WELFARE IMPLICATIONS OF PUBLIC SUBSIDY

TO RURAL WATER SYSTEMS

IN OKLAHOMA

By

SUKI KANG

Bachelor of Science
Seoul National University
Seoul, Korea
1972

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1984

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
December, 1987

WELFARE IMPLICATIONS OF PUBLIC SUBSIDY TO RURAL WATER SYSTEMS IN OKLAHOMA

Thesis Approved:

Dean F. Schreiner
Thesis Adviser

Daniel D. Badger

Raymond Joe Schatzer

Ronald L. Norman

Norman N. Durham
Dean of the Graduate College

ACKNOWLEDGEMENTS

I want to acknowledge one small achievement in my life to my late grandfather, Tong-Young Kang.

I am deeply indebted to many people without whom this work could not have been completed. I wish to express my sincere appreciation to my major adviser, Dr. Dean F. Schreiner, for his invaluable assistance and guidance at all stages of my research. Appreciation is also extended to the members of my advisory committee: Dr. Daniel D. Badger, Dr. Raymond J. Schatzer, and Dr. Ronald L. Moomaw.

Special appreciation is extended to the Departrment of Agricultural Economics for financial support and secretarial assistance. Thanks are expressed to Aida Buck for her typing skills and to Cloye Brower and Brenda Doss for their typing assistance. Thanks are also extended to the following people: computer staff in the Department of Agricultural Economics; librarians in the campus main library; Mr. Leo Hogan in the FmHA State Office; and officials of the sample of rural water systems and the FmHA district offices.

Sincere gratitude is expressed to my parents, brothers and sisters for their moral support, encouragement and financial support. My special affection is extended to my brother, Sang-Ki Kang who was imprisoned for political conscience when I left Korea four years ago.

I wish to express my love and appreciation to my wife, Inja, and my children, Jinwook and Minwook for their sacrifices and understanding. I dedicate this dissertation to Inja.

TABLE OF CONTENTS

LIST OF TABLES

Table		Page

LIST OF FIGURES

Figure | Page

CHAPTER I

INTRODUCTION

Characteristics of Rural Water Systems

Farmers Home Administration (FmHA) defines a rural water system as one which supplies water to a rural community with a population of 10,000 persons or less (Lawrence, 1980). It is a legal state entity created to serve consumers within its district boundaries (Oklahoma Water Resources Board, 1975). Rural water systems provide potable water to many rural areas and small communities. In 1982 such systems accounted for more than 95 percent of the nation's water systems but supplied water to less than 25 percent of the population (Stevie and Clark, 1982). In 1984-85 the Oklahoma Rural Water Association (ORWA) had about 460 systems as members (ORWA, 1984). However, there are more rural water systems than there are members of ORWA. They are operated as units of local government or as private corporations. In 1984-85, 83 percent of the rural water systems in Oklahoma were operated as units of local government while 17 percent were private corporations (ORWA, 1984).

The major beneficiaries of rural water systems are the household customers supplied with water. The households are heterogeneous in income level, occupation of household head, settlement motivation, type of residence, and other characteristics. According to a recent survey for a random sample of ORWA members (Dellenbarger, 1985), 36 percent of the households responding to the survey had annual household income less than $15,000 and 11 percent had annual income over $50,000. In the same survey professional and retired heads of household accounted for 38 percent of the total while the rest were farmers, laborers, and others. Farmers and farm laborers accounted for 11.5 percent. About 87 percent of the households resided in traditional one-family housing and 12 percent resided in mobile homes and other categories. The survey results showed that about 44 percent of the customers were motivated to live within the boundary of the system because of a desire for rural living.

The economic structure of rural water systems can be characterized as a natural monopoly generally with a public interest. A pure monopoly is said to exist if there is one, and only one, seller in a well defined market (Gould and Ferguson, 1980). Neither rivalry nor competition exists in the pure monopoly. Gould and Ferguson (1980) list four major circumstances that give rise to pure monopolies. (1) Pure monopolies can arise when raw material supplies are controlled or (2) when patent laws guarantee exclusive rights to produce certain commodities. (3) Monopolies arise when the minimum average cost of production occurs at a rate of output more than sufficient to supply the entire market at a price covering full costs. The monopoly situation in this case is called a natural monopoly. (4) Monopolies are created when government grants businesses the exclusive right to sell goods or services and in turn, the businesses agree to certain controls of market conduct. Such agreements are called market franchises.

A rural water system can be said to operate as a natural monopoly, a market franchise permitted by government, and partly as the controller of raw material supplies (for example, owning a lake). The pure monopoly condition of a rural water system is reinforced by the fact that there is no substitute for water.

Of course, indirect competition may come from wells or ponds owned by consumers but this is generally negligible in the market as a whole. In the Dellenbarger survey (1985), about two percent of household water and about 25 percent of nonhousehold water came from alternative sources.

