rank	Quantity	Rank	Quantity	Rank
4.4	5	16.5	5	1.000	6	4.4	5	16.5	5	.0091	6	.0091	6	.0576	4
20.2	2	8.1	6	1.067	2	3.8	6	8.7	6	.0093	5	.0099	5	.0555	5
1.1	7	20.0	4	1.051	3	17.5	4	21.0	4	.0148	1	.0155	2	.0864	2
3.6	6	28.0	3	1.936	1	54.2	1	54.2	1	.0146	2	.0283	1	.0659	3
18.2	3	29.2	2	1.030	4	20.7	2	30.0	3	.0117	3	.0121	3	.0474	6
16.9	4	44.8	1	1.000	6	18.2	3	44.8	2	.0110	4	.0110	4	.1216	1
28.0	1	3.4	7	1.000	6	1.1	7	3.4	7	.0079	7	.0079	7	.0231	7
+13		-15		-6		-17		-15		-13		-15		-13	
.035		.015		.191-.281[3]		.0054		.015		.035		.015		.035	
.6190		-.7143		-.2857		-.8095		-.7143		-.6190		-.7143		-.6190	
5.76		6.15		5.75		41.05		12.70		.72		2.20		1.57	

[3]When tied ranks yield S values not reported in the table, the probability for the values above and below the calculated value are reported.

Source: Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71; Bureau of the Census, United States Department of Commerce, 1970 census data tapes, Oklahoma State University Computer Center; City of Stillwater, Oklahoma, Neighborhood Analysis for the City of Stillwater, Oklahoma, James M. Mayo, editor, Stillwater, Oklahoma: City of Stillwater, Oklahoma, September, 1971; United States Geological Survey, aerial photo map of Stillwater, Oklahoma; and United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P4-4.

accounts involve single meters serving group quarters or several apartments whose usage is measured through one meter, however, the median annual electric bill, B_2, against which the costs are compared is based on housing units rather than consuming units which correspond to meters or accounts. It would be expected that as the ratio of housing units per meter increases, the cost of meter reading services per housing unit would be reduced. Also it should be noted that the effects are uneven among tracts since the relationship of meters to housing units varies from tract to tract with Rate Class IV meters serving multiple apartment units or group quarters concentrated in some areas.

The Kendall rank correlation coefficient for the relationship between the electric bill, B_2, and housing units per electric meter is $\tau = -.2857$ significant at the .191-.281 level. The negative sign indicates that as income and consumption of electric energy increase causing the electric bill to increase, there is a tendency away from multi-unit dwellings with commercial electric rates to single unit dwellings where electric service is individually metered for each housing unit.

The low correlation coefficient reflects the fact that the low income student population tends to live in the multi-unit dwellings whereas the low income elderly and minority families of the population live in single unit dwellings as do the higher income families. The pattern is reflected in Table IX below. Tracts 4 and 5 reflect a heavy concentration of students. Tract 2 has some areas of heavy student concentration but the population is heavily weighted with professional families. Tract 8 is occupied by low income elderly and minority families.

TABLE IX

RELATIONSHIP BETWEEN ELECTRIC METERS AND HOUSING UNITS PER DEVELOPED ACRE

Tract	1	2	4	5	6	8	9
Electric meters per developed square acre	16.5	8.1	20.0	28.0	29.2	44.8	3.4
Housing units per developed square acre	16.5	8.7	21.0	54.2	30.0	44.8	3.4
Housing units per electric meter	1.000	1.067	1.051	1.936	1.030	1.000	1.000

Housing units per unit of space. To determine whether the relationship between meters and housing units would affect the results of the test of costs and also because benefits are apportioned on a per housing unit basis, the correlation between costs for meter reading and the annual electric bill, B_2, was assessed on the basis of (1) housing units per acre based on total square acres, (2) housing units per acre based on square acres of developed area, and (3) housing units per linear feet of streets to determine the extent to which there is a variation among income groups with respect to this factor. While the correlation coefficients for housing units differed from those for meters, the signs remained the same except for the case of meters per total acre. The latter is of limited significance because clustering of housing units makes it a less accurate measure of density and consequently of variance in meter reading costs.

Conclusion. Whether the test is based on meters or housing units, the data indicate that there is a negative relationship between the annual bill, B_2, for electric energy and density of the housing units served. Since a negative relationship between meter reading costs and meter density is taken for granted, the data appear to support the hypothesis that there is a positive relationship between meter reading costs and contributions to revenue by the various income groups. The question yet to be answered is whether the electric bill is more, equally, or less responsive to changes in geographic density as compared to meter reading costs. Since direct cost data are not available, changes in density have been used as a surrogate for changes in costs. It is assumed that the relationship between changes in cost of service and density of housing units or meters is linear. Then an elasticity measure may be computed to compare the relative responsiveness of the two variables. Elasticity is calculated according to the formula on page 103. Except for houses per meter and meters per feet of streets, the elasticities were greater than unity indicating that as income increases and quantity of electric energy consumed increases, the electric bill increases, but the cost of meter reading service increases even more causing Tx to be negatively related to B_2.

B.1.2 Accounting, Billing, and Collecting Costs

In addition to the costs associated with meter reading, customer costs include those for billing, collecting, and accounting. There appear to be only two obvious reasons to expect differences in service costs for the different income groups. (1) The existence of cost savings in billing, collecting, and accounting should be reflected in the ratio

of housing units per electric meter. This possibility was analyzed with respect to meter reading costs and the expected relationship confirmed. (2) Delinquency in payments would also impose extra costs. The relationship between accounts receivable and the electric bill, B_2, by tracts was assessed to determine whether there is a difference imposed by different income groups due to this problem and whether that difference is reflected in differences in the contribution to revenue, B_2.

Disconnect notices per electric meter. Accounts receivable require special attention in billing, accounting, and collecting. Payment is due 10 days after a bill is mailed. If the bill is not paid within 5 days after the second bill has been mailed, the service is subject to disconnection and will be restored only after payment of a $5.00 fee. The Kendall rank correlation test was applied to data on the annual electric bill, B_2, and disconnect notices per electric meter as a proxy for variations in cost of service. Results of the test appear in Table VIII and Appendix F.

The correlation coefficient for the annual bill and the number of disconnect notices per meter per year is -.6190. The negative relationship is significant at the .035 level. The data indicate a negative relationship between the annual electric bill, B_2, and this portion of unit cost of providing electric service. However, with respect to the allocative effects, that result is probably nullified by the assessment of penalties for actual disconnection of meters.

Conclusion. No clear cut result is obtained with respect to the relationship between the annual electric bill, B_2, and accounting, billing, and collecting costs. No reliable relationship is found for

housing units per electric meter compared to the electric bill, B_2, and while the relationship between the bill, B_2, and meter disconnect notices is significant the assessment of penalties for disconnection probably offsets the cost imposed where disconnection occurs; however, that does not necessarily negate the allocation issue, for the penalty is assessed only to those for whom meter disconnection actually occurs. Such consumers tend to represent a small portion of those receiving disconnect notices.

B.2 Capacity or Demand Costs

Capacity or demand costs amount to around 29 percent of total costs and refer to the costs of maintaining the capability of supplying the electric energy. It refers to the fixed or capital costs of the firm and includes the generation, transmission, and distribution systems of the electric utility. Demand or capacity costs may vary among income classes of users in two ways. (1) With respect to generation, transmission, and distribution, the facilities must be adequate to meet the system's peak demand; in this case costs would be expected to vary as the level of usage varies. (2) In addition, with respect to transmission and distribution, the cost varies with remoteness from the point of generation and density of consuming units within areas.

The question to be answered is whether the annual bill for electric energy, B_2, varies directly with the cost of service. The existence and nature of a relationship between the electric bill, B_2, and cost will be investigated for both the cases stated above.

Demand or capacity costs vary with the quantity of plant and equipment required to meet peak demand. In block billing schemes it is

customary to develop the first blocks in the schedule to cover capacity costs.[2] Charges to all income groups are assessed by the same schedule and consequently all groups pay the same capacity costs. However, it is hypothesized that in the case under study and probably for all cases in general all groups pay the same capacity costs. It is further hypothesized that the higher income customers impose greater capacity costs on the system. This hypothesis is based on two expected patterns of behavior, (1) that higher income users consistently have a higher level of monthly demand for electric energy and (2) that the higher income consumers make a larger contribution to peak demand. These hypotheses would follow from recognition of electricity's normal good status which has repeatedly been found in studies of the growth of demand for electric energy.[3]

Demand or capacity costs imposed by high income consumers is also expected to be greater in another sense, that of efficient use of resources frozen into investment in capital equipment. Although consumption levels of high income groups would be expected to be consistently higher than those of low income groups, the high income groups' levels of consumption would be expected to exhibit a wider range of variation resulting in less efficient utilization of the capacity which must be available to meet peak demand. The load factor,[4] range of variation in kilowatt hours of energy consumed, and the contribution to peak demand[5] are applied to test this question.

B.2.1 General Demand

It is hypothesized that a positive relationship exists between income and quantity of electric energy consumed, i.e., that from month to

month over the course of the year high income consuming units consistently consume larger quantities of electric energy than low income consuming units. Several approaches were used in testing the hypothesis.

Spearman and Kendall tests of annual demand. The correlation between the electric bill, B_2, and the annual quantity of electric energy was found to be significant at the .007 level under the Spearman rank correlation test[6] where ($z = .9997$) and the .0014 level under the Kendall concordance test[7] where $\tau = .9048$. This simply reflects the fact that as income increases, the quantity of energy demanded increases; and as the quantity of energy demanded increases, B_2, the annual bill for electric services, increases.

Kendall concordance test of monthly demand. To test the hypothesis that the higher income groups consistently demand larger quantities of energy the monthly quantities of energy consumed by each tract were set up in an array and ranked by size. The ranks for each tract were then summed for the twelve months' consumption and the sums of ranks subjected to the Kendall concordance test.[8] The correlation coefficient, $W = .8185$ was significant at the .001 level, indicating that there is much consistency in the rank ordering of consumption by tracts from month to month.

Mosteller test of monthly peak demand. Under the Mosteller k-sample slippage test[9] the matrix of populations of monthly electric energy consumption data for tracts are arrayed horizontally from left to right in ascending numeric order by annual electric bill, B_2, and vertically in descending order by kilowatt hours consumed. The Mosteller test then determines the probability that the highest observation could have come

from the rightmost population in the matrix. Progressive testing with removal of the extreme right tract's data from the matrix after each test indicated that there was some shifting among tracts with regard to the relationship between the annual electric bill, B_2, and the largest quantity of energy consumed. Beyond this, the results were inconclusive and not comparable for the successive tests with data sets removed.

Jonckheere test of monthly demand. The Jonckheere distribution free k-sample test against ordered alternatives[10] yields a test of the hypothesis that higher income tracts consistently consume higher quantities of electric energy creating higher demand for capacity and consequently higher capacity costs. Tract data on electric energy consumption were seasonally adjusted on the basis of seven years' monthly energy consumption by residential consumers of the state of Oklahoma[11] and subjected to the Jonckheere test. A correlation coefficient of .5443 with probability of 9.8376E-11 was found indicating that there is little correlation between the two variables.

However, examination of the data reveals some clustering of consumption values which corresponds to the clustering of incomes. Consumption of Tracts 4, 5, and 8 tend to move together in both direction and level as is reflected in Table X and Figure 6. It will be recalled that these tracts represent the poverty level income groups, Tract 8 having a large concentration of the elderly and minority groups and Tracts 4 and 5 being dominated by students. There is some interchanging of the ranks within the tracts which reduces the result of correlation tests. However, as a group, this cluster of tracts behaves as expected with consistently lower levels of consumption yielding lower annual electric bills, B_2.

TABLE X

DEMAND COSTS
(ZERO VALUES INCLUDED)

Census Tract	Independent Variables: Median annual income of families & unrelated individuals		Independent Variables: Median[1] annual electric bill		Dependent Variable: Median kilowatt hours — Monthly: July 1970		Aug. 1970		Sept. 1970		Oct. 1970		Nov. 1970		Dec. 1970		Jan. 1971	
	Income	Rank	Bill	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank
1	$9,591	1	$215.19	3	1124	4	1250	3	558	4	344	1	438	2	500	2	430	4
2	4,918	4	227.98	2	1162	3	1580	2	632	3	288	3	432	3	409	3	552	2
4	2,862	6	149.54	5	618	5	498	5	380	6	238	5	250	5	288	5	248	5
5	1,237	7	103.67	7	538	6	450	6	410	5	160	7	174	7	200	7	152	7
6	7,385	2	204.78	4	1296	2	892	4	888	2	266	4	307	4	397	4	515	3
8	4,474	5	129.38	6	400	7	412	7	278	7	202	6	244	6	240	6	230	6
9	7,087	3	255.62	1	1622	1	1780	1	1206	1	338	2	510	1	521	1	703	1

Jonckhere distribution-free k-sample test against ordered alternatives (based on median annual electric bill):

$S = 1648$
$\tau = .5443$
$z = 6.4305$
$p(z) = 9.8376E-11$

[1]Zero values for inactive Rate Class IV accounts are included in the count to determine the median.

TABLE X, Continued

of electric energy consumed by consuming units[1]

consumption																				
Feb. 1971		Mar. 1971		Apr. 1971		May 1971		June 1971		Total		Average	Low	Peak		Range		Load Factor	
Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Kwh	Kwh	Rank	Kwh	Rank	Percent	Rank
438	3	392	3	346	3	590	1	1022	1	7492	3	618.3	346	1250	3	903	4	.4946	4
462	2	416	2	392	2	486	3	853	3	7753	2	646	288	1580	2	1292	2	.4089	7
250	5	198	6	216	6	286	5	424	5	3900	5	325	198	618	5	420	5	.5259	2
197	7	201	5	155	7	217	7	417	6	3275	6	276	152	538	6	386	6	.5130	3
382	4	376	4	342	4	354	4	603	4	6622	4	551.83	266	1298	4	1032	3	.4251	6
218	6	196	7	230	5	242	6	286	7	3178	7	265.08	202	400	7	198	7	.6627	1
527	1	452	1	411	1	496	2	982	2	9556	1	796.3	338	1780	1	1548	1	.4452	5

Mosteller k-sample slippage test:

5 < 8 < 4 < 6 < 1 < 2 < 9	r=2	p(r) = .1122
5 < 8 < 4 < 6 < 1 < 2	r=1	p(r) = .9653
5 < 8 < 4 < 6 < 1	r=0	p(r) = 1.0000
5 < 8 < 4 < 6	r=3	p(r) = .0332
5 < 8 < 4	r=1	p(r) = .9722
5 < 8	r=0	p(r) = 1.0000

Kendall rank correlation test for the relationship between median annual electric bill and demand cost		Peak	Range	Load Factor
	S	+19	+17	-1
	p(S)	.0014	.0054	.5000
	τ	.9048	.8095	-.0467
$\varepsilon = \dfrac{\dfrac{\delta(p_e \cdot e)}{p_e \cdot e}}{\dfrac{\delta B_2}{B_2}}$		1.9	2.56	.129

Source: United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P-4; Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71.

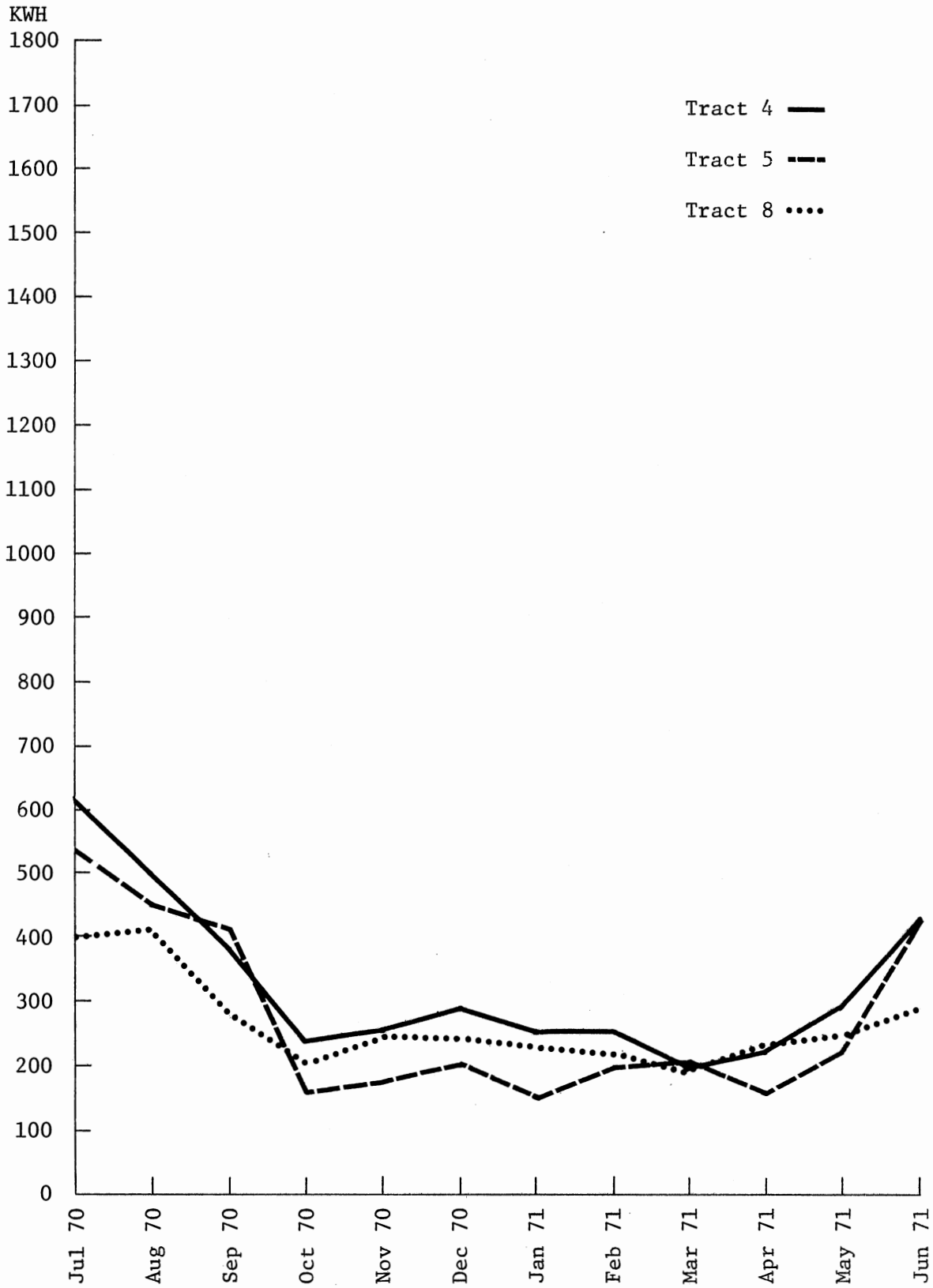


Figure 6. Electric Energy Consumption Behavior of Tracts 4, 5, and 8

Source: Electric utility billing records, Finance Department, City of Stillwater, Oklahoma, Fiscal year 1970-71