A rural water system is generally characterized as a decreasing cost enterprise (Myoung, 1982; Myoung and Schreiner, 1984; and Fox and Hoffler, 1986). The supply of water meets its demand at the point where average cost is higher than marginal cost. Pricing is then generally done monopolistically by individual water system but no profit is allowed under government regulation. A second degree price discrimination is practiced by the overwhelming majority of rural water systems due to its unique cost characteristics. That is, the monopolistic rural water systems are selling blocks of water, charging the highest price for the initial block and selling additional blocks at successively lower prices.

Rural water systems, as public utility industries, are generally "affected with a public interest." Garfield and Lovejoy (1964) distinguish public utilities from other businesses also affected with a public interest in that they are:

(1) free from business competition to a substantial degree, and are often pure monopolies;

(2) required to charge only reasonable rates that are not unjustly discriminatory;

(3) allowed to earn but are not guaranteed a reasonable profit;

(4) obligated to provide adequate service to the entire public on demand; and,

(5) closely associated with the processes of transportation and distribution.

In addition to the general characteristics of public utilities, rural water systems have more features than those stated above, as described by Fletcher (1979) and include:

(1) Demand elasticities that differ among the various groups of customers of the company, making it highly profitable for the company to discriminate in setting prices or rates;

(2) Wide swings in the demand for the service provided;

(3) Customers connected physically to the suppliers; and,

(4) A vital need by the customer for the output from the supplier.

Since rural water systems are affected with public interest they are frequently regulated and financially supported by the government. In Oklahoma, rural water systems are regulated by "Rural Water Districts Acts"[1] enacted in 1963, and by subsequent amendments.

Problem Statement

The Consolidated Farm and Rural Development Act[2] authorizes FmHA to provide grants and long-term, low interest loans for the installation, repair, improvement, or expansion of a rural facility.[3] The FmHA provides grant and loan funding up to 75 percent of an eligible project's cost. The grant and loan funds also can be used for the costs of distribution lines, wells, pumps, and related facilities, and under specified conditions can be used to purchase

[1]House Bill No. 837, 12 June, 1963, Oklahoma Session Laws, pp. 359-365.

[2]PL 92-419, 30 Aug. 1972, United States Statutes at Large 86, pp. 657-677.

[3]Public programs for subsidy to rural households in water consumption through rural water systems is hereafter called STRWS (Subsidy to Rural Water Systems).

existing systems or to pay renovation costs of existing systems.

The median family income level of the people residing in an area served by a rural water system is used in determining the amount of grant funds made available and the interest rate charged. A poverty line interest rate of five percent is used if median income for the system is less than the poverty level of income as prescribed by the Office of Management and Budget (OMB). An intermediate rate is used if median family income is greater than poverty level income but not more than 85 percent of the nonmetropolitan median household income of the State. The market interest rate will be applied to all loans that do not qualify for poverty line rate and intermediate rate. In addition to programs of the FmHA, the Oklahoma public has recently approved a plan to provide loan guarantees for cities and rural water systems to obtain bond financing at the most favorable rate consistent with backing of the State of Oklahoma.

Since the initiation of public subsidy for rural water systems, the subsidized amounts have been substantial. The cumulative amounts provided by FmHA nationally through September, 1986 amounted to $2,896 million for 13,327 applications in grants and $9,132 million for 27,957 applications in subsidized loans (FmHA, 1987). Average size grant and subsidized loan per application was about $217,000 and $327,000, respectively.

The above data indicate a substantial public interest in rural water systems. The major benefactors are the 25 percent of household customers living in rural places. However, because of grants and loans provided by federal and state agencies, the entire nation and state has a public interest in seeing whether such funding is used to meet the goals of public subsidy to rural water systems.

The beneficiaries of rural water systems are quite heterogeneous but can easily be grouped by their economic characteristics and settlement motivation.

The recent survey by Dellenbarger (1985) for Oklahoma indicates that the average income of rural water system households sampled in 1983 was $22,500 which was only slightly lower than household income for all of Oklahoma at $24,250 for the same year. It was also revealed that 11 percent of the rural water system households sampled had annual incomes of over $50,000, and 36 percent had incomes less than$15,000. This may raise a question from the public whether all rural water system households need to be subsidized since many such households have annual incomes close to or higher than the typical taxpayer providing such subsidies.

About half of the rural water system households were motivated in location choice by a desire for rural living. This motivation could be due to locational benefits such as low rent, low land prices, and/or high psychic satisfaction from rural environments, which outweigh the costs of commuting, transportation, increased probability of traffic accidents, higher fire insurance rates, etc. These groups may also be subsidized from the public for their water consumption. Another question from the public could be whether the provision of public subsidies to these groups benefiting from locational preference is efficient, resulting in improved social welfare.

Thus, the policy makers need to know the current performance of public subsidy programs to rural water systems and other economic information to establish strategies for possible improvement of such programs. Little attempt has been made to evaluate the efficiency of such public programs.