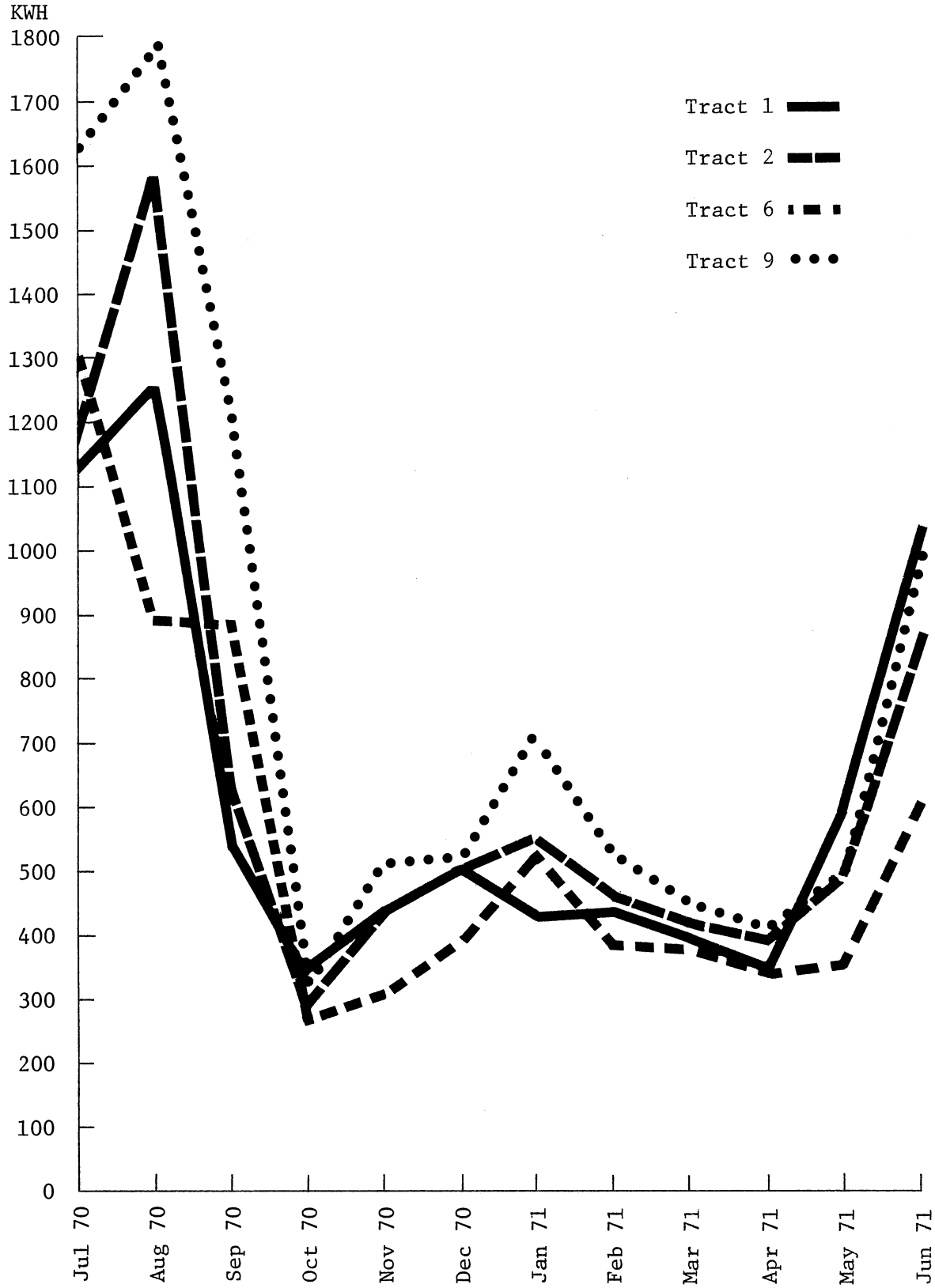


Figure 7. Electric Energy Consumption Behavior of Tracts 1, 2, 6, and 9

Source: Electric utility billing records, Finance Department, City of Stillwater, Oklahoma, Fiscal year 1970-71

Tracts 1, 2, 4, and 9 form another cluster of incomes and likewise another cluster of electric energy consumption behavior patterns as seen in Table X and Figure 7. Consumption is always higher than for the other set of clusters. Although there is some shifting of ranks within the cluster, the pattern of higher income groups consistently consuming more electric energy and creating higher demands for capital is borne out.

B.2.2 Capacity or Demand Costs Associated With Variance of Quantity Demanded

Whereas the general level of demand for generation, transmission, and distribution capacity to supply energy from month to month says something about the quantity of capital equipment which must be installed, the variance in the general level of demand from month to month says something about the efficiency with which the capital stock is employed. Three different data sets were used to assess the month to month stability of demand for electric energy by income groups, (1) peak demand, (2) range of the quantity of energy demanded, and (3) load factor for the various income groups.

Contribution to peak demand. Peak consumption for the system represents the highest level of consumption during a given time period. In this case the time period is defined as one month. The peak demand month for the Stillwater system during the 1970-71 fiscal year occurred in August of 1970. Contributions to the system peak demand represent the responsibility for capacity which must be available at all times and hence represents a capital stock requirement.

Results of the Kendall rank correlation test with respect to the median annual electric bill, B_2, and contribution to peak demand appear in Table X and Appendix G. The data support the hypothesis of a strong positive relationship between the bill, B_2, and the contribution to peak demand. Since contribution to peak demand is assumed to be positively related to $p_e \cdot e$, the cost of supplying electric service, the data indicate a positive relationship between B_2 and $p_e \cdot e$. The elasticity measure reported in Table X is greater than unity indicating that the cost is more sensitive to changes in electric energy consumption than B_2; this implies that as B_2 increases, Tx, the contribution toward the supply of non-self supporting municipal services, decreases.

Range of demand. Whereas peak demand data indicate the upper extreme of the quantity of energy demanded, it provides little information regarding the usage level of the capacity required to meet peak demand. The range of kilowatt hours of energy demanded from month to month serves as one indicator of variance in quantity demanded by various income groups. Results of the Kendall rank correlation test indicate a positive relationship between the annual electric bill, B_2, and the range of kilowatt hours of energy consumed. The correlation coefficient, .8095, is significant at the .005 level. Such a result is predictable from the data in Table X and Figures 6 and 7.

Load factor. Load factor is a standard measure of the efficiency of use of capital equipment. The load factor is derived by dividing the average level of usage per unit of time by the peak usage. A type of load factor measure was computed for each tract on the basis of energy consumed during the 1970-71 fiscal year. The Kendall rank correlation

test was applied to the data to test the relationship between the load factor and the median annual electric bill, B_2. Results are shown in Table X. The coefficient of correlation, -.0467, is significant at the .500 level indicating no discernible relationship.

The lack of correlation between the median annual electric bill, B_2, and the load factor is surprising given the findings with respect to range of consumption and the data relationship apparent in Figures 6 and 7. This may reflect an inadequacy of the load factor as a measure of utilization of capacity in the presence of wide ranges of variation in demand for energy. The elasticity measure was less than unity indicating that the load factor is less responsive to changes in levels of consumption than the electric bill.

B.2.3 Costs Associated with Geographic Dispersion of Consumers

Costs of transmission and distribution facilities also vary with the degree of dispersion of the units served. Since no mapping of the location and capacity of the major portion of the transmission and distribution system exists, housing units per feet of streets was accepted as a reasonable proxy because transmission and distribution facilities tend to follow streets. As noted in Section B.1.1 and Table VIII, the Kendall correlation coefficient between the median annual electric bill, B_2, and housing units per feet of streets has a value of -.7143 and is significant at the .015 level. Since there is an inverse relationship between dispersion of housing units and cost of transmission and distribution facilities per unit, a positive relationship between the electric bill, B_2, and cost of service, $p_e \cdot e$, is indicated. However, the elasticity

measure indicates that the cost of service, $p_e \cdot e$, is more sensitive to changes in consumption than the revenue, B_2. This indicates an inverse relationship between B_2 and Tx, the residual after costs of supplying electric service have been met.

B.2.4 Conclusions Regarding Demand Costs

The tests indicate that higher income consumers consistently demand higher quantities of electric energy than lower income consumers. The positive relationship between the electric bill, B_2, and the level of demand for energy translates to a positive relationship between the bill, B_2, and the demand for capacity. Higher demand for capacity indicates the imposition of higher costs upon the electric system. The data indicate a negative relationship between B_2 and Tx.

B.3 Energy Costs

Energy costs which constitute around 63 percent of total costs correspond to the variable costs of price theory. Per unit energy costs probably do not vary among income groups with the possible exception of their differences in contribution to peak demand. In Section B.2 it was found that higher income groups make greater demands on the system than lower income groups in terms of both (1) a consistent month-to-month demand for larger quantities of energy and (2) in terms of variance in the quantity of electric energy demanded from month to month. The influence of peak demand on costs of electric energy will be examined in this section.

B.3.1 Behavior of Costs of Generated Energy at Peak Demand

It is the greater variance in the quantity of electric energy demanded from month to month by the higher income consuming units which is of interest with respect to energy costs. In the case of capital equipment for which (1) the incremental units are large, (2) demand for its services is growing, and (3) amortization occurs over a long span of time, optimal management of financial resources requires installing a plant which is of greater than optimal scale at the outset but will become suboptimal before its retirement. (Appendix H contains a graphic analysis of this concept.)

Further, when demand for services provided by the equipment involves a low load factor caused by a large discrepancy between peak and normal or average demand, the plant may be operated above its optimal level during peak demand periods at any point along its time path. Thus the principles of price theory and empirical documentation indicate that the plant would operate less efficiently in converting the variable resources into final product during the periods of peak demand.[12] (Appendix I contains a graphic illustration of this concept.)

Consequently, if one consuming group tends to cause greater variance between peak and average load than another income group, the group responsible for the greater variance also has greater responsibility for the technical inefficiencies in resource conversion occurring during the peak demand periods. If quantity demanded by the groups were subject to less variance around the maximum, it would have paid to install larger scale equipment in the first place, and the inefficiencies would have been less likely to occur or would at least have been of smaller magnitude.

In that respect, the Kendall rank correlation test was used to investigate the existence of a relationship between the quantity of fuel used per kilowatt hour of energy generated and the level of output for the Stillwater plant. Results appear in Table XI and Appendix J. The correlation coefficient of -.2424 was significant at the .136 level and provided weak support for the hypothesis that increases in the quantity of energy produced are associated with a reduced level of efficiency in resource conversion. Given previous documentation of the relationship in other studies, more impressive statistical results would be expected if daily or hourly data for individual units were available for testing rather than the aggregated monthly data used here. The monthly plant data obscure much of the informational detail on hour to hour and day to day levels of operation which are crucial in testing the magnitude of the relationship in question.

The data on energy costs supported by findings in Section B would indicate that while higher income groups pay higher electric bills, B_2, they impose greater costs on the system and consequently contribute to the tax residual of utility revenues, Tx, at a lower rate than low income consumers.

B.3.2 Costs of Energy Purchased to Meet Peak Demand

Paralleling the issue of increased energy generation costs at the peak is the matter of purchased power required to meet peak demand in excess of the capability of the local plant. The Stillwater Municipal Utility generates its own energy because in general that practice is nominally less expensive than purchasing the power from another

TABLE XI

KENDALL RANK CORRELATION TEST OF THE RELATIONSHIP BETWEEN KILOWATT HOURS GENERATED AND FUEL USED PER KILOWATT HOUR

H_o: There is no relationship between kilowatt hours of electric energy generated and the quantity of fuel used per kilowatt hour; there is no relationship between intensity of use of generating equipment and efficiency in use of fuel.

H_1: There is a relationship between kilowatt hours of electric energy generated and the quantity of fuel used per kilowatt hour; there is no relationship between intensity of use of generating equipment and efficiency in use of fuel.

Variable	Datum	July 1970	Aug. 1970	Sept. 1970	Oct. 1970	Nov. 1970	Dec. 1970	Jan. 1971	Feb. 1971	Mar. 1971	Apr. 1971	May 1971	June 1971
Total kilowatt hours of electric energy generated	Rank	2	1	4	6	11	7	8	9	10	12	5	3
	Quantity	14,188,700	15,075,100	12,547,900	9,276,800	7,931,400	9,040,200	8,801,600	8,452,800	8,317,400	7,642,200	9,384,400	13,414,100
Mcf of fuel per kilowatt hour generated	Rank	7	8	1	5	3	9	6	2	10	4	11	12
	Quantity	.012323	.012321	.014491	.012881	.013654	.011970	.012330	.014092	.011683	.013149	.011507	.011110

Variable	Datum	Aug. 1970	July 1970	June 1971	Sept. 1970	May 1971	Oct. 1970	Dec. 1970	Jan. 1971	Feb. 1971	Mar. 1971	Nov. 1970	Apr. 1971
Total kilowatt hours of electric energy generated	Rank	1	2	3	4	5	6	7	8	9	10	11	12
Mcf of fuel per kilowatt hour generated	Rank	8	7	12	1	11	5	9	6	2	10	3	4

Rank of mcf of fuel per kilowatt hour generated	Numbers of ranks to the right which are larger	Numbers of ranks to the right which are smaller	Score
8	+4	-7	-3
7	+4	-6	-2
12	+0	-9	-9
1	+8	-0	+8
11	+0	-7	-7
5	+3	-3	0
9	+1	-4	-3
6	+1	-3	-2
2	+3	-0	+3
10	+0	-2	-2
3	+1	-0	+1

S = sum of scores = -16

$$\tau = \frac{S}{1/2\ N\ (N-1)} = .2424$$

$$z = \sqrt{\frac{\tau}{\frac{2(2N+5)}{9\ N\ (N-1)}}} = 4.9650$$

$P(z) = 1.0972$

Conclusion: H_o is significant at the .136 level.

Implication: There is a negative relationship between the intensity of use of the generating system and efficiency in use of fuel over the relevant range of capacity.

Source: Boomer Lake Station, Stillwater, Oklahoma, Operating records for fiscal year 1970-71.

generating system. However, peaking power is purchased. If the high income consuming units can be regarded as responsible for the high cost of generated energy at the peak, they can by the same reasoning be regarded as responsible for the necessity of purchasing more expensive energy. Whereas during fiscal year 1970-71 the Stillwater Municipal Utility paid an average price of $.018 per kilowatt hour for energy purchased, energy generated within the system was estimated to cost $.0115 units per kilowatt hour (Table II and Appendix J). To the extent that increasing income is associated with the variance between normal and peak demand the excess costs imposed for purchasing power can, like the higher costs imposed by operating the plant at an above-optimal level, be regarded as the responsibility of the higher income group.

C. The Price-Marginal Cost Issue

The question of costs imposed by higher income versus lower income housing units, as represented by median values for census tracts, has been examined. Another set of issues involves the relationship between the price at the margin and marginal cost. Three questions will be explored, (1) the relationship between marginal revenue, or marginal price, and marginal cost, (2) the extent to which the energy block of the rate schedule yields revenue over cost to subsidize either other costs of the electric energy supply function or of other municipal services, and (3) the degree to which energy is available to different income groups at the lowest marginal price, if not the marginal cost.

C.1 The Relationship Between Marginal Price and Marginal Cost

Energy costs correspond fairly closely to the marginal cost concept of price theory. The last block of the electric utility rate schedule is designed to cover the cost of producing energy after the customer and capital costs have been paid. In the lowest block of the rate schedule, energy is priced at $.0175 per kilowatt hour (Table XXIII). Marginal Cost for energy generated internally is $.0059 per kilowatt hour (Table II). The revenue over cost for the energy function of the utility amounts to $.0116 for internally generated energy. This indicates that the marginal price exceeds marginal cost of internally generated energy by 51 percent. The overall average cost for purchased energy is $.0179 per kilowatt hour (Table XL). Purchased energy is sold slightly below cost.

C.2 Allocation of Revenue Over Cost Derived from the Energy Function

One logical extension of the above findings might be the question of what becomes of the economic profits earned via the energy function. The profits might offset losses on pricing of the customer services and/or the capital investment or alternatively if those functions also yield revenues in excess of costs, the entire amount of the profit from the energy function would flow into subsidization of other functions of the municipal government.

Assessment of this question requires reference to findings on costs. During 1970-71 total costs per kilowatt hour were estimated to be $.0147. The utility marketed 106,563,000 kilowatt hours of energy and received total revenue on sales of $2,526,392 for an average of $.0237 revenue

per kilowatt hour.[13] This indicates a residual of \$.0090, a substantial contribution to B_2 or to Tx.

C.3 Availability of the Lowest Block Rate to Classes of Customers

A further point to consider is the availability of the lowest block rate to all consuming groups. Table XII indicates the months during which the median quantity of electric energy consumed in each tract exceeded 400 kilowatt hours, the point at which the lowest rate in the block structure begins. Every income group was able to purchase energy at the lowest rate during some month of the year; however for some tracts' medians that opportunity applied to very few months. As would be expected from the findings on the relationship between income and quantity of energy demanded, the higher income groups are more likely to be able to take advantage of the low rate block of the schedule than the low income groups.

C.4 Conclusions with Respect to Energy Costs

The data support the hypothesis that where energy cost differences occur, the higher income consumers tend to contribute more heavily to the costs, $p_e \cdot e$, of electric energy. Further, the low income consumers are not able to reach the lowest price segment of the graduated rate schedule as frequently. And finally, electric energy is not priced at its marginal cost to any group of consumers, although when purchased peaking power is required, all consumers acquire some energy at slightly less than marginal cost.

TABLE XII

MONTHS IN WHICH MEDIAN KILOWATT HOURS OF ELECTRIC ENERGY CONSUMED EXCEEDED 400 KILOWATT HOURS, FISCAL YEAR 1970-71

Tract	Kilowatt hours where zero values are included in the count to determine the median			Kilowatt hours where zero values are excluded from the count to determine the median			Kilowatt hours where average values are substituted for zero values in the count to determine the median		
	Months in which 400 or less kwh were consumed	Months in which over 400 kwh were consumed	Number of months in which over 400 kwh were consumed	Months in which 400 or less kwh were consumed	Months in which over 400 kwh were consumed	Number of months in which over 400 kwh were consumed	Months in which 400 or less kwh were consumed	Months in which over 400 kwh were consumed	Number of months in which over 400 kwh were consumed
1	July Aug. Sept.	Oct. Mar. Nov. Apr. Dec. May Jan. June Feb.	9	July Aug. Sept.	Oct. Mar. Nov. Apr. Dec. May Jan. June Feb.	9	July Aug. Sept.	Oct. Mar. Nov. Apr. Dec. May Jan. June Feb.	9
2	July Aug.	Sept. Feb. Oct. Mar. Nov. Apr. Dec. May Jan. June	10	July Aug.	Sept. Feb. Oct. Mar. Nov. Apr. Dec. May Jan. June	10	July Aug.	Sept. Feb. Oct. Mar. Nov. Apr. Dec. May Jan. June	10
4	July Dec. Aug. Jan. Sept. Feb. Oct. Mar. Nov.	Apr. May June	3	July Dec. Aug. Jan. Sept. Feb. Oct. Mar. Nov.	Apr. May June	3	July Dec. Aug. Jan. Sept. Feb. Oct. Mar. Nov.	Apr. May June	3
5	July Dec. Aug. Jan. Sept. Feb. Oct. Nov.	Mar. Apr. May June	4	July Dec. Aug. Jan. Sept. Feb. Oct. Nov.	Mar. Apr. May June	4	July Dec. Aug. Jan. Sept. Feb. Oct. Nov.	Mar. Apr. May June	4
6	July Nov. Aug. Dec. Sept. Jan. Oct.	Feb. May Mar. June Apr.	5	July Nov. Aug. Dec. Sept. Jan. Oct.	Feb. May Mar. June Apr.	5	July Nov. Aug. Dec. Sept. Jan. Oct.	Feb. May Mar. June Apr.	5
8	July Jan. Aug. Feb. Sept. Mar. Oct. Apr. Nov. May Dec.	June	1	July Jan. Aug. Feb. Sept. Mar. Oct. Apr. Nov. Dec.	May June	2	July Jan. Aug. Feb. Sept. Mar. Oct. Apr. Nov. Dec.	May June	2
9	July	Aug. Feb. Sept. Mar. Oct. Apr. Nov. May Dec. June Jan.	11	July	Aug. Feb. Sept. Mar. Oct. Apr. Nov. May Dec. June Jan.	11	July	Aug. Feb. Sept. Mar. Oct. Apr. Nov. May Dec. June Jan.	11

Source: Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71.

D. Summary and Conclusions Regarding the Distribution of Revenue over Cost Among Income Groups

The data on energy consumption, the median annual electric bill, B_2, and cost of service, $p_e \cdot e$, by tract indicate that on balance lower costs are associated with the lower and more stable levels of consumption of the lower income consumers, and costs of service increase more rapidly than contributions to revenue as consumption increases. Definite support for such a conclusion was found with respect to demand costs and energy costs. Most surrogates tested supported such a conclusion for accounting, billing, and collection costs.

This finding implies that there is a negative relationship between the electric bill, B_2, and the cost of electric energy, $p_e \cdot e$. Then for increases in the bill, B_2, the residual, Tx, which is the portion of the tax subsidizing other municipal services, grows smaller. This result raises the question examined in Chapter VI, i.e., how the benefits of Tx accrue to the various income groups.

FOOTNOTES

[1]Paul A. Garfield and Wallace F. Lovejoy, Public Utility Economics, Englewood Cliffs, N.J.: Prentice-Hall, Inc., (1964), p. 158.

[2]Garfield and Lovejoy, pp. 155-158.

[3]The following studies found empirical evidence supporting the normal good status of electric energy. Larkin B. Warner, Estimates of Electricity Sales, by Utilities, by County and Class of Service, Oklahoma, 1950, and 1960, Bulletin 4, Durant, Oklahoma: Technology Use Studies Center, Southwestern State College (July, 1966); Franklin M. Fisher and Carl Kaysen, A Study in Econometrics: The Demand for Electricity in the United States, Amsterdam: North-Holland Publishing Company (1962), pp. 73-119; Kent P. Anderson, Residential Demand for Electricity: Econometric Estimates for California and the United States R-905-NSF, Santa Monica, California: Rand Corporation (January, 1972) pp. 12-28, Duane Chapman, Timothy Tyrrell, and Timothy Mount, "Electricity Demand Growth and the Energy Crisis," Science 182 (No. 4062, November 17, 1972) pp. 703-708; P. W. MacAvoy, Economic Strategy for Developing Nuclear Breeder Reactors, Cambridge, Massachusetts: MIT Press (1969); Robert Francis Halvorsen, "Residential Demand for Electricity" (unpublished Ph.D. dissertation, Harvard University, December, 1972). Wilson found a negative relationship between income and the quantity of electric energy consumed; however, that finding may have been the result of using cross section data from only low income geographic areas; John William Wilson, "Residential and Industrial Demand for Electricity: An Empirical Analysis" (unpublished doctoral dissertation, Cornell University, 1969).

[4]"The load factor shows the average use of facilities as a percentage of the maximum use. It is defined as the ratio of the average load over a designated period of time to the peak load occurring in that period...The load factor shows how steadily the maximum power requirement has been employed..." Garfield and Lovejoy, p. 153.

[5]Peak demand is the highest quantity of energy demanded per unit of time over some time period, e.g., day, month, year. In this study peak demand refers to the highest monthly quantity of energy demanded over a period of one month during fiscal year 1970-71. Garfield and Lovejoy, p. 20.

[6]Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences, New York: McGraw Hill Book Company, Inc., (1956), pp. 202-213.

[7]Siegel, pp. 213-229.

[8]Siegel, pp. 229-238.

[9]Frederick Mosteller, "A k-Sample Slippage Test for an Extreme Population," Annals of Mathematical Statistics, 19 (1948), pp. 58-66, and Frederick Mosteller and John W. Tukey, "Significance Levels for a k-Sample Slippage Test," Annals of Mathematical Statistics, 21 (1950), pp. 120-123.

[10]R. A. Jonckheere, "A Distribution-Free k-Sample Test Against Ordered Alternatives," Biometrika, 41 (June 1954), pp. 133-145.

[11]Federal Power Commission, Electric Power Statistics, FPC S-17, Washington, D.C.: United States Government Printing Office (July 1967 through June 1974), data series: sales of electric energy to ultimate consumers.

[12]Letter from Norton Savage, Federal Power Commission, Washington, D.C., dated January 1, 1977; W. H. Severns and H. E. Degler, Steam, Air, and Gas Power, (3rd edition) New York: John H. Wiley and Sons (1939), p. 323; and G. A. Gaffert, Steam Power Stations (2nd edition) New York: McGraw-Hill Book Company, Inc. (1940), p. 479.

[13]Federal Power Commission, Statistics of Publicly Owned Electric Utilities in the United States, 1971, FPC S-228, Washington, D.C.: United States Government Printing Office (December 1972), Table 48, Line 67.

CHAPTER VI

THE QUESTION OF EQUITY IN TAXATION: BENEFITS RECEIVED

A. The Benefits Received Criterion

A.1 Introduction

The second concept of tax equity to be examined is measured by the "benefits received" criterion. In this chapter the tax neutrality issue cited in Chapter IV becomes a highly important question, for under the benefits criterion of equity a regressive tax may be called for if the benefits from expenditures of the tax revenue accrue most heavily to persons in the lower income brackets.

In this chapter application of the limited existing data on use of municipal services is made in an exploratory effort to shed light on the functioning of the revenue gathering system as it relates to the benefits received criterion of equity. Since there is no comprehensive data set for assessing the benefits from city services and the gathering of such a collection of data is beyond the scope and purpose of this paper, no conclusions are drawn regarding the overall extent to which the benefits received criterion has been served. A further limitation of the findings which should be kept in mind is the fact that they apply to the period around 1970. A different distribution of benefits may have been produced

by urban renewal and community development programs which have been completed or become operative since that date.

A.2 The Benefits Received Concept

The hallmark of the benefits criterion of equity is a *quid pro quo* relationship between the publicly supplied commodity and the tax paid. This essentially boils down to the operational proposition that those who benefit are the ones who should pay for a publicly supplied commodity.

A.3 Conceptual Framework

For purposes of this study the benefits criterion will be regarded as having been fulfilled if there is a positive relationship between the tax contribution and the rate of benefit derived from the commodities provided. It is assumed that the benefits received criterion is met with respect to electric service per se. The issue is the degree to which the criterion is met with respect to the excess of revenue over electricity costs created through the billing system.

In Chapter V the relationship of costs imposed for electricity, defined as $p_e \cdot e$, and revenues yielded by income groups, defined as B_2, were studied in an effort to determine the sources of the residual revenue defined as Tx.

It was found that while B_2 tends to be positively related to the costs of supplying electric service, $p_e \cdot e$, the cost tends to be more responsive to increases in demand for energy than B_2 indicating that there is a negative relationship between B_2 and Tx, the residual which subsidizes the other publicly supplied commodities. One conclusion to

be drawn then is that Tx is larger for low income groups than for higher income groups. The question to be examined then is whether the low income groups who are taxed at a higher rate accrue benefits from the tax at a higher rate.

A.3.1 Limitations of This Study

In this study the contributions to the residual by income groups, regarded as their tax share in financing other municipal services, is compared with the costs and benefits of those other services as they accrue to the various income groups. Since the revenue from the electric utility is not the only source of revenue and since there is no earmarking of funds, it must be recognized that the residual electric service revenues do not fully support the other services but rather support a portion of all other services. Therefore, the findings with respect to the utility's share of the tax will not be expected to reveal a true market type equilibrium wherein marginal benefits equal marginal cost, but will reveal whether some positive relationship exists between contribution to the finance of the activities of the municipal government and enjoyment of the resulting benefits. This is accomplished by ranking census tracts.

It should be noted further that the availability of data limited the study of benefits to the following municipally supplied commodities besides electric service: fire protection, police protection, use of park and recreation facilities, and the existence and condition of improved streets. While examination of the city budget (Table IV) indicates that this collection of services covers a large portion of city expenditures and a strong correlation would be expected between the

services assessed directly and those which have not come into the analysis undertaken here, the shortage of data precludes making any overall assessment of equity.

B. The Benefits

Total benefit is assumed to be a function of use, and level of usage is the only assessment of level of benefits made, i.e., ranking of benefits received by tracts is on the basis of the level of usage per unit of time.

B.1 Benefits from Electric Service

In Chapter V a strong negative relationship was found between the median annual bill for electric energy, B_1, and the cost of supplying the energy, $p_e \cdot e$. Since the cost of energy services is a direct result of demand for such services, a positive relationship between cost and benefit exists by definition, and the relationship between cost and benefit may be taken for granted. Consequently, no violation of the benefits criterion is detected. It is with regard to the other city services that the question of equity arises.

B.2 Benefits from Park Use

The Kendall rank correlation test was applied to park use per housing unit and the annual electric bill, B_2. The correlation coefficient $\tau = -.2381$ was significant at the .281 level. The implication is that as the electric bill increases, or Tx decreases, the use of city parks decreases (Table XIII and Appendix K). While Crum found that small local park and recreation facilities are fairly evenly distributed over the

TABLE XIII

ACCRUAL OF BENEFITS FROM MUNICIPAL SERVICES (ZERO VALUES INCLUDED)

	Independent Variables				Tract Characteristics							
	Median annual income of families & unrelated individuals		Median annual[1] electric bill				Fire service calls				Feet of streets	
Tract	Income	Rank	Bill	Rank	Total[2] housing units	Total use of parks	Residential	Site	Total	Total crimes reported	Total linear feet	Linear feet in good condition
1	$9,591	1	$215.19	3	1110	57	23	44	65	72	121,985	77,585
2	4,918	4	227.98	2	1440	32	32	37	69	158	146,250	72,600
4	2,862	6	149.54	5	620	16	35	8	43	114	39,990	15,380
5	1,237	7	103.67	7	910	8	20	10	30	141	32,090	16,560
6	7,385	2	204.78	4	1390	17	56	22	78	153	115,020	82,630
8	4,474	5	129.38	6	880	52	56	55	111	160	79,990	13,155
9	7,087	3	255.62	1	130	0	2	5	7	8	16,480	9,520

Kendall rank correlation test for the relationship between median annual electric bill and benefits from municipal services	S
	p(S)
	τ

$$\varepsilon = \frac{\dfrac{\delta(p_e \cdot e)}{p_e \cdot e}}{\dfrac{\delta B_2}{B_2}}$$

[1]Zero values in inactive Rate Class IV accounts included in the count to determine the median.

[2]Total housing units is based on an adjustment of group quarters reported in the census to housing units by using an index of household size for that tract.

TABLE XIII, Continued

Dependent Variables															
Park use		Fire service calls						Crimes reported		Feet of streets					
		Residential		Site		Total				Total		In good condition			
Mean number of park uses per housing unit	Rank	Calls per housing unit	Rank	Calls per housing unit	Rank	Calls per housing unit	Rank	Crimes per housing unit	Rank	Linear feet per housing unit	Rank	Linear feet per housing unit	Rank	Percent of all streets	Rank
.057	2	.0189	6	.0396	3	.0585	4	.0649	7	109.9	2	69.9	2	63.6	2
.022	4	.0636	1.5	.0256	4	.2479	6	.1097	5	101.6	3	50.4	4	49.6	5
.026	3	.0564	3	.0129	6	.0693	2	.1838	1	64.5	6	24.8	5	38.5	6
.009	6	.0219	5	.0109	7	.0329	7	.1550	3	35.3	7	18.2	6	51.1	4
.013	5	.0402	4	.0158	5	.0561	5	.1101	4	82.6	5	59.4	3	71.8	1
.059	1	.0636	1.5	.0636	1	.1261	1	.1818	2	90.9	4	14.9	7	16.8	7
0	7	.0181	7	.0454	2	.0636	3	.0727	6	126.8	1	73.2	1	57.8	3
-5		-4		+11		-1		+3		+15		+15		+5	
.281		.281-.386[3]		.068		.500		.386		.015		.015		.281	
-.2381		-.1905		+.5238		-.0476		.1429		.7143		.7143		.2381	
0		.52		2.69		.89		.96		2.24		2.57		.10	

[3]When tied ranks yield S values not reported in the table, the probability for the values above and below the calculated value are reported.

Source: United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P-4; United States Department of Commerce, Bureau of the Census, 1970 Census data tapes, Oklahoma State University Computer Center; City of Stillwater, Oklahoma, Neighborhood Analysis for the City of Stillwater, Oklahoma, James M. Mayo, editor, Stillwater, Oklahoma: City of Stillwater, Oklahoma, September 1971, pp. I-1 through I-9; Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71; Boomer Lake Generating Station, Stillwater, Oklahoma, Production records for fiscal year 1970-71; Anna Coe Crum, "Urban Park Planning: A Case Study of Stillwater, Oklahoma," unpublished M.S. thesis, Oklahoma State University, May 1973.

city,[1] the findings show the greatest park use occurring for Tracts 1 and 8 in which Boomer Lake and Couch Park, the city's two largest major recreational facilities, are located. Tract 1 is a high income tract; Tract 8 is a low income tract.

Examination of Table XIV indicates a considerable amount of shifting among the ranks which accounts for the low correlation coefficient. However, some interesting patterns exist. Tract 8, which has the second lowest bill, B_2, indicating a relatively high Tx contribution and also has a major recreation facility within the tract, exhibited the highest use and therefore the greatest benefit. Tract 9, which has the lowest median annual electric bill, B_2, and therefore makes the lowest Tx contribution, is the most remotely situated relative to city recreation facilities; Tract 9's park use was the lowest. Both these results indicate a positive correlation between Tx and benefits.

TABLE XIV

COMPARISON OF PRICE AND PARK USE

Rank	1	2	3	4	5	6	7
Tracts ranked by price	8	4	5	6	2	1	9
Tracts ranked by park use	8	1	4	2	6	5	9

Examination of the rankings of the other tracts reveals four tracts for which the ranking by the bill, B_2, is higher than the ranking by use and three tracts for which ranking by bill, B_2, exceeds rankings by use. This too indicates a mildly negative relationship overall although there is much shifting within. Consequently, the status of this item which represents around 5 percent of the city budget seems inconclusive with respect to the benefits criterion of equity.

B.3 Benefits from Fire Protection Service

The Kendall rank correlation coefficient for total fire service calls and the median annual electric bill is -.0476 and is significant at the .500 level. Breaking the fire service calls into two classes, residential fires and site fires or those in open area, produced additional results (Table XIII). A positive relationship with $\tau = -.1905$ with a probability of the null hypothesis between .281-.386 is found for residential fires. This reflects the congestion and housing conditions of the low income residents who pay the higher electric bill, B_2, and higher Tx. The positive correlation coefficient $\tau = .5238$ for site calls reflects the dispersion of residences and greater open space of the higher income tracts where a lower Tx is paid.

B.4 Benefits from Police Protection Service

The data indicate a very strong positive correlation between crimes reported per housing unit and the contributions to Tx. The Kendall rank correlation coefficient, $\tau = .1429$, is significant at the .386 level. This finding indicates a weak negative relationship between Tx and benefits received from municipal services.

B.5 Benefits from Improved Streets

Building and maintenance of city streets is financed in part from special budgetary funds and in part through property owner assessment. However, if those special budgetary funds are regarded as part of the overall tax burden, then channeling of those funds into streets and roads represents an opportunity cost in terms of other tax-supported goods or services. To the extent that they are tax supported, it then becomes possible to treat streets and roads within the context of the tax under study.

The data indicate a Kendall correlation coefficient of .7143 significant at the .015 level for linear feet of streets per housing unit and annual electric bill, B_2. This largely reflects the degree of dispersion of residences among tracts (Table XIII). Another approach involves comparison of quality of the streets. The data indicate that not only are the high income tracts likely to enjoy a higher rate of benefits due to having more streets per housing unit, but also that more of their streets are in good condition as defined by Mayo in the neighborhood analysis of Stillwater. A Kendall rank correlation coefficient of $\tau = .7143$ is found for linear feet of good streets. For percentage of good streets in the tract, $\tau = .2381$. The value is significant at the .281 level.

C. Conclusion

Since $p_e \cdot e$ represents payments covering the costs of electric service, it has been defined as increasing with use. Consequently $p_e \cdot e$ is by definition positively related to benefits and in compliance with the benefits received criterion of equity. No strong general support was found for the existence of a positive relationship between the tax,

Tx, and the consumption of benefits from the commodities studied. Evidence of both slight positive and negative correlation and cases of doubtful correlation were found with regard to Tx and the commodities it subsidized. A consistent and strong negative correlation between Tx and benefits could be taken as proof of violation of the benefits principle of equity with respect to the collection of services evaluated. A consistent strong positive correlation would suggest but not conclusively confirm the existence of equity with respect to the collection of services evaluated. The inconclusive results obtained indicate that the matter is questionable even where the services evaluated are concerned. Given the limited number of services for which data existed, no conclusion can be drawn regarding the equity of the arrangement in general.

FOOTNOTES

[1]Anna Coe Crum, "Urban Park Planning: A Case Study of Stillwater, Oklahoma." (unpublished M.S. thesis, Oklahoma State University, 1973).

CHAPTER VII

SUMMARY AND CONCLUSIONS

The city of Stillwater, Oklahoma, was used as a study case for undertaking economic analysis with respect to the technical, allocative, and equity effects of certain institutional arrangements which encourage operation of municipally owned electric generating facilities. The institutional arrangements include a tax-interest subsidy to municipal generating systems and a history of stringent statutory constraints on the tax gathering powers of municipal governments.

A. Findings Regarding Technical and Allocative Effects

Existing data on scale economies available in the electric utility industry indicate significant disadvantages in terms of technical efficiency for small municipal generating systems. Comparison of total costs per kilowatt hour for the Stillwater municipal generating system and that of Oklahoma Gas and Electric Company with which Stillwater maintains an interconnection confirm the scale disadvantages of the smaller system.

When accounting data and Federal Power Commission data are used to reconstruct the costs of the two utilities with Stillwater's costs adjusted to remove the effects of the subsidy, total costs of generation per kilowatt hour for the Stillwater system are estimated to be 149 percent of the costs for the OG&E system. Total delivered costs per

kilowatt hour for the Stillwater system are 124 percent of costs for the OG&E system.

These findings support the hypothesis that the current institutional arrangements which create the subsidies contribute to a technically inefficient allocation of factors both into and within the electric utility industry. The current arrangement is not the least-cost technique for supplying the electric energy needs of the community; one consequence of the arrangement is a welfare loss to the society.

B. Findings Regarding Allocative and Distributive Effects

Distributive effects were assessed in terms of tax equity. The equitableness of the typical practice of using monopoly profits from the electric utility as a major source of revenue in lieu of the more conventional forms of taxation to support municipal government was examined from the standpoint of both the ability to pay and the benefits criteria of tax equity. Nonparametric statistical methods and measures of elasticity were used to study the distribution of the tax and benefits.

B.1 Findings Regarding the Ability to Pay Criterion of Equity

For purposes of this study a minimal definition of the ability to pay criterion was used, i.e., the rate should not be regressive with respect to income. Comparison of median annual income of families and unrelated individuals for seven census tracts with the median annual price paid per kilowatt hour of electric energy indicated that the electricity bill is regressive with respect to income. Comparison of income

with median annual expenditures for electric energy as a share of income indicated that the charges are regressive with respect to income. Such a distribution of the burden is in violation of the ability to pay principle.

B.2 Findings Regarding the Benefits Criterion of Equity

The equity of the tax in terms of the benefits criterion was assessed through comparison of the contributions to costs of electric service and receipt of benefits from the subsidized municipally provided commodities. Equity was defined as a positive relationship between contributions of revenue to the tax residual from the electric bill and benefits from subsidized municipal services.

The electric bill, B_2, was defined as the sum of a user charge, $p_e \cdot e$, equal to the cost of electric service and a residual, Tx, treated as a tax flowing into the general fund. Since it was expected that B_2 and $p_e \cdot e$ are both positively related to income and the quantity of energy demanded, a comparison of the relative responsiveness of B_2 and $p_e \cdot e$ was made for each cost surrogate tested to determine whether the change in B_2 was equal to, greater than, or less than the change in $p_e \cdot e$; with the relationship between B_2 and $p_e \cdot e$ known, the relationship between B_2 and Tx is determined. When the relationship between B_2 and benefits can be ascertained, the relationship between contributions toward the cost of supplying the service and benefits received from the service is indicated.

B.2.1 Costs

A variety of proxies for meter reading costs and meter disconnection notices were compared to the median annual bill paid for electric energy. A positive and significant relationship was found between the median annual bill for electric energy and the more desirable measures of meter reading costs. The elasticity measure indicated that costs were more sensitive to changes in quantity purchased than the bill was; Tx and B_2 are inversely related. A negative and significant relationship was found between the bill and billing, accounting, and collecting costs measured by electric utility disconnection notices per meter per year. The negative relationship found for houses per meter indicated a positive relationship between Tx and benefits.