Purpose and Objectives

The purpose of this research is to provide policy makers with information about the performance of public subsidies to rural water systems in meeting specified social goals. The primary objectives are to: (1) measure the distribution of benefits generated from the subsidy programs among major socio-economic groups within rural water systems; (2) evaluate social benefits and costs of the subsidy programs; and, (3) provide economic strategies for bringing about improved efficiency in the use of such public subsidies.

Specific objectives include:

(1) examine government statutes and documents associated with public goals, policies, and forms of public subsidies to rural water systems;

(2) review concepts and economic theories of public subsidy and relate to rural water systems;

(3) formulate theoretical models to evaluate efficiency of public subsidies to rural water systems;

(4) empirically estimate and evaluate results of models for efficiency of public subsidy programs;

(5) provide economic strategies for the improved efficiency of public subsidy programs to rural water systems;

(6) examine policy implications of the above analytical and empirical results for government policy makers.

Plan of Presentation

Chapter II examines economic rationale of public subsidy and subsidy policy for rural water systems in the U.S. and Oklahoma. The concept and history of cost-benefit analysis (CBA)[4] are discussed. Finally, rationale for the use of CBA in this study is presented. Chapter III outlines a theoretical

[4]There is no general agreement in the use of this terminology. Benefit-cost analysis is also used. This study uses cost-benefit analysis simply because it is familiar to the author.

framework for analysis of the subsidy program. Chapter IV provides specification of rural water demand models and empirical results of demand estimation. Chapter V presents results of measurements of the benefits and costs to society under the Subsidy to Rural Water Systems (STRWS). Chapter VI provides economic strategies for the improved efficiency of the STRWS program. Chapter VII presents a summary of the research, conclusions, and policy implications. Limitations of this research, and suggestions for further work are discussed.

CHAPTER II

ECONOMICS OF PUBLIC SUBSIDY FOR RURAL WATER SYSTEMS

This chapter discusses the economic rationale for public subsidies to rural water systems. A review of public policies governing rural water systems is provided. The use of cost-benefit analysis (CBA) in evaluation of government programs is reviewed. Finally, the use of CBA in this study is briefly outlined.

Economic Rationale for Public Subsidy

Definition of Public Subsidy

A public subsidy is defined as "a transfer payment; a payment other than one made in consideration of services rendered or factors or goods supplied at the order of payer, to a firm, factor owner, or household that is conditioned on some actions by the recipient and is designed to induce a change in relative prices (market prices, or price to seller or to buyer) of a good, or service, or a factor, or a group of goods or services or factors" (Shoup, 1972, p. 55). Subsidy is distinguished from welfare payment which is not conditioned on desired action by the recipient household, firm, or owner of a factor of production.

A subsidy may be provided in different ways. It may be provided in cash or in kind. It may be a tax subsidy, credit subsidy, or lump sum subsidy depending on its financial supportive form. It may be provided to producers or to consumers depending on the policy objectives of society. It could be provided for purposes of activity increasing or activity decreasing depending on externalities generated by the economic units.

Allocation of Resources in Competitive Markets

A resource allocation may be described as specific consumption levels for each consumer, and specific input and output levels for each producer (Henderson and Quandt, 1980). A resource allocation is said to be Pareto optimal when resources are allocated such that production and consumption can not be reorganized to increase utility of some individuals without decreasing the utility of others. In competitive markets resource allocation is consistent with Pareto optimality which defines economic efficiency of resource allocation that serves as the basis for much of welfare analysis. Following Henderson and Quandt (1980), this can be illustrated as below.

First, consider Pareto optimality for consumption where reallocation of goods that increases the utility of one or more consumers would result in a utility reduction for at least one other consumer. Thus Pareto optimality will be obtained if each consumer's utility is at a maximum given the utility levels of other consumers. Suppose there are only two consumers, A and B, and two goods, Q_1 and Q_2. The utility functions of the two consumers are denoted as $U_A(q_{A1}, q_{A2})$ and $U_B(q_{B1}, q_{B2})$ where $q_{A1} + q_{B1} = q_1^o$ and $q_{A2} + q_{B2} = q_2^o$. Assume that consumer B enjoys the constant utility level, q_B^o. Then the Lagrangian objective function for utility maximization of consumer A is formed as:

$$U_A^* = U_A(q_{A1}, q_{A2}) + \gamma[U_B(q_1^o - q_{A1}, q_2^o - q_{A2}) - U_B^o] \qquad (2.1)$$

where γ is a Lagrange multiplier. The first-order condition gives:

$$\partial U_A^*/\partial q_{A1} = \partial U_A/\partial q_{A1} - \gamma\partial U_B/\partial q_{B1} = 0 \qquad (2.2)$$

$$\partial U_A^*/\partial q_{A2} = \partial U_A/\partial q_{A2} - \gamma\partial U_B/\partial q_{B2} = 0 \qquad (2.3)$$

$$\partial U_A^*/\partial \gamma \quad = U_B(q_1^o - q_{A1}, q_2^o - q_{A2}) - U_B^o = 0 \qquad (2.4)$$

Solving (2.2) and (2.3) gives

$$\partial q_{A2}/\partial q_{A1} = \partial q_{B2}/\partial q_{B1} \qquad (2.5)$$

This result shows that marginal rates of substitution must be equal between the consumers to achieve Pareto optimality in consumption. The condition (2.5) also holds when the utility of B is maximized given a constant level for A's utility.