Demand costs were assessed in terms of the consistency of the level of contribution to demand on a month-to-month basis and of contribution to peak demand, range of demand, and load factor. Positive and significant relationships were found between the electric bill and consistency of level of month-to-month contributions to demand, contributions to peak demand, and range of demand. Since these variables are assumed to be positively related to costs, the relationship between the rank of the median electric bill and costs is positive. Measures of elasticity indicate that costs increase more rapidly than the electric bill or that the relationship between contributions to costs and the tax residual are inversely related. A negative but not significant relationship was found between price and load factor.

Energy costs were assessed in terms of contributions to peak demand and behavior of energy costs at the peak. Analysis of demand costs revealed a negative relationship between price and contributions to peak

demand. Examination of costs of energy indicate energy used at the peak is more costly whether self-generated by the system or purchased. A negative relationship is then indicated between price and energy costs.

In general, the demand for energy, annual electric bill, and cost of service by tract indicate that higher prices are associated with lower costs. Support for such a conclusion was found with respect to demand costs, energy costs, and meter reading costs. No particular pattern was discernible for accounting, billing, and collecting costs which account for around 6 percent of utility costs. The indication is that a negative relationship is likely to exist between the electric bill and contributions to the revenue for providing the services subsidized by operation of the electric utility.

B.2.2 Benefits

Accrual of benefits was examined on the basis of consumption of selected goods and services supplied by the municipal government for which data were readily available. Benefit was assumed to be proportional to the level of use.

A negative relationship significant at the .281 level was found between park use and the electric bill. A negative relationship significant at the .281 level was found for residential fire service calls. A positive relationship significant at the .068 level was found for fire service calls to nonresidential sites. A negative but not significant relationship was found for fire service calls in general. A positive relationship significant at the .386 level was found between the electric bill and use of police services. The relationship between the electric bill and both the quantity of improved streets per housing unit and the

quantity of good streets per housing unit were found to be positive and significant at the .015 level. The percent of good streets was found to be significant at the .281 level.

B.2.3 Inconclusive Results Regarding the Benefits Criterion

In general the data do not indicate compliance with the benefits criterion of equity by the monopoly price-tax scheme in the case under study. For individual items there are cases where the criterion as defined in this study is served and cases where it is violated.

B.3 The Price-Marginal Cost Relationship

In the lowest block of the utility rate schedule, marginal price exceeds marginal cost by $.0116 although the marginal cost of purchased power exceeds the marginal price by $.0004. The average revenue over cost per kilowatt hour of $.0090 indicates that even higher revenues over cost are obtained from the other two blocks of the rate schedule; consequently it may be assumed that the monopoly profits over the lowest price range are all contributions to the tax, i.e., there is no internal subsidization of one type of service of the utility by another. While every income group was capable of reaching the lowest block of the rate structure during some months of the year under study, those paying the higher price were able to consume in that range less frequently.

C. Conclusions

From the standpoint of economic efficiency, the municipal electric utility under study does not measure up very well in terms of either its

function as (1) a supply of electric energy or (2) a source of municipal revenue. However, within the context of the existing institutional setting which subsidizes municipal utilities and restricts use of alternative revenue sources, the practice is the optimal choice for the municipality and may be expected to continue as long as these incentives remain intact. In a democratic setting the question of whether a change should be made can be ascertained only through the voting process; it seems sufficient to note that the scope of political values encompasses and extends beyond matters of economic efficiency.

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APPENDIX A

DETERMINATION OF THE INTEREST RATE

TABLE XV

SCHEDULE OF BONDED DEBT, STILLWATER MUNICIPAL UTILITY, JUNE 30, 1970

Bond issue	Bond	Rating	Amount	Date of Maturity
Electric Light & Power Plant Improvement & Extension, Serial A	2 1/8 '54 11/15/70 M&N 15	A	$ 35,000	11/15/74
	2 1/4 '54 Ser. 11/15/71-74 M&N 15	A	260,000	
Electric Light & Power Plant Improvement & Extension, 1954, Serial B	2 1/2 '55 Ser. to 11/1/70 M&N 1	A	60,000	11/1/75
	2 5/8 '55 Ser. 11/1/71-75 M&N 1	A	140,000	
Electric Light & Power Plant Improvement & Extension, and Repair Bonds, 1958	3 1/2 '58 Ser. to 11/1/75 M&N 1	A	890,000	11/1/75
Electric Distribution, 1964	2 3/8 '64 Ser. to 8/1/78 F&A 1	A	358,000	8/1/78
	2.65			
	2.70			
	2.80			
	2.85			
	2.90			
	2.95			
	3.			
General Obligation Bond, 1966, Series A	4 '66 Ser. to 7/1/71 J&J 1	A	190,000	7/1/81
	3 3/4 '66 7/1/72 J&J 1	A	95,000	
	3 1/2 '66 1/73-76 J&J 1	A	380,000	
	3.55 '66 1/77-80 J&J 1	A	380,000	
	3.60 '66 7/1/81 J&J 1	A	95,000	
General Obligation Bond, 1967, Series B	4 '67 Ser. to 9/1/71 M&S 1	A	140,000	9/1/82
	3.35 '67 9/1/72 M&S 1	A	70,000	
	3.40 '67 9/1/73 M&S 1	A	70,000	
	3.45 '67 9/1/74 M&S 1	A	70,000	
	3 1/2 '67 Ser. to 1/75-76 M&S 1	A	140,000	
	3.55 '67 9/1/77 M&S 1	A	70,000	
	3.60 '67 Ser. to 1/78-79 M&S 1	A	140,000	
	3.65 '67 Ser. to 1/80-81 M&S 1	A	140,000	
	3.70 '67 9/1/82 M&S 1	A	70,000	
General Obligation Bond 1970, Series A	5 1/8 '70 Ser. 5/1/72-74	A	300,000	5/1/76
General Obligation Bond	4.95 '70 Ser. 5/1/75-76	A	200,000	12/1/81

Source: City Treasurer's Office, City of Stillwater, Oklahoma, Bond records, and Moody's Investors Services, Moody's Municipal and Government Manual, New York: Moody's Investors Service, 1971, p. 3622.

TABLE XVI

COST OF CAPITAL BY INDIVIDUAL BOND ISSUE, STILLWATER MUNICIPAL ELECTRIC UTILITY, 1970-71

Bond issue	C_t [a] Interest coupons received in period t t = 1970-71	Market price range per bibd ub period t t = 1970-71 [m]	P_t [j] Average market price per bond in period t t = 1970-71	Market price range per bond in period t-1 t-1 = 1969-70 [m]	P_{t-1} [j] Average market price per bond in period t-1 t-1 = 1969-70	$i_t = \frac{C_t+P_t}{P_{t-1}} - 1$ [k] Rate of return in period t t = 1970-71
Debt Capital:						
Electric Series A, 1954	$ 11.25 [b]	m	$ 980.00 [m]	m	$ 925.00 [m]	.071622
Electric Series B, 1954	26.25 [c]	m	980.00 [m]	m	925.00 [m]	.087838
Electric, 1958	35.00 [d]	m	980.00 [m]	m	925.00 [m]	.097297
Electric, 1964	140.00 [e]	m	4900.00 [m]	m	4625.00 [m]	.089730
General Obligation Series A, 1966	200.00 [f]	m	4900.00 [m]	m	4625.00 [m]	.102703
General Obligation Series B, 1967	200.00 [g]	m	4900.00 [m]	m	4625.00 [m]	.102703
General Obligation Series A, 1970	256.25 [h]	m	4900.00 [m]	m	4625.00 [m]	.114865
General Obligation Series B, 1970	112.50 [i]	m	4900.00 [m]	m	4625.00 [m]	.083783

[a]Data is from the bond records on file in the City Treasurer's Office, Stillwater, Oklahoma.

[b]Coupon amount: $11.25, paid May 15 and November 15.

[c]Coupon amount: $13.12 + 13.13, paid May 10 and November 10.

[d]Coupon amount: $17.50, paid May 1 and November 1.

[e]Coupon amount: $70.00, paid February 1 and August 1.

[f]Coupon amount: $100.00, paid January 1 and July 1.

[g]Coupon amount: $100.00, paid March 1 and September 1.

[h]Coupon amount: $128.13, paid November 1.

[i]Coupon amount: $112.50, first coupon paid June 1, 1971.

[j]Data on bond prices supplied by Municipal Securities Department of Drexel, Burnham, and Company.

[k]The single period investments formula for both the internal rate of return and the geometric mean rate of return are identical and equal to the formula used in calculating the rate of return in the table above; the same formula is applicable in assessing the rate of return of common stocks, preferred stock, and bonds. See Heim Levy and Marshall Sarnat, Investment and Portfolio Analysis, New York: John Wiley and Sons, Inc., 1972, pp. 80-81, 99-100.

[m]Sales of Stillwater Municipal Bonds in 1970 and 1971 occurred only for General Obligation Bond Series B, 1967 which sold for 92½ and General Obligation Bond Series B, 1970, which sold for 98.

TABLE XVII

WEIGHTED AVERAGE COST OF CAPITAL TO STILLWATER MUNICIPAL ELECTRIC UTILITY, 1970-71

Bond issue		Number of bonds[a] outstanding 1970-71	Average[b] price per bond 1970-71	Total value[c] of this issue 1970-71	Percent[d] of this issue applicable to electric utility	Dollar amount of this issue applicable to electric utility	Amount of[e] this issue as a percent of overall capital amount	i = [f] Rate of interest of this issue	Contribution[g] of this issue to the weighted average cost of capital 1970-71
Electric Series A	1954	260 @ $1000 ea.	.98 x $1000	$ 254,800.00	100	$ 254,800.00	.024131	.071622	.0017288
Electric Series B	1954	140 @ $1000 ea.	.98 x $1000	137,200.00	100	137,200.00	.0129978	.087838	.0011417
Electric	1958	750 @ $1000 ea.	.98 x $1000	735,000.00	100	735,000.00	.060631	.097297	.0006748
Electric	1964	545 @ $5000 ea.	.98 x $5000	2,670,500.00	100	2,670,500.00	.252994	.089730	.0022715
General Obligation Series A	1966	1045 @ $5000 ea.	.98 x $5000	5,102,500.00	38	1,938,950.00	.183689	.102703	.0188654
General Obligation Series B	1967	850 @ $5000 ea.	.98 x $5000	4,116,000.00	40	1,646,400.00	.1559740	.102703	.0160188
General Obligation Series A	1970	500 @ $5000 ea.	.98 x $5000	2,450,000.00	65	1,592,500.00	.1508678	.114865	.0173294
General Obligation Series B	1970	750 @ $5000 ea.	.98 x $5000	3,675,000.00	43	1,580,250.00	.149707	.083783	.0125490

Overall value of capital applicable to electric utility = $\sum\left(\text{amount of this issue as a percent of overall capital amount}\right)$ = 10,555,600.00

Weighted average cost of capital to the electric utility = $\sum\left(\text{(amount of this issue as a percent of overall capital amount) x (rate of return of this issue)}\right)$ = .0971

[a] Data are from the bond records on file in the City Clerk's Office, Stillwater, Oklahoma.

[b] Sales of Stillwater Municipal Bonds in 1970-71 occurred only for General Obligation Bond, Series B, 1967, which sold for 97½ and General Obligation Bond, Series B, 1970, which sold for 98.

[c] Total value of this issue, 1970-71 = (Number of bonds outstanding, 1970-71) x (Average price per bond, 1970-71).

[d] When proceeds of bond issues are to be used for more than one purpose, the amount to be distributed to each use is predetermined and designated. The record of distribution is included in the bond records in the City Treasurer's Office, Stillwater, Oklahoma.

[e] Amount of this issue as a percent of overall capital amount = (Amount of this issue applicable to electric utility) x (Overall value of capital applicable to electric utility).

[f] See Table XIV for computation of "i", the rate of return on this issue, 1970-71.

[g] Contribution of this issue to the weighted average cost of capital, 1970-71 = (Amount of this issue as a percent of overall capital amount) x (i, the rate of return of this issue, 1970-71).

TABLE XVIII

SCHEDULE OF BONDED DEBT, OKLAHOMA GAS AND ELECTRIC COMPANY, 1970

Dated	Issue	Rating	Amount outstanding
Feb. 1, 1945	First 2¾, Feb. 1, 1975, F&A1	Aa	$ 35,000,000
June 1, 1949	First 3, June 1, 1979, J&D1	Aa	10,000,000
May 1, 1950	First 2⅞, May 1, 1980, M&N1	Aa	17,500,000
Mar. 1, 1952	First 3⅜, Mar. 1, 1982, M&S1	Aa	12,000,000
June 1, 1955	First 3¼, June 1, 1985, J&D1	Aa	15,000,000
Jan. 1, 1957	First 4½, Jan. 1, 1987, J&J1	Aa	20,000,000
June 1, 1958	First 3⅞, June 1, 1988, J&D1	Aa	15,000,000
Mar. 1, 1963	First 4¼, Mar. 1, 1993, M&S1	Aa	15,000,000
Mar. 1, 1965	First 4½, Mar. 1, 1995, M&S1	Aa	25,000,000
Jan. 1, 1967	First 5⅛, Jan. 1, 1997, J&J1	Aa	15,000,000
Jan. 1, 1968	First 6⅜, Jan. 1, 1998, J&J1	Aa	25,000,000
Jan. 1, 1969	First 7⅛, Jan. 1, 1999, J&J1	Aa	12,500,000
Jan. 1, 1970	First 8⅝, Jan. 1, 2000, J&J1	Aa	30,000,000

Source: Moody's Investors Service, Moody's Public Utility Manual, New York: Moody's Investor's Service, 1971, pp. xxx, 601, 606-608.

TABLE XIX

COST OF CAPITAL BY INDIVIDUAL BOND ISSUE, OKLAHOMA GAS AND ELECTRIC COMPANY, 1970

Issue	D_t [a] Cash dividend or interest coupon received in period t t = 1970	Market price[a] range per share in period t t = 1970	P_t [b] Average market price per share in period t t = 1970	Market price [a] range per share in period t-1 t-1 = 1969	P_{t-1} [b] Average market price per share in period t-1 t-1 = 1969	i_t = rate of return [c] in period t $= \frac{D_t+P_t}{P_{t-1}} - 1$ t = 1970
Equity capital						
Common	$ 1.72	$ 28¼-18	$ 23.13	$ 25⅝-19⅛	$ 21.38	.1646
Pfd. 4% Cum.	0.80	12½-11	11.75	13⅝-11⅛	12.38	.0444
Pfd. 4.2% Cum. Series	4.20	d	48.06[d]	d	53.36[d]	-.0206
Pfd. 4.24% Cum. Series	4.24	58½-51½	55.00	68-55½	61.75	-.0406
Pfd. 4.44% Cum. Series	4.44	d	57.12[d]	d	63.85[d]	-.0318
Pfd. 4.80% Cum. Series	4.80	d	60.99[d]	d	67.71[d]	-.0284
Pfd. 5.34% Cum. Series	5.34	71½-62	66.75	e	73.43[e]	-.0183
Debt capital						
1st mtge. 2¾, 1945	$27.50	$ 85⅛-75	$800.60	$ 79¼-75	$771.30	.0736
1st mtge. 3, 1949	30.00	f	729.90[f]	f	739.90[f]	.0270
1st mtge. 2⅞, 1950	28.75	f	763.70[f]	f	754.90[f]	.0497
1st mtge. 3⅜, 1952	33.75	64-64	640.00	70-70	700.00	-.0375
1st mtge. 3¼, 1955	32.50	f	641.80[f]	62-62	620.00	.0876
1st mtge. 4½, 1957	45.00	72⅜-60	661.90	77-62	695.00	.0171
1st mtge. 3⅞, 1958	38.75	f	627.50[f]	63-63	630.00	.0575
1st mtge. 4¼, 1963	42.50	61-57	590.00	70-63½	662.50	-.0453
1st mtge. 4½, 1965	42.50	66-66	660.00	72-65¾	686.30	.0236
1st mtge. 5⅛, 1967	51.25	74⅜-60	671.90	77-65	710.00	.0185
1st mtge. 6⅜, 1968	63.75	86½-76	812.50	92-75½	817.50	.0719
1st mtge. 7⅛, 1969	71.25	92⅜-87	896.90	101-84	925.00	.0466
1st mtge. 8⅝, 1970	86.25	102⅜-97	996.90	g	996.90[g]	.0865

[a]Moody's Investors Service, Inc., Moody's Public Utility Manual, New York: Moody's Investors Service, Inc., 1971, pp. 601, 602.

[b]Average market price per unit is substituted for the year end price for two reasons; data regarding the average price is more readily available, and year end price may be misleading if the price during other parts of the year differed by a large amount. Average market price as used here is obtained by averaging the high and low price for the year.

[c]For single period investments, formulas for both the internal rate of return and the geometric mean rate of return are identical and equal to the formula used in calculating the rate of return in the table above; the same formula is applicable in assessing the rate of return of common stock, preferred stock, and bonds. See Haim Levy and Marshall Sarnat, Investment and Portfolio Analysis, New York: John Wiley and Sons, Inc., 1972, pp. 80-81, 99-100.

[d]The stock is privately held; no price exists. Average market price is estimated by interpolation based on the average price of preferred stock having the next smaller interest rate and the preferred stock having the next larger interest rate. All stocks are subject to the same conditions. See Moody's Investors Service, Inc., Moody's Public Utility Manual, New York: Moody's Investors Service, Inc., 1971, pp. 608-609.

[e]Sold in January 1970. A price is computed by averaging the percent change between the prices for all preferred stocks sold in 1969 and those sold in 1970.

[f]No sales were made in 1970. An average price is estimated by interpolation based on the average of price of the bond having the next smaller interest rate and the bond having the next larger interest rate. All bonds are issued subject to the same conditions and have the same ratings. See Moody's Investors Service, Inc., Moody's Public Utility Manual, New York: Moody's Investors Service, Inc., 1971, pp. 606-608.

[g]Bonds were sold in January 1970. Average price for 1970 is substituted for average price in 1969.

TABLE XX

WEIGHTED AVERAGE COST OF CAPITAL, OKLAHOMA GAS AND ELECTRIC COMPANY, 1970

Issue[a]	Number of[a] units outstanding 1970	Average[b] price per unit 1970	Total value of[a,c] this issue 1970	Value of this issue as a percent of: type of[d] capital	Value of this issue as a percent of: annual cost[e] of capital	i Rate of[f] return of this issue	Contribution of this issue to the weighted average cost of capital 1970: type of[g] capital	Contribution of this issue to the weighted average cost of capital 1970: all types[h] of capital
Equity capital								
Common	14,789,559	$ 23.18	$342,821,977.62	.91278	.60937	.1646	$ .15024	$ .10030
Pfd. 4% Cum.	675,000	11.75	7,931,250.00	.02112	.01410	.0444[j]	.00089	.00626
Pfd. 4.2% Cum. Series	50,000	48.06	2,403,000.0	.00640	.00427	-.0206[j]	-.00013	-.00009
Pfd. 4.24% Cum. Series	75,000	55.00	4,125,000.00	.01098	.00733	-.0406[j]	-.00045	-.00030
Pfd. 4.44% Cum. Series	65,000	57.12	3,712,000.00	.00989	.00660	-.0318[j]	-.00031	-.00021
Pfd. 4.80% Cum. Series	75,000	60.99	4,574,250.00	.01218	.00813	-.0284[j]	-.00035	-.00023
Pfd. 5.34% Cum. Series	150,000	66.75	10,012,500.00	.02666	.01780	-.0182[j]	-.00049	-.00032
Total equity capital			$375,580,777.62		.66760		.14952	
Debt capital								
1st mtge. 2¾, 1945	35,000	$800.60	$ 28,021,000.00	.14984	.04931	.0736	.01103	.00367
1st mtge. 3, 1949	10,000	729.90	7,299,000.00	.03903	.01297	.0270	.00105	.00035
1st mtge. 2⅞, 1950	17,500	763.70	13,364,750.00	.07147	.02376	.0497	.00355	.00118
1st mtge. 3⅜, 1952	12,000	640.00	7,680,000.00	.04107	.01365	.0375	.00154	.00051
1st mtge. 3¼, 1955	15,000	641.30	9,627,000.00	.05148	.01711	.0876	.00451	.00150
1st mtge. 4½, 1957	20,000	661.90	13,239,000.00	.07079	.02353	.0171	.00121	.00040
1st mtge. 3⅞. 1958	15,000	727.50	10,912,500.00	.05836	.01940	.0575	.00356	.00112
1st mtge. 4½, 1963	15,000	590.00	8,850,000.00	.04733	.01573	.0453	.00214	.00071
1st mtge. 4½, 1965	25,000	660.00	16,500,000.00	.08823	.02933	.0236	.00208	.00069
1st mtge. 5⅛, 1967	15,000	671.90	10,078,500.00	.05390	.01791	.0185	.00100	.00331
1st mtge. 6⅜, 1968	25,000	812.50	20,312,500.00	.01862	.03611	.0719	.00781	.00260
1st mtge. 7⅛, 1969	12,500	896.90	11,211,250.00	.05995	.01993	.0466	.00230	.00093
1st mtge. 8⅝, 1970	30,000	996.90	29,907,000.00	.15993	.05316	.0865	.01383	.00460
Total debt capital			$187,001,500.00		.33241		.05611	

Overall value of capital = ∑(Total value of this issue 1970) = $562,582,277.62

Weighted average cost of capital = ∑(Contribution of this issue to the weighted average cost of capital 1970) = $.14698

[a]Moody's Investors Service, Inc., Moody's Public Utility Manual, New York: Moody's Investors Service, Inc., 1971, p. 601.