Next, consider Pareto optimality for production. If consumers are insatiate and each individual's utility level is independent of the quantities of goods consumed by others, an increase of any consumer good without a decrease of any other consumer good can lead to a utility increase for at least one consumer without utility decrease for others. Thus, Pareto optimality for production will be obtained when the output level of each consumer good is at a maximum given the output levels of all other consumer goods. Suppose there are only two producers, A and B, producing goods, q_A and q_B respectively, using two inputs, x_1 and x_2. The production functions for the producers are specified as:

$$q_A = f_A\,(x_{A1}, x_{A2}) \text{ and} \qquad (2.6)$$

$$q_B = f_B\,(x_{B1}, x_{B2}) \qquad (2.7)$$

where $x_{A1} + x_{B1} = x_1^o$ and $x_{A2} + x_{B2} = x_2^o$ are the input quantities available. Assume that producer B is at the constant level of output, q_B^o. Then the

Lagrangian objective function for output maximization of producer A is formed as:

$$V_A^* = f_A(x_{A1}, x_{A2}) + \lambda[f_B(x_1^o - x_{A1}, x_2^o - x_{A2}) - q_B^o] \qquad (2.8)$$

where λ is a Lagrange multiplier. The first-order condition gives:

$$\partial V_A^*/\partial x_{A1} = \partial f_A/x_{A1} - \lambda\partial f_B/\partial x_{B1} = 0 \qquad (2.9)$$

$$\partial V_A^*/\partial x_{A2} = \partial f_A/x_{A2} - \lambda\partial f_B/\partial x_{B2} = 0 \qquad (2.10)$$

$$\partial V_A^*/\partial \lambda \quad = f_B(x_1^o - x_{A1}, x_2^o - x_{A2}) - q_B^o = 0 \qquad (2.11)$$

Solving (2.9) and (2.10) gives:

$$\partial x_{A2}/\partial x_{A1} = \partial x_{B2}/\partial x_{B1} \qquad (2.12)$$

This result shows that rates of technical substitution of producers needs to be equal to achieve Pareto optimality in production.

Finally, a similar approach can be used to derive the condition that allows Pareto optimality for product-mix. The condition is:

$$\partial q_{A2}/\partial q_{A1} = \partial x_{B2}/\partial x_{B1} \qquad (2.13)$$

where the left hand side is the marginal rate of substitution for consumer A and the right hand side is the marginal rate of transformation for producer B in the economy of two goods, q_1 and q_2 (Just, Hueth and Schmitz, 1982).

Economic theory shows that under competitive market equilibrium each utility maximizing consumer equates marginal rate of substitution of good i for another good j to the price ratio of the goods, while each profit maximizing producer equates marginal rate of transformation of a good i for another good j to the price ratio of the goods. Since all consumers and producers face the same set of prices for the same set of goods in competitive markets, the following conditions are obtained:

$$MRS_{ij}^{i} = \ldots = MRS_{ij}^{n} = P_i/P_j = MRT_{ij}^{i} = \ldots = MR_{ij}^{m} \qquad (2.14)$$

where MRS_{ij}^{n} denotes marginal rate of substitution of good i for j with individual n; P_i and P_j are market prices of i and j; and MRT_{ij}^{m} represents marginal rate of transformation of good i for j with producer m.

Comparison of (2.5), (2.12) and (2.13) with (2.14) shows that the conditions for Pareto optimality are fulfilled in competitive markets. Thus resource allocations in competitive markets are consistent with maximum welfare in the sense that the requirements of Pareto optimality are met.

However, perfectly competitive markets rarely exist in reality. Market failures are quite common. Market failure exists in an economy because of the existence of public goods and externalities, the presence of decreasing cost industry, incomplete information, and uncertainty (Brown and Jackson, 1982). In addition, competitive markets may fail to provide equity and "merit wants" (Atkinson and Stiglitz, 1980). The merit wants as called by Musgrave (1959) are goods whose "goodness" or "badness" are judged by the government, and the goods are encouraged or discouraged by the government depending on its judgement.

In the event of market failure, government frequently intervenes to improve the performance of the market system. The government may play an allocative role as well as a distributive role (Musgrave, 1959). The government may intervene in the market to correct market failure in its allocative function. It may intervene in the market to bring about a distribution of incomes considered more socially desirable. However, it is possible that government intervention itself may be inefficient if the problems which beset the market mechanism and prevent it from allocating resources efficiently also beset government.