[b]See Table XIX for computation of average price per unit in 1970.

[c]Total value of this issue, 1970 = (Number of issues outstanding, 1970) x (Average price per unit, 1970).

[d]Value of this issue as a percent of equity (or debt) capital = [Value of this issue of equity (or debt) capital, 1970] x Σ[Value of this issue of equity (or debt) capital, 1970].

[e]Value of this issue as a percent of overall capital value = (Total value of this issue, 1970) ÷ (Overall value of capital).

[f]See Table XIX for computation of "i", rate of return on this issue, 1970.

[g]Contribution of this issue to the weighted average cost of equity (or debt) capital, 1970 = [Value of this issue as a percent of equity (or debt) capital] x [i, rate of return of this issue, 1970].

[h]Contribution of this issue to the weighted average cost of capital, 1970 = (value of this issue as a percent of overall capital value) x (i, rate of return of this issue, 1970).

[j]The negative values reflect irregularities in the stock market during 1970; in early June, 1970, the market broke and fell for nine straight months. During that period the Dow Jones average fell from 960 to 620.

TABLE XXI

SUMMARY OF AVERAGE YIELDS ON
PUBLIC UTILITY BONDS,
1967-1973

Year	Yearly average (composite)	Aaa	Aa	A
1973	7.80	7.44	7.66	7.84
1972	7.63	7.21	7.48	7.66
1971	7.94	7.39	7.78	8.03
1970	8.51	8.04	8.32	8.57
1969	7.36	7.30	7.20	7.40
1968	6.51	6.18	6.38	6.54
1967	5.82	5.51	5.66	5.86
Sum	51.57	49.07	50.48	51.90
7 year average	7.3671	7.0100	7.2114	7.4143

Source: Moody's Investors Service, Inc., Moody's Industrial Manual, Vol. I, 1975. pp. a48-a50.

TABLE XXII

PUBLIC UTILITIES Aa LONG TERM SECURED DEBT OF THE SAME ISSUE DATE AS PUBLIC UTILITIES LONG TERM UNSECURED DEBT OUTSTANDING, 1945-1970

Unsecured debt					Secured debt				
Year	Date	Corporation	Yield	Length	Year	Date	Corporation	Yield	Length
1948	Mar. 1	Southern New England Telephone Co.	3.125	32	1948	Mar. 1	Kansas Gas and Electric Company	3.125	30
						Mar. 1	San Diego Gas and Electric Co.	3.000	30
						Mar. 1	Southern Counties Gas Co. of Calif	3.250	30
						Mar. 1	West Penn Power Company (Pa.)	3.000	30
	Apr. 1	Dallas Power & Light Company	3.125	25		Apr. 1	Gulf Power Company	3 1/8	30
						Apr. 1	Gulf States Utility Company	3.000	30
	Nov. 1	New Bedford and Edison Light Co.	3.000	21		Nov. 1	Florida Power Corporation	3.250	30
1949	Oct. 1	Commonwealth Edison Co. (Ill.)	2.750	50	1949	Oct. 1	Duquesne Light Company	2 5/8	30
						Oct. 1	Indianapolis Power & Light Company	2 7/8	30
1952	July 1	Southern New England Telephone Co.	3.250	33	1952	July 1	Boston Edison Company	3 1/8	30
						July 1	Georgia Power Company	3 3/8	30
						July 1	Gulf Power Company	3 3/8	30
						July 1	Public Service Company of Indiana	3 3/8	30
1954	Apr. 1	Southern New England Telephone Co.	3.000	33	1954	Apr. 1	Central Power & Light Company	3 1/8	30
	June 1	Consolidated Natural Gas Co. (Del)	3.125	25		June 1	Central Illinois Public Service Co	3.250	30
						June 1	Southwest Public Service Co.	3.20	25
	Aug. 1	Consolidated Natural Gas Co. (Del)	3.000	24		Aug. 1	Boston Edison Co.	3 1/8	30
						Aug. 1	Georgia Power & Light Company	3 1/8	30
						Aug. 1	Hackensack Water Company	3.250	30
						Aug. 1	San Diego Gas & Electric Co.	2 7/8	30
						Aug. 1	Southern Indiana Gas & Electric Co	3 1/8	30
						Aug. 1	Western Massachusetts Electric Co.	2.95	19
						Aug. 1	West Penn Power Company (Pa.)	3	30
	Oct. 1	Commonwealth Edison Co. (Ill.)	3.125	50		Oct. 1	Central Hudson Gas & Electric Co.	3.20	30
						Oct. 1	Columbus & South Ohio Electric Co.	3.250	30
						Oct. 1	Wisconsin Power & Light Co.	3.250	30
1955	Feb. 1	Dallas Power & Light Company	3.125	18	1955	Feb.15	Kansas City Power & Light Co.	3.250	30
	June 1	Southern New England Telephone Co.	3.250	34		June 1	Central Illinois Power & Light Co.	3.125	30
1957	Aug. 1	Consolidated Natural Gas Co. (Del)	4 7/8	25	1957	June 1	Georgia Light & Power Co.	5.250	30
						June 1	Pacific Gas & Electric Co.	5.000	32
						June 1	South Jersey Gas Co.	5.00	25
1958	Jan. 1	Commonwealth Edison Co. (Ill.)	3 7/8	50	1958	Jan. 1	Cambridge Electric Light Co.	3 7/8	30
						Jan. 1	Columbus & South Ohio Electric Co.	4 1/8	30
						Jan. 1	Connecticut Light & Power Company	3 7/8	30
						Jan. 1	Iowa Power & Light Company	3 5/8	30
						Jan. 1	Rochester Telephone Corporation	5.000	33
						Jan. 1	West Texas Utility Company	3 7/8	30
1959	Jan. 1	Commonwealth Edison Co. (Ill.)	4 5/8	50	1959	Jan. 1	Gulf States Utility Co.	3 3/4	30
						Jan.15	San Diego Gas & Electric Co.	4 5/8	25
1960	Feb. 1	Consolidated Natural Gas Co. (Del)	5.000	15	1960	Feb. 1	Connecticut Light & Power Co.	4 7/8	30
1961	Feb. 1	Consolidated Natural Gas Co. (Del)	4 3/8	25	1961	Feb. 1	Southwest Public Service Co.	4.500	30
	May 1	Consolidated Natural Gas Co. (Del)	4.750	25		May 1	Iowa-Illinois Gas & Electric Co.	4 7/8	30
	June15	Baltimore Gas & Electric	4 7/8	25		June 1	Pacific Gas & Electric Company	4.500	32
						July 1	Gulf States Utilities	4 7/8	30
						July 1	Union Electric Company	4.750	30
	Dec. 1	Southern New England Telephone Co.	4 3/8	40		Dec. 1	Pacific Gas & Electric Company	4 3/8	33
	Dec. 1	Commonwealth Edison Co. (Ill.)	4.750	50		Dec. 1	Pennsylvania Power & Light Co.	4 5/8	30
1963	Apr. 1	Consolidated Natural Gas Co. (Del)	4 3/8	25	1963	Apr. 1	Hartford Electric Light Co.	4.500	30
						Apr. 1	Southwestern Electric Power Co.	4 3/8	30
1964	Feb. 1	Dallas Power & Light Company	4.500	25	1964	Feb. 1	Southwest Public Service Co.	4.500	30
	Aug. 1	Consumers Power Company (Mich.)	4 5/8	40		Aug. 1	Indianapolis Power & Light Co.	4.500	30
						Aug. 1	Northern Illinois Gas Co.	4 5/8	25
1966	Nov. 1	Southern New England Telephone Co.	5.75	30	1966	Nov. 1	Wisconsin Electric Power Co.	5 7/8	26
1967	July 1	New Bedford & Edison Light Company	5 5/8	25	1967	July 1	Iowa Electric Power & Light Co.	6 3/8	25
						July 1	Natural Gas Pipeline Co. of Amer.	6.000	20
						July 1	Northern Illinois Gas Company	6.000	25
						July 1	Public Service Company (Colorado)	5 7/8	30
						July15	Iowa-Illinois Gas & Electric Co.	5 7/8	30
1968	Feb. 1	Dallas Power & Light Company	6.750	25	1968	Feb. 1	Duke Power Company	6 3/8	30
						Feb. 1	Duquesne Light Company	6 3/8	30
						Feb. 1	Gulf States Utility Company	6.500	30
						Feb. 1	Hartford Electric Light Company	6.500	30
1969	July 1	Consolidated Natural Gas Co. (Del)	7.750	25	1969	July 1	Madison Gas & Electric Co.	8.000	30
						July 1	West Pennsylvania Power Company	7 1/8	30
1970	Feb. 1	Houston Power & Light Co.	5.500	15	1970	Feb. 1	Gulf States Utility Company	8.500	30
						Feb. 1	San Diego Gas & Electric Company	8.750	30
	Dec. 1	New Bedford & Edison Light Co.	7 7/8	25		Dec. 1	Delmrva Power & Light Co.	8 3/8	30
	Dec. 1	New Bedford & Edison Light Co.	5 5/8	22		Dec. 1	Gulf States Utility Co.	7 7/8	30
						Dec. 1	New England Power Co.	7.000	6
	Dec.31	Edison Light Company	4.500	16		Dec.31	Wisconsin Power & Light Co.	8 7/8	30

Source: Moody's Investors Service, Inc., Moody's Public Utility Manual, New York: Moody's Investors Service, Inc., 1971.

APPENDIX B

ELECTRIC ENERGY RATE SCHEDULE

TABLE XXIII

RATE SCHEDULES APPLICABLE TO RESIDENTIAL UNITS SERVED BY STILLWATER MUNICIPAL ELECTRIC UTILITY IN EFFECT DURING 1970

STILLWATER WATER AND LIGHT DEPARTMENT

Available: In Stillwater

RATE CLASS I

(192) RESIDENTIAL SERVICE

Desig: RES-60 Aug. 1, 1964.

Applicable: To residential customers for all domestic uses. Not applicable to boarding houses or other residences not used solely for family residence purposes.

Rate:

6.00¢ per kwh	first	50	kwh
5.00¢ " "	next	50	"
4.00¢ " "	"	100	"
2.00¢ " "	"	200	"
1.75¢ " "	all over	400	"

Minimum Bill: $1.00

Multiple Dwellings: When two or more dwelling units such as duplexes, apartments, and trailers, each having separate kitchen facilities, are served through one meter, the above rate shall be applied by multiplying the kwh blocks by the number of dwelling units served, or at the utility's option, (195) will be applied.

RATE CLASS II

(193) RESIDENTIAL SERVICE - LARGE USE

Desig: RHW-60 Aug. 1, 1964.

Applicable: Same as (192) except that hereunder customer must use an electric water heater conforming with utility's specifications as the sole source of energy for water heating.

Rate:

6.00¢ per kwh	first	50	kwh
5.00¢ " "	next	50	"
4.00¢ " "	"	100	"
1.10¢ " "	"	300	"
2.00¢ " "	"	200	"
1.75¢ " "	all over	700	"

Minimum Bill: $1.00.

Multiple Dwellings: Same as (192)

RATE CLASS IV

(195) COMMERCIAL LIGHTING SERVICE

Desig: CES-60 Aug. 1, 1964.

Applicable: To commercial customers for lighting, heating, and single-phase power purposes.

Rate:

6.00¢ per kwh	first	50	kwh
5.00¢ " "	next	50	"
4.00¢ " "	"	100	"
3.00¢ " "	"	800	"
2.00¢ " "	"	2,000	"
1.75¢ " "	all over	3,000	"

Minimum Bill: $1.00

Source: Federal Power Commission, National Electric Rate Book, Vol. 2, 1967, Washington, D.C.: Federal Power Commission, Oklahoma Schedule No. 35-674.

APPENDIX C

INCOME BY TRACTS

TABLE XXIV

ANNUAL INCOME IN 1969 OF FAMILIES AND UNRELATED INDIVIDUALS
IN THE CITY OF STILLWATER AND PAYNE COUNTY, OKLAHOMA

Income in 1969 of families and unrelated individuals	County 119	Census Tracts										
		Tract 0001	Tract 0002	Tract 0003	Tract 0004	Tract 0005	Tract 0006	Tract 0007	Tract 0008	Tract 0009	Tract 0010	Tract 0011
All families	8,537	943	1,336	814	739	279	1,252	286	815	416	474	1,183
Less than $1,000	205	22	31	20	18	16	4	20	35	5	23	11
$1,000 to $1,999	417	9	53	74	50	13	39	20	60	10	12	77
$2,000 to $2,999	693	31	82	124	88	42	61	22	90	22	39	92
$3,000 to $3,999	815	49	93	129	100	41	86	54	58	50	41	114
$4,000 to $4,999	752	34	91	113	108	15	83	22	71	22	53	140
$5,000 to $5,999	768	42	98	80	101	25	78	39	116	36	68	85
$6,000 to $6,999	583	42	85	32	51	39	68	27	91	33	29	86
$7,000 to $7,999	538	45	57	69	46	15	52	15	71	23	15	130
$8,000 to $8,999	670	85	90	53	64	-	102	18	59	45	57	97
$9,000 to $9,999	501	91	81	16	12	15	64	18	37	32	27	108
$10,000 to $11,999	708	99	112	41	33	26	207	14	59	24	26	67
$12,000 to $14,999	732	199	137	31	25	26	124	12	23	18	42	95
$15,000 to $24,999	846	152	242	32	33	-	192	-	40	91	14	50
$25,000 to $49,999	290	33	84	-	10	6	88	5	-	5	28	31
$50,000 or more	19	10	-	-	-	-	4	-	5	-	-	-
Median income	$ 7,066	$10,434	$ 8,867	$ 4,531	$ 5,054	$ 5,500	$ 9,828	$ 5,128	$ 5,806	$ 8,156	$ 6,034	$ 6,843
Mean income	8,739	11,839	10,561	5,565	6,388	6,585	11,226	5,611	6,887	9,414	8,463	7,642
Families and unrelated individuals	20,092	1,075	2,353	6,349	1,937	2,298	1,846	683	1,122	488	555	1,486
Median income	$ 2,449	$ 9,591	$ 4,918	$ 988	$ 2,862	$ 1,237	$ 7,356	$ 3,104	$ 4,474	$ 7,087	$ 5,480	$ 5,294
Mean income	4,699	10,750	7,296	1,597	3,978	2,058	8,817	3,776	5,837	8,577	7,533	6,541
Unrelated individuals	11,555	132	1,017	5,535	1,198	2,019	594	297	307	72	81	303
Median income	$ 1,177	$ 2,053	$ 1,917	$ 928	$ 1,866	$ 1,009	$ 2,440	$ 1,766	$ 1,763	$ 2,471	$ 1,767	$ 1,408
Mean income	1,714	2,966	3,007	1,014	2,492	1,432	3,735	2,009	3,049	3,737	2,093	2,243

Source: United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P-4.

TABLE XXV

COMPARISON OF VALUES OF CENTRAL TENDENCY OF ANNUAL INCOME BY TRACT FOR FAMILIES, FAMILIES AND UNRELATED INDIVIDUALS, AND INDIVIDUALS

Tract	Item	Families	Families and Unrelated Individuals	Unrelated Individuals
1	Count[1]	943	1,075	132
	Median income	$10,434	$9,591	$2,053
	Mean income	$11,839	$10,750	$2,999
2	Count	1,336	2,353	1,017
	Median income	$8,867	$4,918	$1,917
	Mean income	$10,561	$7,296	$3,007
4	Count	739	1,937	1,198
	Median income	$5,054	$2,862	$1,866
	Mean income	$6,388	$3,978	$2,492
5	Count	279	2,298	2,019
	Median income	$5,550	$1,237	$1,009
	Mean income	$6,585	$2,058	$1,432
6	Count	1,252	1,846	594
	Median income	$9,828	$7,385	$2,440
	Mean income	$11,226	$8,817	$3,735
8	Count	815	1,122	307
	Median income	$5,806	$4,474	$1,763
	Mean income	$6,887	$5,837	$3,049
9	Count	416	488	72
	Median income	$8,156	$7,087	$2,471
	Mean income	$9,414	$8,577	$3,737

[1]Count refers to the number of income units, i.e., families and/or families and unrelated individuals in the sample.

Source: United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P-4.

APPENDIX D

INFLUENCE OF TREATMENT OF INACTIVE RATE CLASS IV ACCOUNTS ON MEDIAN VALUES FOR ELECTRIC ENERGY CONSUMPTION BY TRACT

INFLUENCE OF TREATMENT OF INACTIVE RATE CLASS IV ACCOUNTS ON MEDIAN VALUES FOR ELECTRIC ENERGY CONSUMPTION BY TRACT

The method used in handling the consumption data for Commercial Lighting, Rate Class IV, accounts when combined with the sharp variance of occupancy rates between the academic year and the summer months, which is characteristic for housing units occupied by college students, created some peculiarities in the data which it became necessary to resolve before median values could be determined. During the summer months the student population of the city as a whole shrinks to approximately one-third of its academic year level.

Further, the student population is not evenly distributed throughout the city but tends to cluster about the University in Tracts 1, 2, 4, and 5. The Rate Class IV accounts under consideration here are concentrated most heavily in Tract 5 where most of the sorority and fraternity houses are located. A fairly large proportion of Rate Class IV accounts occur in Tract 1 where they represent apartment complexes rather than group quarters. However, the group quarters would be expected to have a higher variance in occupancy rates between the academic year and summer months than the apartment complexes since they are occupied exclusively by single students and the residences are usually closed and the organization inactive during the summer months.

In preparing the account numbers for drawing the random sample, the account numbers representing group quarters were entered in the population more than once in order to achieve a proportionate representation of that group of consumers in the sample. The number of times that any particular commercial lighting account should be entered in the population of account numbers was determined by dividing the number of persons occupying the group quarters during the academic year by the average number of persons per housing unit in that enumeration district as determined from the census data.

Designing the data space in the computer memory. When the sample had been drawn, spaces in the computer memory were allotted to the Rate Class IV accounts according to the number of times that particular account number appeared in the sample, e.g., if an account number appeared seven times in the sample, seven spaces were allotted to it in the array established for each month's data in the computer memory.

Generation of the data entering the computer memory. Since there is sharp variance in the residence rates associated with Rate Class IV accounts between the academic year and summer months, before the consumption and billing data for each month which had been collected in the aggregated, unadjusted form could be entered in the array of data on consumption, it had to be adjusted by dividing the total values for the month by the number of housing units represented by that month's consumption; the number of housing units represented was determined as in preparing the accounts for selection of the sample, i.e., the number of occupants for the month was divided by the average number of persons then

entered in the array for only the number of housing units determined to be occupied that month.

It should be noted that, at this level, there is no correlation between the number of housing units represented by the consumption data for any given commercial lighting account number and the number of spaces in the array allotted to that account number. In some cases, group quarters served by a commercial lighting account were occupied by only one or two persons whereas during the academic year, occupancy was large enough to result in that account's appearing in the sample several times representing several living units. Where such cases developed, the question arose as to how those excess housing units associated with an account which did not receive an assigned value of consumption in some months when occupancy rates were low should be treated with respect to the entry of consumption data.

Alternative approaches for dealing with the problem of missing data in Rate Class IV accounts. Three alternative approaches to the question were considered. (1) Treat the excess Rate Class IV housing unit as an inactive account and enter zeros for the missing data. (2) Treat the excess Rate Class IV housing unit as an active account and use statistical techniques for supplying the missing data. (3) Replace the missing data in the Rate Class IV account for which no value had been generated by the same value that had been used for the other housing units associated with that account number. Of the latter two alternatives, alternative three was regarded as being more appropriate for this special case than a value based on the values of all other accounts in the array as would have resulted from procedures under alternative two.

The question then became a matter of whether (1) the account number for which no kilowatt hours consumption value had been generated should be treated as an inactive account and assigned a value of zero since in actuality no consumption was occurring, or (2) a value should be supplied for the account consistent with the treatment of inactive Rate Class I and Rate Class IV accounts.

The prospect of assigning zero values to Rate Class IV accounts for which no values had been generated raised further problems with regard to determination of the median. Thus the question became a matter of how the alternatives would influence the location and interpretation of median values to be used for making the economic tests.

Evaluation of the problem. As a first approximation of the seriousness of the problem, medians were determined by (1) including the units with zero usage in the count to locate the median (Table XXVI), and also by (2) excluding units with zero usage values by beginning the count to locate the median with the first non-zero number in the array (Table XXVII). Visual comparison of the median values of kilowatt hours consumed indicated that missing values were heavily concentrated in Tracts 1 and 5 where the populations are heavily weighted with student residents (Tables XXVIII, XXIX). Also, it was noted that the disparate values occurred in months when the student population is typically small.

Visual comparison of the differences between the medians indicated that significant size differences occurred only in Tracts 1 and 5 and that only the difference in Tract 5 would appear to be alarming in the sense of altering the results of later analysis. The result in Tract 5 reflects the heavy concentration of sorority and fraternity houses within

TABLE XXVI

MEDIAN VALUES OF ELECTRIC ENERGY CONSUMPTION OF RATE CLASS I, II, & IV ACCOUNTS[1] COMBINED WITH ZERO VALUES INCLUDED IN THE COUNT TO DETERMINE THE MEDIAN[2]

Tract	Census data count[3] and annual income families and unrelated individuals	Item	July 1970	Aug. 1970	Sept. 1970	Oct. 1970	Nov. 1970	Dec. 1970	Jan. 1971	Feb. 1971	Mar. 1971	Apr. 1971	May 1971	June 1971	Annual
5	Count = 2298	Median kwh	538	450	410	160	174	200	152	197	201	155	217	417	3495
	Median = $1237	Total bill	16.72	15.71	8.06	5.84	8.71	4.17	5.61	2.28	4.38	3.48	4.58	14.64	103.67
	Mean = $2028	Price/kwh	.03108	.03491	.01966	.03650	.05006	.02087	.03688	.01159	.02177	.02246	.02106	.03512	.02966
4	Count = 1937	Median kwh	618	498	380	238	250	288	248	250	198	216	286	424	4490
	Median = $2862	Total bill	17.84	15.68	13.49	10.57	10.82	11.60	10.77	10.82	9.70	10.11	11.56	14.34	149.54
	Mean = $3978	Price/kwh	.02887	.03149	.03550	.04441	.04328	.04028	.04343	.04328	.04899	.04681	.04042	.03382	.03331
8	Count = 1122	Median kwh	400	412	278	202	244	240	230	218	196	230	242	286	3314
	Median = $4474	Total bill	13.91	14.12	11.39	9.83	10.69	10.61	10.40	10.16	9.62	10.40	10.65	11.56	129.38
	Mean = $5837	Price/kwh	.03477	.03427	.04097	.04866	.04381	.04421	.04522	.04661	.04908	.04522	.04401	.04042	.03904
2	Count = 2353	Median kwh	1162	1580	632	288	432	498	552	462	416	392	485	853	8192
	Median = $4918	Total bill	27.65	35.17	18.09	11.60	14.48	12.08	16.64	11.43	14.19	13.74	11.85	20.12	227.98
	Mean = $7296	Price/kwh	.02380	.02226	.02862	.04028	.03352	.02426	.03014	.02475	.03411	.03505	.02442	.02359	.02783
9	Count = 488	Median kwh	1622	1788	1206	338	510	521	703	527	452	411	496	982	9774
	Median = $7087	Total bill	35.94	38.93	28.43	12.62	15.89	16.09	18.57	16.19	14.84	14.05	15.63	24.39	255.62
	Mean = $8577	Price/kwh	.02216	.02177	.02358	.03735	.03116	.03088	.02642	.03073	.03284	.03420	.03152	.02484	.02615
6	Count = 1846	Median kwh	1298	892	888	266	307	397	515	382	376	342	354	603	7094
	Median = $7385	Total bill	30.10	22.77	22.70	11.14	11.99	13.84	15.98	13.35	13.41	12.71	12.96	17.56	204.78
	Mean = $8817	Price/kwh	.02319	.02553	.02556	.04190	.03906	.03486	.03104	.03495	.03566	.03716	.03661	.02913	.02887
1	Count = 1075	Median kwh	1124	1250	558	344	438	500	430	438	392	346	590	1022	7768
	Median = $9591	Total bill	26.96	29.33	16.76	12.75	14.60	15.71	14.45	14.60	13.74	12.79	17.33	25.12	215.19
	Mean = $10750	Price/kwh	.02399	.02338	.03004	.03706	.03333	.03142	.03360	.03333	.03505	.03697	.02937	.02458	.02770

[1]Rate Class I is Residential Service; Rate Class II is Residential Service-Large Use; Rate Class IV is Commercial Lighting Service. See Table XXIII for further information.

[2]Monetary values are stated in dollars.

[3]Count refers to the number of income units, i.e., families and unrelated individuals in the sample.

Source: United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P-4; Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71.

TABLE XXVII

MEDIAN VALUES OF ELECTRIC ENERGY CONSUMPTION OF RATE CLASS I, II, & IV ACCOUNTS[1] COMBINED WITH ZERO VALUES EXCLUDED FROM THE COUNT TO DETERMINE THE MEDIAN[2]

Tract	Census data count[3] and annual income of families and unrelated individuals	Item	July 1970	Aug. 1970	Sept. 1970	Oct. 1970	Nov. 1970	Dec. 1970	Jan. 1971	Feb. 1971	Mar. 1971	Apr. 1971	May 1971	June 1971	Annual
5	Count = 2298	Median kwh	840	832	410	160	174	200	152	197	201	155	217	754	3495
	Median = $1237	Total bill	24.25	21.69	8.06	5.84	8.71	4.17	5.61	2.28	4.38	3.48	4.58	21.37	103.67
	Mean = $2058	Price/kwh	.02887	.02607	.01966	.03650	.05006	.02087	.03688	.01159	.02177	.02246	.02109	.02839	.02966
4	Count = 1937	Median kwh	618	498	381	238	250	288	248	250	198	216	286	424	4490
	Median = $2862	Total bill	17.84	15.68	13.51	10.57	10.82	11.60	10.77	10.82	9.70	10.11	11.56	14.34	149.54
	Mean = $3978	Price/kwh	.02887	.03149	.03546	.04441	.04328	.04028	.04343	.04328	.04899	.04681	.04042	.03382	.03331
8	Count = 1122	Median kwh	400	412	280	202	244	240	230	218	197	230	242	286	3314
	Median = $4474	Total bill	13.91	14.12	11.43	9.83	10.69	10.61	10.40	10.16	9.66	10.40	10.65	11.56	129.38
	Mean = $5837	Price/kwh	.03477	.03427	.04082	.04866	.04381	.04421	.04522	.04661	.04904	.04522	.04401	.04042	.03904
2	Count = 2353	Median kwh	1162	1580	632	288	432	498	552	462	416	392	486	853	8192
	Median = $4918	Total bill	25.65	35.17	18.09	11.60	14.48	12.08	16.64	11.43	14.19	13.74	13.67	20.12	227.98
	Mean = $7295	Price/kwh	.02380	.02226	.02862	.04028	.03352	.02426	.03014	.02475	.03411	.03505	.02812	.02359	.02783
9	Count = 488	Median kwh	1622	1788	1206	338	510	521	703	527	452	411	496	982	9774
	Median = $7087	Total bill	35.94	38.93	28.43	12.62	15.89	16.09	18.57	16.19	14.84	14.05	15.63	24.39	255.62
	Mean = $8577	Price/kwh	.02216	.02177	.02358	.03735	.03116	.03088	.02642	.03073	.03283	.03420	.03152	.02484	.02615
6	Count = 1846	Median kwh	1298	892	888	266	307	397	515	382	376	344	354	603	7094
	Median = $7385	Total bill	30.10	22.77	22.70	11.14	11.99	13.84	15.98	13.35	13.41	12.75	12.96	17.56	204.78
	Mean = $8817	Price/kwh	.02319	.02553	.02556	.04190	.03906	.03486	.03104	.03495	.03566	.03706	.03661	.02913	.02887
1	Count = 1075	Median kwh	1128	1295	561	347	438	500	431	438	392	346	590	1031	7768
	Median = $9591	Total bill	27.03	30.04	16.81	12.81	14.60	15.71	14.46	14.60	13.74	12.79	17.33	25.28	215.19
	Mean = $10750	Price/kwh	.02396	.02320	.02996	.03693	.03333	.03142	.03356	.03333	.03505	.03697	.02937	.02452	.02770

[1]Rate Class I is Residential Service; Rate Class II is Residential Service-Large Use; Rate Class IV is Commercial Lighting Service. See Table XXIII for further information.

[2]Monetary values are stated in dollars.

[3]Count refers to the number of income units, i.e., families and unrelated individuals in the sample.

Source: United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P-4; Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71.

TABLE XXVIII

COMPARISON OF MEDIAN VALUES OF ELECTRIC ENERGY CONSUMPTION OF RATE CLASS I, II, & IV[1] ACCOUNTS COMBINED WHEN ZERO VALUES ARE INCLUDED AND EXCLUDED IN THE COUNT TO DETERMINE THE MEDIAN[2]

Tract	Census data count[3] and annual income of families and unrelated individuals	Treatment of zero values in the count to determine the median	July 1970	Aug. 1970	Sept. 1970	Oct. 1970	Nov. 1970	Dec. 1970	Jan. 1971	Feb. 1971	Mar. 1971	Apr. 1971	May 1971	June 1971	Annual
5	Count = 2298	Include zeros	538	450	410	160	174	200	152	197	201	155	217	417	3495
	Median = $1237		*	*										*	
	Mean = $2058	Exclude zeros	840	832	410	160	174	200	152	197	201	155	217	754	3495
4	Count = 1937	Include zeros	618	498	380	238	250	288	248	250	198	216	286	424	4490
	Median = $2862				*										
	Mean = $3978	Exclude zeros	618	498	381	238	250	288	248	250	198	216	286	424	4490
8	Count = 1122	Include zeros	400	412	278	202	244	240	230	218	196	230	242	286	3314
	Median = $4474				*						*				
	Mean = $5837	Exclude zeros	400	412	280	202	244	240	230	218	197	230	242	286	3314
2	Count = 2353	Include zeros	1162	1580	632	288	432	498	552	462	416	392	485	853	8192
	Median = $4918												*		
	Mean = $7296	Exclude zeros	1162	1580	632	288	432	498	552	462	416	392	486	853	8192
9	Count = 488	Include zeros	1622	1788	1206	338	510	521	703	527	452	411	496	982	9774
	Median = $7087														
	Mean = $8577	Exclude zeros	1622	1788	1206	338	510	521	703	527	452	411	496	982	9774
6	Count = 1846	Include zeros	1298	892	888	266	307	397	515	382	376	342	354	603	7094
	Median = $7385											*			
	Mean = $8817	Exclude zeros	1298	892	888	266	307	397	515	382	376	344	354	603	7094
1	Count = 1075	Include zeros	1124	1250	558	344	438	500	430	438	392	346	590	1022	7768
	Median = $9591		*	*	*	*			*					*	
	Mean = $10750	Exclude zeros	1128	1295	561	347	438	500	431	438	392	346	590	1031	7768

[1]Rate Class I is Residential Service; Rate Class II is Residential Service-Large Use; Rate Class IV is Commercial Lighting Service. See Table XXIII for further information.

[2]Monetary values are stated in dollars.

[3]Count refers to the number of income units, i.e., families and unrelated individuals in the sample.

Source: United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P-4; Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71.

TABLE XXIX

DIFFERENCES BETWEEN MEDIAN VALUES OF ELECTRIC ENERGY CONSUMPTION OF RATE CLASS I, II, & IV[1] ACCOUNTS COMBINED WHEN ZERO VALUES ARE INCLUDED OR EXCLUDED IN THE COUNT TO DETERMINE THE MEDIAN

Tract	Month												Annual
	July 1970	Aug. 1970	Sept. 1970	Oct. 1970	Nov. 1970	Dec. 1970	Jan. 1971	Feb. 1971	Mar. 1971	Apr. 1971	May 1971	June 1971	
5	302	382	0	0	0	0	0	0	0	0	0	337	0
4	0	0	1	0	0	0	0	0	0	0	0	0	0
8	0	0	2	0	0	0	0	0	1	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	2	0	0	0
1	4	45	3	3	0	0	1	0	0	0	0	9	0

[1]Rate Class I is Residential Service; Rate Class II is Residential Service-Large Use; Rate Class IV is Commercial Lighting Service. See Table XXIII for further information.

Source: Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71.

the tract. These residences represent a large proportion of the total population and consequently a large share of the sample accounts. These consumption units have very high vacancy rates during the summer months. In all cases other than Tract 5, the choice between the two methods of determining the median did not affect the position of the median in relation to other medians when they were set up in an ordered array (Tables XXIX and XXX).

Median values for Tract 5 were then drawn with the zero values for Rate Class IV accounts replaced by average values of consumption per housing unit obtained by dividing the aggregate consumption figure for the group quarters by the number of housing units determined as being occupied for that account during each month in question. These median values were then compared with the median values obtained when zeros were used for the housing units under that account which had been treated as inactive accounts (Table XXXI).

The medians based on the average value proved to be surprisingly larger than those based on zero values. Attempts to rationalize this development raised a question of the relationship between patterns of consumption reflected by Rate Class I and II accounts where residents of each housing unit directly pay for energy consumed and Rate Class IV accounts where families and unrelated individuals do not make direct payment for energy consumed but contribute to the payment of a collective bill through their housing rental payments. Rate Class I and II accounts were separated from Rate Class IV accounts and medians obtained for the two sets of accounts (Table XXXII).

Medians for the set of Rate Class I and II accounts were the same regardless of whether zeros were included or excluded in the count to

TABLE XXX

COMPARISON OF NUMERICAL RANKING OF TRACTS BY MEDIAN VALUES OF ELECTRIC ENERGY CONSUMPTION OF RATE CLASS I, II, & IV[1] ACCOUNTS COMBINED WHEN ZERO VALUES ARE INCLUDED OR EXCLUDED IN THE COUNT TO DETERMINE THE MEDIAN

Rank[2]	Treatment of zero values in the count to determine the median	July 1970	Aug. 1970	Sept. 1970	Oct. 1970	Nov. 1970	Dec. 1970	Jan. 1971	Feb. 1971	Mar. 1971	Apr. 1971	May 1971	June 1971	Annual
		Tract	Tract	Tract	Tract	Tract	Tract	Tract	Tract	Tract	Tract	Tract	Tract	Tract
1	Include zeros	9	9	9	1	9	9	9	9	9	9	1	1	9
	Exclude zeros	9	9	9	1	9	9	9	9	9	9	1	1	9
2	Include zeros	6	2	6	9	1	1	2	2	2	2	9	9	2
	Exclude zeros	6	2	6	9	1	1	2	2	2	2	9	9	2
3	Include zeros	2	1	2	2	2	2	6	1	1	1	2	2	1
	Exclude zeros	2	1	2	2	2	2	6	1	1	1	2	2	1
4	Include zeros	1	6	1	6	6	6	1	6	6	6	6	6	6
	Exclude zeros	1	6	1	6	6	6	1	6	6	6	6	* 5	6
5	Include zeros	4	4	5	4	4	4	4	4	5	8	4	4	4
	Exclude zeros	* 5	* 5	5	4	4	4	4	4	5	8	4	* 6	4
6	Include zeros	5	5	4	8	8	8	8	8	4	4	8	5	5
	Exclude zeros	* 4	* 4	4	8	8	8	8	8	4	4	8	* 4	5
7	Include zeros	8	8	8	5	5	5	5	5	8	5	5	8	8
	Exclude zeros	8	8	8	5	5	5	5	5	8	5	5	8	8

*Indicates choice of means of determining median influences the rank of the tract with respect to kilowatt hours of energy consumed.

[1]Rate Class I is Residential Service; Rate Class II is Residential Service-Large Use; Rate Class IV is Commercial Lighting Service. See Table XXIII for further information.

[2]Ranks are arranged in descending numeric order; Rank 1 represents the largest quantity of kilowatt hours consumed.

Source: Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71.

TABLE XXXI

COMPARISON OF MEDIAN VALUES OF ELECTRIC ENERGY CONSUMPTION[1] OF RATE CLASS I, II, & IV ACCOUNTS COMBINED WHEN ZERO VALUES ARE INCLUDED, ZERO VALUES ARE EXCLUDED, OR AVERAGE VALUES ARE SUBSTITUTED FOR ZERO VALUES IN THE COUNT TO DETERMINE THE MEDIAN

Treatment of zero values in the count to determine the median	July 1970	Aug. 1970	Sept. 1970	Oct. 1970	Nov. 1970	Dec. 1970	Jan. 1971	Feb. 1971	Mar. 1971	Apr. 1971	May 1971	June 1971	Annual
Tract 5													
Zeros included	538	450	410	160	174	200	152	197	201	155	217	417	3495
Zeros excluded	840	832	410	160	174	200	152	197	201	155	217	754	3495
Average values[2] substituted for zeros	1147	900	410	163	174	200	152	197	201	155	217	880	5555
Tract 1													
Zeros included	1124	1250	558	334	438	500	430	438	392	346	590	1022	3495
Zeros excluded	1128	1295	561	347	438	500	431	438	392	346	590	1031	3495
Average values[2] substituted for zeros	1124	1250	558	344	438	500	430	438	392	346	590	1022	7768

[1]Values are stated in kilowatt hours.

[2]Values were computed for Rate Class IV Commercial Lighting Service accounts on the basis of occupancy. When occupancy was below that for the academic year, no values were assigned to some accounts regarded as inactive. Medians were determined either with zero values for those inactive accounts or with the average values for the accounts regarded as active supplied as values for the inactive accounts. For further information see pp. 75, 80, and 176-189.

Source: Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71.