In general, the rationale for government intervention based on market failure rests on the basic acceptance of an individualistic view of society's goals

(Boadway and Wildasin, 1984). That is, the intervention may be intended to achieve the efficiency of resource allocation which is to be judged ultimately by the Pareto optimality principle having reference to social preferences of all the individuals that make up the society.

Intervention may take place in several forms such as taxation, regulation, government production, and subsidization through government expenditure. Specifically, subsidization is called for when external economies exist but where excludability is possible, or where scale economies appear to exist (Cohn, 1972).

Potential for Market Failure with Rural Water Markets

Potential for market failure with rural water markets stems from the characteristics of a natural monopoly. That is, the technology associated with water supplying firms makes the minimum efficient size of a single firm so large relative to market size that it would not be economically feasible for additional water supplying firms to enter, thus eventually leading to the existence of only one monopolistic water supplying firm in a given market area. This situation occurs when (1) the size of market is small relative to the most efficient size of a firm in that market; (2) the firm's production function shows increasing returns to size or decreasing cost to size; and, (3) the firm's long-run average cost curve shows economies of size throughout all economically feasible output levels (Leftwich and Eckert, 1985).

When there exists only one water supplying firm in a given rural market as a form of natural monopoly, the profit maximizing firm restricts quantity of water supplied to the point where marginal revenue intersects marginal cost and prices where demand meets the restricted water supply. The firm may discriminate among groups of rural consumers and may exclude or deny hook-ups to consumers if it is to the profit interests of the firm. Equity or benefit distribution among consumers may not be important to the firm and thus ignored. There may also exist uncertainty in the supply of (raw water) water resources to the firm. Water supply to a customer or group of customers may be cut off for purposes of efficiency of water management. These market situations may not be consistent with Pareto optimality due to violation of competitive market conditions and negligence of distributional equity among consumers.

Rural household water markets are frequently intervened through government regulation, taxation, direct production, and/or subsidization. Regulations require that rural water systems make no profits, reasonably price the product, and have no unjust discrimination among customers. Government frequently allows monopoly of water supply by allowing only one rural water system in a given rural market area. Rural water systems are generally exempted from taxation. Some local governments operate water systems directly. Subsidization is provided to many rural water systems.

The economic rationale for these forms of intervention may be intended to correct market failure and to bring results of rural household water markets closer to Pareto optimality having reference to social preferences.

This study concerns the welfare evaluation of government intervention in rural household water markets in the form of subsidization. The Consolidated Farm and Rural Development Act[1] Section 306 allows FmHA to provide subsidies in the form of grants and low interest loans to rural water systems. The new state of rural household water markets after the public subsidy may

---

[1]PL 92-419, 30 Aug. 1972, United States Statutes at Large 86, pp. 657-677.

cause change of resource allocation and distribution of market benefits. This needs to be evaluated since it may be important for the decision makers or the public to know whether the subsidy brings the rural household water markets closer to Pareto optimality. The evaluation is carried out with the use of social cost-benefit analysis (CBA) which is commonly used as an efficiency criterion in policy analysis (Tweeten, 1979). The concept and history of CBA is discussed in the last part of this Chapter.

Policies Governing Rural Water Systems

Federal Policy (FmHA, 1985)

In 1937 the Water Facilities Act (WFA) was enacted to provide loans to individuals and associations of farm water systems in 17 western states where drought and water shortage was a constant hardship. This Act was the beginning of rural water programs now administered by FmHA.

In 1940 the first loan was made to a small group of Idaho farmers for $1,600. The WFA was amended in 1954 to be applied nationwide, rather than to be limited to the 17 western states. The amendment also let farm area water systems take on nonfarm customers in rural communities.

In 1961 WFA was incorporated into the newly enacted Consolidated Farmers Home Administration Act, which opened the water system program to the general rural population, including incorporated towns of up to 2,500 population. The limit per loan was raised from $250,000 to $500,000 for a direct FmHA loan and to $1,000,000 for an insured loan.

In 1965 the loan limit was raised again to $4,000,000 per project. At the same time, the loan program was transformed into a loan-and-grant program for both water and waste disposal systems. Population size for loan eligibility was increased form 2,500 to 5,500. In 1968 Congress raised the national total authorization for water and waste disposal grants from $50 million to $100 million a year.

In 1970 legislation removed technical barriers in the use of FmHA insured funds, rather than direct appropriated funds, for loans to tax-exempt public bodies such as municipalities and public service districts. This amendment marked the beginning of a period for increased service to small towns.

In 1972 the Rural Development Act (RDA) abolished the loan limit of $4 million per project on FmHA financed water and waste disposal systems. The RDA increased the national grants authorization to $300 million a year. It also raised the population limit on towns eligible for FmHA financed systems to 10,000. In 1978 the Agricultural Credit Act (ACT) increased the maximum allowable grant for water and waste disposal projects from 50 percent to 75 percent.