TABLE XXXII

MEDIAN VALUES FOR TRACT 5 COMPARED BY RATE CLASS GROUPINGS AND METHOD OF DETERMINING MEDIAN

Time Period	Item	Median Values, Rate Classes I, II, IV Combined			Median Values, Rate Classes I and II Combined		Median Values, Rate Class IV		
		Zeros included	Zeros excluded	Zeros replaced with a value[1]	Zeros included	Zeros excluded	Zeros included	Zeros excluded	Zeros replaced with a value[1]
Total annual	Kwh	3495	3495	5555	4672	4672	3219	3219	5768
	Bill	103.67	103.67	145.21	157.36	157.36	86.97	86.97	134.46
	Price/kwh	.02966	.02966	.02614	.03368	.03368	.02702	.02702	.02331
July 1970	Kwh	538	840	1047	738	738	85	1080	1120
	Bill	16.72	24.25	30.51	26.41	26.41	3.53	32.68	30.02
	Price/kwh	.03108	.02887	.02915	.03579	.03579	.04150	.03026	.02681
Aug. 1970	Kwh	450	832	900	546	546	322	1430	478
	Bill	15.71	21.69	13.42	16.54	16.54	9.51	36.41	11.37
	Price/kwh	.03491	.02607	.01491	.03029	.03029	.02952	.02546	.02380
Sept. 1970	Kwh	410	410	410	618	618	231	231	233
	Bill	8.06	8.06	8.06	17.84	17.84	4.79	4.79	4.66
	Price/kwh	.01966	.01966	.01966	.02887	.02887	.02074	.02074	.02001
Oct. 1970	Kwh	160	160	163	186	186	153	153	160
	Bill	5.84	5.84	3.49	9.21	9.21	3.44	3.44	3.54
	Price/kwh	.03650	.03650	.02143	.04952	.04952	.02248	.02248	.02212
Nov. 1970	Kwh	174	200	-	226	226	171	171	171
	Bill	8.71	4.17	-	10.32	10.32	3.65	3.65	3.65
	Price/kwh	.05006	.02087	-	.04566	.10566	.02136	.02136	.02136
Dec. 1970	Kwh	200	200	-	252	252	186	186	193
	Bill	4.17	4.17	-	10.86	10.86	3.18	3.18	3.26
	Price/kwh	.02081	.02087	-	.04310	.04310	.01708	.01708	.01689
Jan. 1971	Kwh	152	152	-	274	274	116	116	116
	Bill	5.61	5.61	-	11.31	11.31	2.54	2.54	2.54
	Price/kwh	.03686	.03686	-	.04128	.04128	.02188	.02188	.02188
Feb. 1971	Kwh	197	197	-	254	254	189	189	197
	Bill	2.28	2.28	-	10.90	10.90	3.06	3.06	2.28
	Price/kwh	.01159	.01159	-	.04291	.04291	.01621	.01621	.01159
Mar. 1971	Kwh	201	201	-	260	260	188	188	188
	Bill	4.38	4.38	-	11.02	11.02	3.97	3.97	3.97
	Price/kwh	.02177	.02177	-	.04238	.04238	.02114	.02114	.02114
Apr. 1971	Kwh	155	155	-	210	210	138	138	138
	Bill	3.48	3.48	-	9.99	9.99	2.93	2.93	2.93
	Price/kwh	.02244	.02244	-	.04757	.04757	.02121	.02121	.02121
May 1971	Kwh	217	217	-	252	252	217	217	217
	Bill	4.58	4.58	-	10.86	10.86	4.58	4.58	4.58
	Price/kwh	.02109	.02109	-	.04310	.04310	.02109	.02109	.02109
June 1971	Kwh	417	754	880	334	334	408	408	408
	Bill	14.65	21.38	25.08	12.55	12.55	10.40	10.40	10.40
	Price/kwh	.03512	.02834	.02850	.03757	.03757	.02549	.02549	.02549

[1]Values were computed for Rate Class IV Commercial Lighting Service accounts on the basis of occupancy. When occupancy was below that for the academic year, no values were assigned to some accounts regarded as inactive. Medians were determined with either zero values for those inactive accounts or with the computed values for the accounts regarded as active supplied as values for the inactive accounts. For further information see pp. 75, 80, and 176-189.

Source: Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for the year 1970-71.

determine the median. This merely reflected the fact that no zero values existed in the Rate Class I and II accounts, for statistical means had been used to replace missing data for those accounts in the first stages of handling the data. However, median values obtained for Rate Class IV accounts exhibited a considerable amount of variation depending upon whether the median was determined with the average values substituted for zero values which had been determined to be inactive. Data were analyzed and reported with respect to each of the three methods of drawing the median.

APPENDIX E

RELATIONSHIP OF TAX TO INCOME

TABLE XXXIII

RELATIONSHIP OF TAX TO INCOME
(ZERO VALUES EXCLUDED)

	Independent variable	Dependent variable: Cost of electric energy (Median values where zero values in inactive Rate Class IV accounts were excluded from the count to determine the median)					
Tract[1]	Median annual income of families & unrelated individuals	Median annual kwh	Total bill for median annual kwh	Electric energy cost as a percent of income		Median annual average price per kwh[2]	
				Percent	Rank	Price	Rank
1	$9,591	7768	$215.19	2.2437	7	$.02770	6
2	4,918	8132	227.98	4.6356	3	.02783	5
4	2,862	4490	149.54	5.2250	2	.03331	2
5	1,237	3495	103.67	8.3808	1	.02966	3
6	7,385	7094	204.78	2.7729	6	.02887	4
8	4,474	3314	129.38	2.8918	5	.03904	1
9	7,087	9774	255.62	3.1836	4	.02615	7
Kendall rank correlation test for the relationship between tax and income:			S	-17		-9	
			p(S)	.0054		.119	
			τ	-.8095		-.4286	

[1]Tracts 3, 7, and 10 were eliminated because they were not residential areas.

[2]Median annual average price = Total bill for median annual kwh divided by median annual kwh.

Source: Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71, and United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P-4.

TABLE XXXIV

RELATIONSHIP OF TAX TO INCOME
(AVERAGE VALUES SUBSTITUTED FOR ZERO VALUES)

Tract[1]	Independent variable: Median annual income of families & unrelated individuals	Dependent variable: Cost of electric energy (Median values where average values were substituted for zero values in inactive Rate Class IV accounts in the count to determine the median): Median annual kwh	Total bill for median annual kwh	Electric energy cost as a percent of income: Percent	Rank	Median annual average price per kwh[2]: Price	Rank
1	$9,591	7768	$215.19	2.2437	7	$.02770	5
2	4,918	8132	227.98	4.6356	4	.02783	4
4	2,862	4490	149.54	5.2250	3	.03331	2
5	1,237	5555	145.21	11.7389	1	.02614	7
6	7,385	7094	204.78	2.7729	6	.02887	3
8	4,474	3314	129.38	2.8918	5	.03904	1
9	7,087	9774	255.62	3.1836	2	.02615	6
Kendall rank correlation test for the relationship between tax and income:			S	-3		-3	
			p(S)	.386		.386	
			τ	-.1429		-.1429	

[1]Tracts 3, 7, and 10 were eliminated because they were not residential areas.

[2]Median annual average price = Total bill for median annual kwh divided by median annual kwh.

Source: Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71, and United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P-4.

APPENDIX F

CUSTOMER COSTS

TABLE XXXV

CUSTOMER COSTS
(ZERO VALUES EXCLUDED)

	Independent Variables				Tract Characteristics					
	Median annual income of families & unrelated individuals		Median annual[1] electric bill							
Tract	Income	Rank	Bill	Rank	Total number of electric meters in tract	Total[2] number of housing units in tract	Total acres in tract	Total developed acres in tract	Total linear feet of streets	Electric utility cut-off notices
1	$9,591	1	$215.19	3	1110	1110	252	67	121,985	64
2	4,918	4	227.98	2	1350	1440	376	166	145,250	75
4	2,862	6	149.54	5	590	620	35	29	39,990	51
5	1,237	7	103.67	7	470	910	17	17	32,090	31
6	7,385	2	204.78	4	1350	1390	66	46	115,020	64
8	4,474	5	129.38	6	880	880	85	20	79,990	107
9	7,087	3	255.62	1	130	130	123	39	16,480	3

Kendall rank correlation test for the relationship between median annual electric bill and customer cost for electric service:

S

$p(S)$

τ

$$\varepsilon = \frac{\dfrac{\delta(p_e \cdot e)}{p_e \cdot e}}{\dfrac{\delta B_2}{B_2}}$$

[1]Median values where zero values in inactive Rate Class IV accounts were excluded from the count to determine the median.

[2]Total housing units is based on the adjustment of group quarters reported in the census to housing units by using an index of household size for that tract.

TABLE XXXV, Continued

Dependent Variables															
Meter Reading Costs														Accounting, Billing, and Collecting Costs	
Electric meters per total square acre		Electric meters per developed square acre		Housing units per electric meter		Housing units per total square acre		Housing units per developed square acre		Electric meters per linear foot of streets		Housing units per linear foot of streets		Electric utility cut-off notices per meter per year	
Quantity	Rank	Quantity	Rank	Quantity	Rank	Quantity	Rank	Quantity	Rank	Quantity	Rank	Quantity	Rank	Quantity	Rank
4.4	5	16.5	5	1.000	6	4.4	5	16.5	5	.0091	6	.0091	6	.0576	4
20.2	2	8.1	6	1.067	2	3.8	6	8.7	6	.0093	5	.0099	5	.0555	5
1.1	7	20.0	4	1.051	3	17.5	4	21.0	4	.0148	1	.0155	2	.0064	2
3.6	6	28.0	3	1.936	1	54.2	1	54.2	1	.0146	2	.0283	1	.0659	3
18.2	3	29.2	2	1.030	4	20.7	2	30.0	3	.0117	3	.0121	3	.0474	6
16.9	4	44.8	1	1.000	6	18.2	3	44.8	2	.0110	4	.0110	4	.1216	1
28.0	1	3.4	7	1.000	6	1.1	7	3.4	7	.0079	7	.0079	7	.0231	7
+13		-15		-6		-17		-15		-13		-15		-13	
.035		.015		.191-.281[3]		.0054		.015		.035		.015		.035	
.6190		-.7143		-.2857		-.8095		-.7143		-.6190		-.7143		-.6190	
5.76		6.15		5.75		41.05		12.70		.72		2.20		1.57	

[3]When tied ranks yield S values not reported in the table, the probability for the values above and below the calculated value are reported.

Source: Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71; Bureau of the Census, United States Department of Commerce, 1970 census data tapes, Oklahoma State University Computer Center; City of Stillwater, Oklahoma, Neighborhood Analysis for the City of Stillwater, Oklahoma, James M. Mayo, editor, Stillwater, Oklahoma: City of Stillwater, Oklahoma, September, 1971; United States Geological Survey, aerial photo map of Stillwater, Oklahoma; and United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P4-4.

TABLE XXXVI

CUSTOMER COSTS
(AVERAGE VALUES SUBSTITUTED FOR ZERO VALUES)

	Independent Variables				Tract Characteristics					
	Median annual income of families & unrelated individuals		Median annual[1] electric bill							
Tract	Income	Rank	Bill	Rank	Total number of electric meters in tract	Total[2] number of housing units in tract	Total acres in tract	Total developed acres in tract	Total linear feet of streets	Electric utility cut-off notices
1	$9,591	1	$215.19	3	1110	1110	252	67	121,985	64
2	4,918	4	227.98	2	1350	1440	376	166	145,250	75
4	2,862	6	149.54	5	590	620	35	29	39,990	51
5	1,237	7	145.21	6	470	910	17	17	32,090	31
6	7,385	2	204.78	4	1350	1390	66	46	115,020	64
8	4,474	5	129.38	7	880	880	85	20	79,990	107
9	7,087	3	255.62	1	130	130	123	39	16,480	3

Kendall rank correlation test for the relationship between median annual electric bill and customer cost for electric service:

S

$p(S)$

τ

$$\varepsilon = \frac{\dfrac{\delta(p_e \cdot e)}{p_e \cdot e}}{\dfrac{\delta B_2}{B_2}}$$

[1]Median values where average values were substituted for zero values in inactive Rate Class IV accounts in the count to determine the median.

[2]Total housing units is based on the adjustment of group quarters reported in the census to housing units by using an index of household size for that tract.

TABLE XXXVI, Continued

Dependent Variables															
Meter Reading Costs														Accounting, Billing, and Collecting Costs	
Electric meters per total square		Electric meters per developed square acre		Housing units per electric meter		Housing units per total square acre		Housing units per developed square acre		Electric meters per linear foot of streets		Housing units per linear foot of streets		Electric utility cut-off notices per meter per year	
Quantity	Rank	Quantity	Rank	Quantity	Rank	Quantity	Rank	Quantity	Rank	Quantity	Rank	Quantity	Rank	Quantity	Rank
4.4	5	16.5	5	1.000	6	4.4	5	16.5	5	.0091	6	.0091	6	.0576	4
20.2	2	8.1	6	1.067	2	3.8	6	8.7	6	.0093	5	.0099	5	.0555	5
1.1	7	20.0	4	1.051	3	17.5	4	21.0	4	.0148	1	.0155	2	.0864	2
3.6	6	28.0	3	1.936	1	54.2	1	54.2	1	.0146	2	.0283	1	.0659	3
18.2	3	29.2	2	1.030	4	20.7	2	30.0	3	.0117	3	.0121	3	.0474	6
16.9	4	44.8	1	1.000	6	18.2	3	44.8	2	.0110	4	.0110	4	.1216	1
28.0	1	3.4	7	1.000	6	1.1	7	3.4	7	.0079	7	.0079	7	.0231	7
+11		-17		-4		-15		-17		-11		-13		+7	
.068		.0054		.281-.386[3]		.015		.0054		.068		.035		.015	
.5238		-.8095		-.1905		-.7143		-.8095		-.5238		-.6190		-.7143	
.867		21.16		0		20.52		16.06		.52		.52		5.63	

[3]When tied ranks yield S values not reported in the table, the probability for the values above and below the calculated value are reported.

Source: Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71; Bureau of the Census, United States Department of Commerce, 1970 census data tapes, Oklahoma State University Computer Center; City of Stillwater, Oklahoma, Neighborhood Analysis for the City of Stillwater, Oklahoma, James M. Mayo, editor, Stillwater, Oklahoma, City of Stillwater, Oklahoma September, 1971 United States Geological Survey, aerial photo map of Stillwater, Oklahoma; and United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P4-4.

APPENDIX G

DEMAND COSTS

TABLE XXXVII

DEMAND COSTS
(ZERO VALUES EXCLUDED)

Census Tract	Independent Variables: Median annual income of families & unrelated individuals		Independent Variables: Median[1] annual electric bill		Dependent Variable: Median kilowatt hours — Monthly: July 1970		Aug. 1970		Sept. 1970		Oct. 1970		Nov. 1970		Dec. 1970		Jan. 1971	
	Income	Rank	Bill	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank
1	$9,591	1	$215.19	3	1128	4	1295	3	561	3	347	1	438	2	500	2	431	4
2	4,918	4	227.98	2	1162	3	1580	2	632	4	288	3	432	3	498	3	552	2
4	2,862	6	149.54	5	618	6	498	6	381	6	238	5	250	5	288	5	248	5
5	1,237	7	103.67	7	840	5	832	5	410	5	160	7	174	7	200	7	152	7
6	7,385	2	204.78	4	1298	2	892	4	888	2	266	4	307	4	397	4	515	3
8	4,474	5	129.38	6	400	7	412	7	280	7	202	6	244	6	240	6	230	6
9	7,087	3	255.62	1	1622	1	1788	1	1206	1	338	2	510	1	521	1	703	1

Jonckhere distribution-free k-sample test against ordered alternatives (based on median annual electric bill):

$S = 1646$
$\tau = .5443$
$z = 6.4305$
$p(z) = 9.8376E-1$

[1]Zero values for inactive Rate Class IV accounts are excluded from the count to determine the median.

TABLE XXXVII, Continued

of electric energy consumed by consuming units[1]

consumption																			
Feb. 1971		Mar. 1971		Apr. 1971		May 1971		June 1971		Total		Average	Low	Peak		Range		Load Factor	
Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Kwh	Kwh	Rank	Kwh	Rank	Percent	Rank
438	3	392	3	346	3	590	1	1031	1	7497	3	624.75	346	1295	3	949	4	.4824	3
462	2	416	2	392	2	486	3	853	3	7753	2	646	288	1580	2	1292	2	.4089	7
250	5	198	6	216	6	286	5	424	6	3900	6	325	198	618	6	420	6	.5259	2
197	7	201	5	155	7	217	7	754	4	4292	5	357.6	152	840	5	688	5	.4258	4
382	4	376	4	344	4	354	4	603	5	6622	4	551.83	266	1298	4	1032	3	.4251	5
218	6	197	7	230	5	242	6	286	7	3181	7	265.08	202	400	7	198	7	.6627	1
527	1	452	1	411	1	496	2	982	2	9556	1	796.3	338	1788	1	1450	1	.4453	6

Mosteller k-sample slippage test:

5 < 8 < 4 < 6 < 1 < 2 < 9	r=2	p(r) = .1122
5 < 8 < 4 < 6 < 1 < 2	r=1	p(r) = .9653
5 < 8 < 4 < 6 < 1	r=0	p(r) = 1.0000
5 < 8 < 4 < 6	r=3	p(r) = .0332
5 < 8 < 4	r=0	p(r) = 1.0000
5 < 8	r=0	p(r) = 1.0000

Kendall rank correlation test for the relationship between median annual electric bill and demand cost	S	+19	+17	-1
	p(S)	.0014	.0054	.5000
	τ	.9048	.8095	-.0467
$\varepsilon = \dfrac{\dfrac{\delta(p_e \cdot e)}{p_e \cdot e}}{\dfrac{\delta B_2}{B_2}}$		.959	.942	.039

Source: United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P-4; Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71.

TABLE XXXVIII

DEMAND COSTS
(AVERAGE VALUES SUBSTITUTED FOR ZERO VALUES)

Census Tract	Independent Variables: Median annual income of families & unrelated individuals		Independent Variables: Median[1] annual electric bill		Dependent Variable: Median kilowatt hours — Monthly: July 1970		Aug. 1970		Sept. 1970		Oct. 1970		Nov. 1970		Dec. 1970		Jan. 1971	
	Income	Rank	Bill	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank
1	$9,591	1	$215.19	3	1124	4	1250	3	558	4	344	1	438	2	500	2	431	4
2	4,918	4	227.98	2	1162	3	1580	2	632	3	288	3	432	3	498	3	552	2
4	2,862	6	149.54	5	618	6	498	6	381	6	238	5	250	5	288	5	248	5
5	1,237	7	145.21	6	1047	5	900	5	410	5	163	7	174	7	200	7	152	7
6	7,385	2	204.78	4	1298	2	892	4	888	2	266	4	307	4	397	4	515	3
8	4,474	5	129.38	7	400	7	412	7	280	7	202	6	244	6	240	6	230	6
9	7,087	3	255.62	1	1622	1	1788	1	1206	1	338	2	510	1	521	1	703	1

Jonckhere distribution-free k-sample test against ordered alternatives (based on median annual electric bill):

$S = 1646$
$\tau = .5443$
$z = 6.4305$
$p(z) = 9.8376E-1$

[1]Average values are substituted for zero values in inactive Rate Class IV accounts in the count to determine the median.

TABLE XXXVIII, Continued

of electric energy consumed by consuming units[1]

consumption																			
Feb. 1971		Mar. 1971		Apr. 1971		May 1971		June 1971		Total		Average	Low	Peak		Range		Load Factor	
Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Rank	Kwh	Kwh	Kwh	Rank	Kwh	Rank	Percent	Rank
438	3	392	3	346	3	590	1	1020	1	7419	3	618.3	346	1250	3	904	4	.4946	3
462	2	416	2	392	2	486	3	853	4	7753	2	646	288	1580	2	1292	2	.4089	6
250	5	198	6	216	6	286	5	424	6	3900	6	325	198	618	6	420	6	.5259	2
197	7	201	5	155	7	217	7	880	3	4696	5	391.3	152	1047	4	1032	5	.3747	7
382	4	376	4	344	4	354	4	603	5	6622	4	551.83	266	1298	5	198	5	.4251	5
218	6	197	7	230	5	242	6	286	7	3181	7	265.08	202	400	7	1540	7	.6627	1
527	1	452	1	411	1	496	2	982	2	9556	1	796.3	338	1788	1	1450	1	.4453	4

Mosteller k-sample slippage test:

8 < 5 < 4 < 6 < 2 < 1 < 9	r=2	p(r) = .1122
8 < 5 < 4 < 6 < 2 < 1	r=0	p(r) = 1.0000
8 < 5 < 4 < 6 < 2	r=1	p(r) = .9667
8 < 5 < 4 < 6	r=1	p(r) = .9688
8 < 5 < 4	r=0	p(r) = 1.0000
8 < 5	r=3	p(r) = .1719

Kendall rank correlation test for the relationship between median annual electric bill and demand cost		Peak	Range	Load Factor
	S	+3	+1	-3
	p(S)	.386	.500	.386
	τ	.1764	.0467	-.1764
$\varepsilon = \dfrac{\dfrac{\delta(p_e \cdot e)}{p_e \cdot e}}{\dfrac{\delta B_2}{B_2}}$		4.66	.08	.65

Source: United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P-4; Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71.

APPENDIX H

CAPITAL COSTS I

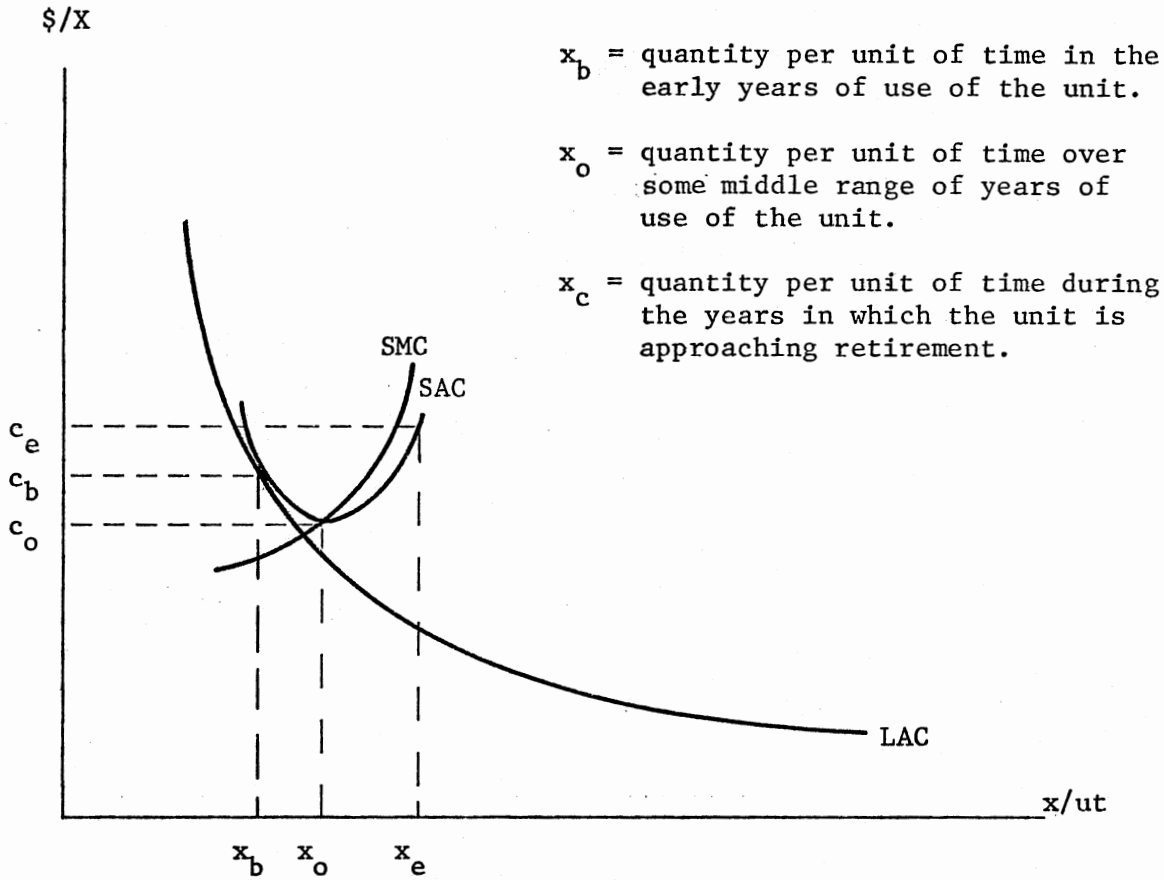

Figure 8. Hypothetical Cost and Output Over Time for a Plant Faced with Growing Demand, Indivisible Units of Capital, and Capital Having a Long Life

In the case of capital equipment for which (1) the incremental units are large, (2) demand for its services are growing, and (3) amortization occurs over a long span of time, optimal management of financial resources requires installing a plant which is of greater than optimal scale at the outset but will become suboptimal before its retirement.

Figure 8 illustrates the situation conceptually. In the early stages of use, the plant would tend to be operated at some output level x_b less than the optimal level x_o and the average cost during this

period would be some cost c_b greater than the optimal cost c_o. During some middle range of years, the plant would be expected to operate at its most technically efficient level and would convert resources to final product at a cost of c_o, the lowest possible cost for a plant of that size. As the plant approached the end of its life, the growth of demand would cause operation of the plant at some output level x_e above the optimal level x_o and at some average cost c_e greater than c_o until variable costs became such that it was more profitable to install the next larger unit.

The implication is that for any firm preparing to enter the industry, the traditional continuous long run average cost does exist, but once the firm has entered the industry and installed a plant of some given size, it no longer has the option of a continuous long run average cost curve, but thereafter faces a disjointed one separated by scales of plant which would no longer represent economic choices and consequently for all practical purposes do not exist insofar as the firm in question is concerned.

APPENDIX I

CAPITAL COSTS II

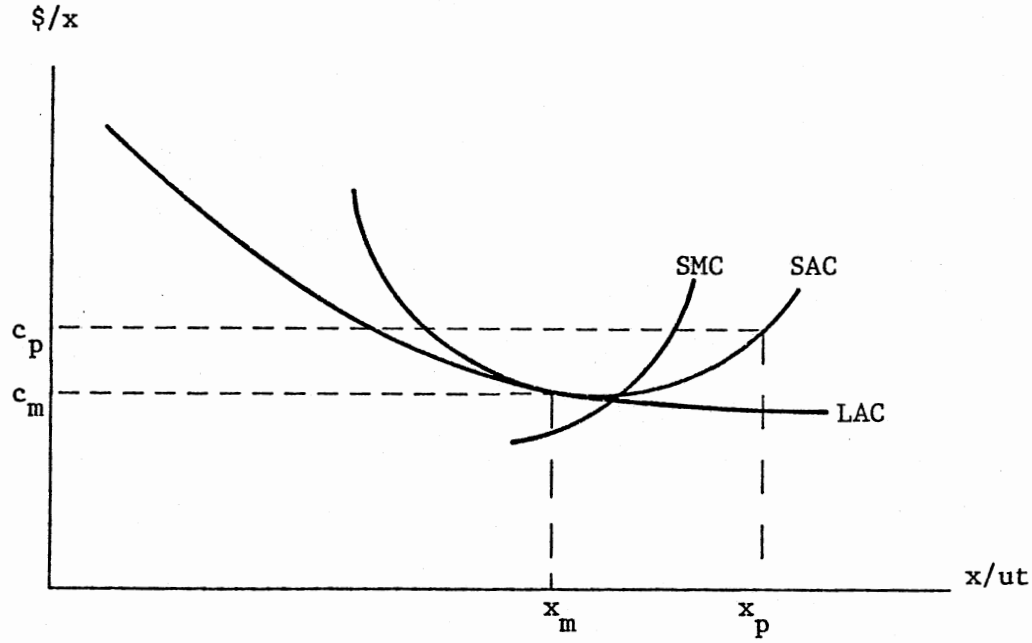

Figure 9. Hypothetical Cost and Output for a Plant Faced with a Low Load Factor

The electric utility being considered in this study operates with a low annual load factor. Low load factor is the result of peak demand which is large relative to the average demand and is associated with a wide range of variance of demand over the relevant time period. Figure 9 illustrates the low load factor situation.

If we regard x_m as the modal level of output and c_m as the average cost associated with it, we may represent x_p as the peak level of output and c_p as the cost associated with the peak output. The relationship c_p and c_m will be determined by the location of x_m and x_p on the short run average cost curve. However, data on plant operations at Boomer Lake Station indicate that operation at the peak consistently over a number of years has produced c_p greater than c_m or also the median cost.

This indicates that whether the plant is operating most of the time at the optimal level or at output levels greater than or less than the optimal level, the variation in demand is sufficiently great to cause the cost at peak to exceed the normal cost.

APPENDIX J

ENERGY COSTS

TABLE XXXIX

EFFICIENCY OF FUEL USE RELATIVE TO TOTAL ENERGY GENERATED, BOOMER LAKE STATION, STILLWATER, OKLAHOMA, FISCAL YEAR 1970-71

Month	Total quantity of fuel used (mcf)	Total kilowatt hours of electric energy generated	Rank	Mcf of fuel used per kilowatt hour of electric energy generated	Rank
July 1970	174,859	14,188,700	2	.012,323,821	7
August	185,749	15,075,100	1	.012,321,576	8
September	181,862	12,547,900	4	.014,491,030	1
October	181,851	9,276,800	6	.012,811,637	5
November	108,298	7,931,400	11	.013,654,335	3
December	108,219	9,040,200	7	.011,970,863	9
January 1971	108,529	8,801,600	8	.012,330,598	6
February	119,118	8,452,800	9	.014,092,135	2
March	97,150	8,317,400	10	.011,683,332	10
April	100,491	7,642,200	12	.013,149,485	4
May	107,994	9,384,400	5	.011,507,821	11
June	149,035	13,414,100	3	.011,110,324	12

Kendall rank correlation test of the relationship between kilowatt hours generated and fuel used per kilowatt hour:

$S = 7$
$\tau = -.106060$
$z = 2.17240$
$p(z) = .0150$

Source: Boomer Lake Generating Station, Stillwater, Oklahoma, Production records for fiscal year 1970-71.

TABLE XL

EXPENDITURES FOR ELECTRIC ENERGY PURCHASED, STILLWATER MUNICIPAL UTILITY, 1970-71

Month	Net charge	Firm demand charge[a]		Firm energy charge[b]		Fuel charge[c]		Economy energy[d]	
		KW	Total charge	kwh	Total charge	Rate	Total charge	kwh	Total charge
July 1970	$ 19,029.37	10,770	$ 13,468.75	1,140,000	$ 5,295.00	$.000233	$ 265.62	0	$ 0.00
August 1970	23,802.39	12,000	15,006.25	1,824,379	8,374.71	.000231	421.43	0	0.00
September 1970	30,695.87	17,190	21,493.75	1,911,000	8,764.50	.000229	436.62	0	0.00
October 1970	1,649.04	1,050	1,318.75	41,000	320.00	.000251	10.29	0	0.00
November 1970	2,537.38	600	756.25	15,000	127.00	.000235	3.53	569,000	1,650.10
December 1970	1,016.65	660	831.25	5,000	45.00	.000239	1.20	48,000	139.20
January 1971	7,225.28	4,680	5,856.25	253,000	1,303.50	.000259	65.53	0	0.00
February 1971	831.25	600	831.25	0	0.00	.0	0.00	0	0.00
March 1971	11,831.49	7,080	8,856.25	537,000	2,581.50	.000474	254.54	48,000	139.20
April 1971	12,605.60	7,200	9,006.25	330,000	1,650.00	.000485	160.05	617,000	1,789.30
May 1971	1,219.40	510[e]	680.00[e]	0	0.00	.000463	0.00	186,000	539.40
June 1971	18,326.62	11,370	14,218.75	787,000	3,706.50	.000510	410.37	0	0.00
Total	$130,769.95		$ 92,323.75	6,843,379	$ 32,168.21		$2,021.18	1,468,000	$4,257.20

Total energy purchased = firm energy + economy energy = 7,311,379 kwh

Average cost of energy purchased = total energy purchased ÷ total energy charge = $0.017886

[a]The firm demand charge is determined as a charge per kilowatt of capacity required to meet the purchasing system's peak hour demand during each month.

[b]Firm energy includes an assessment per kilowatt hour plus the cost of fuel.

[c]Fuel costs vary according to market conditions; the purchaser is assessed according to market price for fuel used in producing electric energy purchased.

[d]During off-peak periods the producer and purchaser split the fuel cost as an incentive to purchase larger quantities of energy and improve the efficiency of operation of the producer's plant.

[e]Figures represent contracted minimum rather than actual figures.

Source: Boomer Lake Station, Stillwater, Oklahoma, Operating records 1970-71.

APPENDIX K

ACCRUAL OF BENEFITS FROM MUNICIPAL SERVICES

TABLE XLI

ACCRUAL OF BENEFITS FROM MUNICIPAL SERVICES
(ZERO VALUES EXCLUDED)

	Independent Variables				Tract Characteristics							
	Median annual income of families & unrelated individuals		Median annual[1] electric bill				Fire service calls				Feet of streets	
Tract	Income	Rank	Bill	Rank	Total[2] housing units	Total use of parks	Residential	Site	Total	Total crimes reported	Total linear feet	Linear feet in good condition
1	$9,591	1	$215.19	3	1110	57	21	44	65	72	121,985	77,585
2	4,918	4	227.98	2	1440	32	32	37	69	158	146,250	72,600
4	2,862	6	149.54	5	620	16	35	8	43	114	39,990	15,380
5	1,237	7	103.67	7	910	8	20	10	30	141	32,090	16,560
6	7,385	2	204.78	4	1390	17	56	22	78	153	115,020	82,630
8	4,474	5	129.38	6	880	52	56	55	111	160	79,990	13,155
9	7,087	3	255.62	1	130	0	2	5	7	8	16,480	9,520

Kendall rank correlation test for the relationship between median annual electric bill and benefits from municipal services	S
	p(S)
	τ

$$\varepsilon = \frac{\dfrac{\delta(p_e \cdot e)}{p_e \cdot e}}{\dfrac{\delta B_2}{B_2}}$$

[1]Zero values in inactive Rate Class IV accounts excluded from the count to determine the median.

[2]Total housing units is based on an adjustment of group quarters reported in the census to housing units by using an index of household size for that tract.

TABLE XLI, Continued

Dependent Variables															
Park use		Fire service calls						Crimes reported		Feet of streets					
		Residential		Site		Total				Total		In good condition			
Mean number of park uses per housing unit	Rank	Calls per housing unit	Rank	Calls per housing unit	Rank	Calls per housing unit	Rank	Crimes per housing unit	Rank	Linear feet per housing unit	Rank	Linear feet per housing unit	Rank	Percent of all streets	Rank
.057	2	.0189	6	.0396	3	.0585	4	.0649	7	109.9	2	69.9	2	63.6	2
.022	4	.0636	1.5	.0256	4	.0479	6	.1097	5	101.6	3	50.4	4	49.6	5
.026	3	.0564	3	.0129	6	.0693	2	.1838	1	64.5	6	24.8	5	38.5	6
.009	6	.0219	5	.0109	7	.0329	7	.1550	3	35.3	7	18.2	6	51.6	4
.013	5	.0402	4	.0158	5	.0561	5	.1101	4	82.7	5	59.4	3	71.8	1
.059	1	.0636	1.5	.0636	1	.1261	1	.1818	2	90.9	4	14.9	7	16.8	7
0	7	.0181	7	.0454	2	.0636	3	.0727	6	126.8	1	73.2	1	57.8	3
-5		-4		+11		-1		+3		+15		+15		+5	
.281		.281-.386[3]		.068		.500		.386		.015		.015		.281	
-.2381		-.1905		.5238		-.0476		.1429		.7143		.7143		.2381	
0		.52		2.69		.89		.96		2.24		2.57		.10	

[3]When tied ranks yield S values not reported in the table, the probability for the values above and below the calculated value are reported.

Source: United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P-4; United States Department of Commerce, Bureau of the Census, 1970 Census data tapes, Oklahoma State University Computer Center; City of Stillwater, Oklahoma, Neighborhood Analysis for the City of Stillwater, Oklahoma, James M. Mayo, editor, Stillwater, Oklahoma: City of Stillwater, Oklahoma, September 1971, pp. I-1 through I-9; Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71; Boomer Lake Generating Station, Stillwater, Oklahoma, Production records for fiscal year 1970-71; Anna Coe Crum, "Urban Park Planning: A Case Study of Stillwater, Oklahoma," unpublished M.S. thesis, Oklahoma State University, May 1973.

TABLE XLII

ACCRUAL OF BENEFITS FROM MUNICIPAL SERVICES
(AVERAGE VALUES SUBSTITUTED FOR ZERO VALUES)

	Independent Variables				Tract Characteristics							
	Median annual income of families & unrelated individuals		Median annual[1] electric bill				Fire service calls				Feet of streets	
Tract	Income	Rank	Bill	Rank	Total[2] housing units	Total use of parks	Residential	Site	Total	Total crimes reported	Total linear feet	Linear feet in good condition
1	$9,591	1	$215.19	3	1110	57	21	44	65	72	121,985	77,585
2	4,918	4	227.98	2	1440	32	32	37	69	158	146,250	72,600
4	2,862	6	149.54	5	620	16	35	8	43	114	39,990	15,380
5	1,237	7	145.21	6	910	8	20	10	30	141	32,090	16,560
6	7,385	2	204.78	4	1390	17	56	22	78	153	115,020	82,630
8	4,474	5	129.38	7	880	52	56	55	111	160	79,990	13,155
9	7,087	3	255.62	1	130	0	2	5	7	8	16,480	9,520

Kendall rank correlation test for the relationship between median annual electric bill and benefits from municipal services	S
	p(S)
	τ

$$\varepsilon = \frac{\dfrac{\delta(p_e \cdot e)}{p_e \cdot e}}{\dfrac{\delta B_2}{B_2}}$$

[1]Average values substituted for zero values in inactive Rate Class IV accounts in the count to determine the median.

[2]Total housing units is based on an adjustment of group quarters reported in the census to housing units by using an index of household size for that tract.

TABLE XLII, Continued

Dependent Variables															
Park use		Fire service calls						Crimes reported		Feet of streets					
		Residential		Site		Total				Total		In good condition			
Mean number of park uses per housing unit	Rank	Calls per housing unit	Rank	Calls per housing unit	Rank	Calls per housing unit	Rank	Crimes per housing unit	Rank	Linear feet per housing unit	Rank	Linear feet per housing unit	Rank	Percent of all streets	Rank
.057	2	.0189	6	.0396	3	.0585	4	.0649	7	109.9	2	69.9	2	63.6	2
.022	4	.0636	1.5	.0256	4	.0479	6	.1097	5	101.6	3	50.4	4	49.6	5
.026	3	.0564	3	.0129	6	.0693	2	.1838	1	64.5	6	24.8	5	38.5	6
.009	6	.0219	5	.0109	7	.0329	7	.1550	3	35.3	7	18.2	6	51.6	4
.013	5	.0402	4	.0158	5	.0561	5	.1101	4	82.6	5	59.4	3	71.8	1
.059	1	.0636	1.5	.0636	1	.1261	1	.1818	2	90.9	4	14.9	7	16.8	7
0	7	.0181	7	.0454	2	.0636	3	.0727	6	126.8	1	73.2	1	57.8	3
-7		-7		+7		-3		-13		+13		+17		+11	
.191		.191		.191		.386		.035		.035		.0054		.068	
-.3333		-.3333		.3333		-.1429		-.6190		.6190		.8095		.5238	
0		3.38		.53		45.7		2.02		.53		6.25		3.24	

Source: United States Department of Commerce, Bureau of the Census, Income Characteristics of the Population: 1970, Unpublished Tracts, Sample Counts, P4-4, State 73, County 119, Table P-4; United States Department of Commerce, Bureau of the Census, 1970 Census data tapes, Oklahoma State University Computer Center; City of Stillwater, Oklahoma, Neighborhood Analysis for the City of Stillwater, Oklahoma, James M. Mayo, editor, Stillwater, Oklahoma: City of Stillwater, Oklahoma, September 1971, pp. I-1 through I-9; Finance Department, City of Stillwater, Oklahoma, Electric utility billing records for fiscal year 1970-71; Boomer Lake Generating Station, Stillwater, Oklahoma, Production records for fiscal year 1970-71; Anna Coe Crum, "Urban Park Planning: A Case Study of Stillwater, Oklahoma," unpublished M.S. thesis, Oklahoma State University, May 1973.

VITA

Dorothy Marie Mercer

Candidate for the Degree of

Doctor of Philosophy

Thesis: AN ECONOMIC ANALYSIS OF THE TECHNICAL, ALLOCATIVE AND EQUITY EFFECTS OF FINANCING MUNICIPAL GOVERNMENT FROM REVENUE OVER COST EARNED BY THE MUNICIPAL ELECTRIC UTILITY: A CASE STUDY OF STILLWATER, OKLAHOMA

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