In 1980 the Rural Development Policy Act increased FmHA's annual authorization for planning grants which had been authorized by the Rural Development Act of 1972. Since 1980, Federal Policy on rural water systems has appeared stable.

Oklahoma Policy (Oklahoma Water Resources Board, 1980)

The Oklahoma Rural Water District Act (ORWDA)[2] enacted in 1963 was the first Oklahoma legislation allowing organization, formation, and operation of public non-profit rural water districts. The purpose of the Act was to develop and provide rural water supply facilities adequate to serve the needs of rural

---

[2]Senate Bill No. 837, 12 June, 1963, Oklahoma Session Laws, pp. 359-365.

residents. Boards of county commissioners were given the authority to incorporate and organize rural water districts. The districts were empowered to borrow money and accept grants from the Federal government and to secure the payment thereof by mortgage, pledge or deed of trust of property, assets, franchise, rights, privileges, licenses, rights-of-way, easements, revenues or incomes.

Rural Water District No. 2 in Nowata County was organized in 1963 as the first non-profit rural water district in Oklahoma. The district was funded by a $65,760 loan at 3.8 percent interest from FmHA.

The ORWDA has expanded rural water district purposes over time to include water and sewage in 1965, solid waste management in 1972, and gas distribution in 1975. The current Oklahoma legislation under which rural water utility districts may be formed and operated as public non-profit organizations is known as the "Rural Water, Sewer, Gas and Solid Waste Management District Act."[3]

The Act requires the following four conditions for the formation of rural water districts:

(1) rural residents within the proposed district are without an adequate water supply to meet their needs;

(2) construction, installation, improvement, maintenance or operation of the water project is necessary to provide an adequate water supply to the rural residents;

(3) improvements or works will be conducive to and will promote the public health, convenience, and welfare; and,

---

[3]Senate Bill No. 145, 14 May, 1975, Oklahoma Session Laws, pp. 262-270.

(4) there is sufficient water available for purchase or available for appropriation by the Oklahoma Water Resources Board to serve the needs of the district.

Every district incorporated under the Act has perpetual existence, subject to dissolution as provided within the Act. Certain operative obligations are imposed on the districts: (1) each district must operate without profit; (2) the revenues of the district should be devoted first to the payment of operation and maintenance expenses, then to the principal and interest on outstanding obligations, and thereafter to such revenues for improvement, new construction, and related expenses as the Board of Directors in the districts may prescribe; and, (3) revenues left over after the above purposes should be returned to the customers on a pro rata basis.

Some privileges are also awarded to rural water districts: (1) water rate charges are exempted from the jurisdiction and control of the Oklahoma Corporation Commission; (2) the district is also exempted from all taxing levied upon the property of the district, whether real, personal or mixed; and, (3) securities and evidences of indebtedness issued by a district, and the income interest and capital gains thereon are not subject to income tax laws of the state and persons owning or holding securities and evidences of indebtedness or their heirs, devisees, successors, or assignees shall not be required to pay income tax upon the profits and capital gains upon such securities and evidences of indebtedness.

The largest rural water district in Oklahoma in 1986 served about 4,300 customers via a 2,000 mile distribution network. The smallest district served about 45 people via a 1.5 mile distribution network.[4]

---

[4]This information was obtained from Oklahoma Water Resources Board.

Allocation of Public Subsidy to Rural Water Systems

Major external sources of financing the construction and expansion of rural water systems are government agency loans, commercial loans, government agency grants, and municipal bonds. The federal agencies that provide loans are FmHA, the Housing and Urban Development Department (HUD), and the Economic Development Administration (EDA). Federal agencies providing grants are FmHA, HUD, EDA, Environmental Protection Agency (EPA), Department of Defense (DOD), and the Ozark Regional Commission (ORC).

A national survey (Francis, 1980) in 1978 showed that FmHA accounted for 93 percent of total government agency loans and 50 percent of total government agency grants. The average size loan in the survey from FmHA was $288,000 and the maximum was $4.9 million. The average size grant provided to a system was $231,000 with the maximum of $1.1 million in 1978 value. Federal agency loans accounted for 95.7 percent and state agency loans accounted for 0.6 percent while federal agency grants accounted for 69 percent, and state/regional grants accounted for 22 percent. Average repayment periods on loans from federal sources were 40 years and standardized interest rates[5] ranged from 4.0 percent to 15.4 percent. Average amounts of loans obtained from private financial institutions were $76,000 with average interest rates of 9.8 percent. The FmHA loans provided to rural water systems through September 1986 reached $9,132 million for 27,957 loan applications and $2,896 million for 13,327 grant applications.

State financing is also available in Oklahoma (Oklahoma Water Resources Board, 1980). Rural water districts may generate funds by issuing tax-exempt

---

[5]Standardized Interest Rate = [Actual Interest Rate (t)/long-term government bond yield (t)] x 7.89]. This interest rate reflects the rates FmHA would have charged if all loans were made in 1978.

municipal bonds or notes. A portion of sales taxes can be earmarked for financing or can be applied to retire general obligation bonds or revenue bonds or notes. A state loan program is available through Title 82 O.S. 1979, Section 1085.31, et. seq.[6] The Oklahoma Water Resources Board (OWRB) is authorized to administer the loans for constructing water storage projects, distribution systems, and water treatment facilities, as well as sewage treatment facilities. Grants are also available under S.B. 215[7] with the passage of H.B. 1710.[8] This Bill authorizes OWRB to make grants up to $50,000 for eligible projects. The Oklahoma office of FmHA provided $271.1 million for 1,345 loan applications and $74.9 million for 514 grant applications from 1963-1986.[9] This implies an average of $201,561 per loan and an average of $145,720 grant during the period. A cumulative total of 533,725 families were served through the FmHA loans and grants during the period.

Evaluating Public Programs Using Cost-Benefit Analysis

Concept and History of CBA

The definitions of cost-benefit analysis (CBA) are many. CBA is a technique for assessing the economic utility of a public investment (Burkhead

---

[6]Senate Bill No. 215, 31 May, 1979, Oklahoma Session Laws, pp. 627-630.

[7]Senate Bill No. 215, 31 May, 1979, Oklahoma Session Laws, pp. 627-630.

[8]House Bill No. 1710, 7 April, 1980, Oklahoma Session Laws, pp. 308-311.

[9]This information was obtained from documents of the FmHA State Office.

and Miner, 1971). CBA refers to the measurement of the net economic benefits from any change in resource allocation (Boadway and Wildasin, 1984). CBA is a practical way of assessing the desirability of projects (Brown and Jackson, 1982). CBA is an estimation and evaluation of net benefits associated with alternatives for achieving defined public goods (Sassone and Schaffer, 1978). Evidence shows CBA is a broad concept and with wide applications in practice.

In the most general sense CBA includes all techniques for program or project evaluation that involves systematic comparison of benefits and costs in the context of an implicit or explicit objective function (Burkhead and Miner, 1971). Thus CBA can be applied to public programs as well as to private business. However, it is common to refer to CBA in private investment decisions as capital budgeting and to public programs as cost-benefit analysis. CBA is usually confined to public projects because it weighs up social gains and losses (Dasgupta and Pearce, 1972). From these concepts the following interpretations and applications of CBA are delineated.

(1) CBA is not confined only to evaluation of alternatives. It is also applied to whether a program should be implemented or not, that is, "go or not go" decision.

(2) CBA is not confined only to investment projects. It is applied to broad policy areas such as public expenditure, taxation, and regulation.

(3) CBA is also used to evaluate current on-going programs to determine whether the capacity of existing programs should be extended or cut and by how much (Mishan, 1976).

(4) CBA is an aid for decision makers in policy issues. It may inform the decision makers as to which one from a series of alternatives is socially preferred or whether a policy should be implemented or not.

CBA can thus be defined as an analytical technique to aid policy makers in decision making for public policy in terms of social benefits and costs, which have implicit and explicit social objectives.

The concept of CBA was initiated in 1844 by Dupuit (Sassone and Schaffer, 1978) when he pointed out that the output of a project multiplied by the price is equal to the minimum social benefit. But it is generally considered that general application of CBA started with enactment of the United States Flood Control Act in 1936. This Act suggests the principle that flood-control projects should be deemed desirable if the benefits, "to whomever they may accrue", exceed the estimated costs. However, the Act provided no consistent analytical method to examine costs and benefits (Sassone and Schaffer, 1978).

In 1950 the U.S. Federal Inter-Agency River Basin Committee issued "Proposed Practices for Economic Analysis of River Basin Projects," subsequently called the "Green Book". This Book attempted to lay down guidance on the use of CBA (Pearce and Nash, 1981).

In 1952 the Bureau of the Budget in the U.S. issued its Budget Circular A-47, which would guide the Bureau in the assessment of proposed programs. The Circular was criticized for its emphasis on gains and losses as measured by changes in GNP and for ignoring income distribution issues (Sassone and Schaffer, 1978). Circular A-47 remained the official guide for project evaluation into the 1960's.

Budget Circular A-47 was replaced by Senate Document 97 in 1962 which again was replaced in 1973 by "Principles and Standards for Planning Water and Related Land Resources," which mainly updated policies, standards, procedures relating to cost allocation, reimbursement, and cost sharing. In 1983, the above Principles and Standards were repealed and replaced by "Economic and Environmental Principles and Guidelines for Water and Related

Land Resources Studies" which contains currently available methods for calculating the costs and benefits of water resources development alternatives to ensure proper and consistent planning by Federal agencies in the formulation and evaluation of water and related land resources implementation studies. In the 1960's the emphasis was on the principle of allocative efficiency. In the 1970's, due regard was paid, in theory and practice, to the fact that social objectives as well as pure allocation efficiency are legitimate goals (Pearce and Nash, 1981).

CBA and Welfare Economics

Welfare economics focuses on using resources optimally so as to achieve the maximum well-being for individuals in society (Just, Hueth and Schmitz, 1982). CBA is based on welfare economics. Welfare economics involves two major issues: (1) measurement of social welfare change due to new government policies; and, (2) identification of social objectives or preferences to be satisfied by the policies. These two issues are also core areas of CBA.

The concept of social welfare and its measurement has a long history. Ricardo (1829) introduced the concept of economic rent when discussing the effects of England's "Corn Laws" passed by British Parliament in 1815. Then, Dupuit (1844) coined the notion of consumer surplus in the analysis of the effects of building a bridge. In Dupuit's way price is placed on the horizontal axis and quantity on the vertical axis as shown in Figure 1. Suppose p_1, p_2 and p_3 represent various prices for a commodity, and q_1, q_2 and p_3 represent quantities of the commodity consumed corresponding to the prices. Then, a curve connecting $s_1s_2s_3$ is constructed. This is called a consumption curve (demand curve). The utility for consuming q_1 is at least p_1. According to Dupuit,

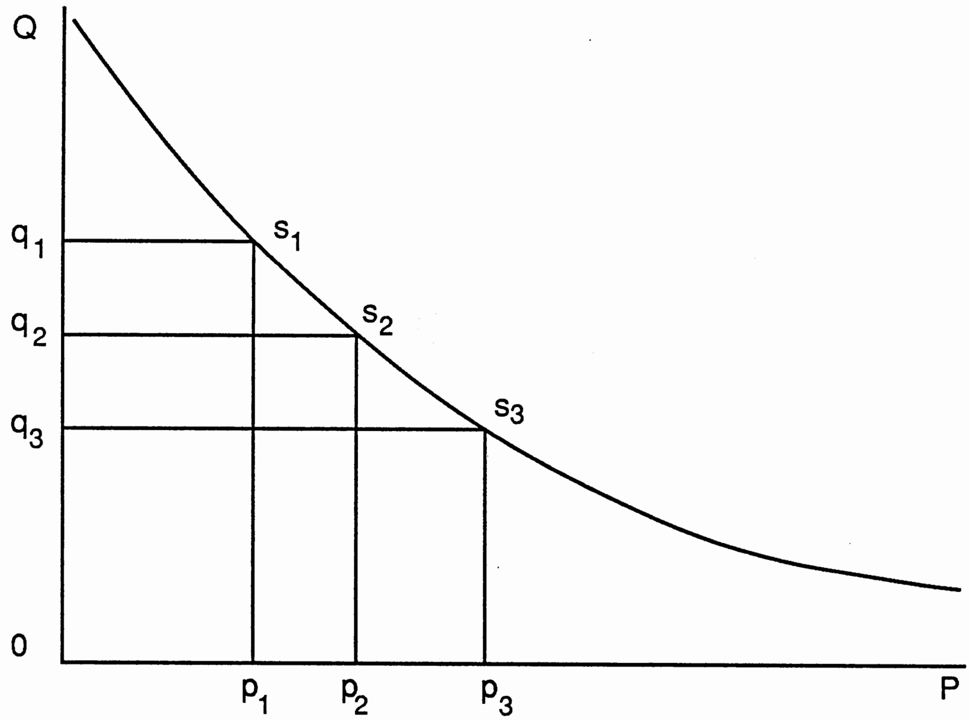


Figure 1. Dupuit's "Utility Remaining to Consumers".

the total area under the demand curve represents the total utility produced by the commodity. At the price p_1 the area under the demand curve and above the price p_1 is "utility remaining to consumers". The area which represents the total payment made by the consumer or firms receipts at price p_3 and quantity q_3 is called "producers' surplus" or "producers' rents". This theory was original in linking the demand curve with utility.

Marshall (1930, p. 124) developed these concepts more fully and named the concepts as consumer surplus. He described consumer's surplus as follows:

> The price which a person pays for a thing can never exceed, and seldom comes up to that which he would be willing to pay rather than go without it: so that the satisfaction which he gets from its purchase generally exceeds that which he gives up in paying away its price; and he thus derives from the purchase a surplus of satisfaction. The excess of the price which he would be willing to pay rather than go without the thing, over that which he actually does pay, is the economic measure of his surplus satisfaction. It may be called consumer's surplus.

This concept of consumer surplus has since formed the economic basis for empirical welfare studies. However, these concepts have been criticized by economists associated with the so called "new welfare economics". Samuelson (1942) showed that the basic welfare measure of consumer surplus is not well defined. He argued that consumer surplus is not generally a unique measure of utility of the individual, and that its uniqueness depends on the use of empirical data. Since this criticism, economists have been reluctant to use the concept of consumer surplus in welfare analysis without imposing restrictive assumptions until Willig (1976) demonstrated its economic reasonableness.

Social objectives or preferences in cost-benefit analysis are identified by three approaches: potential Pareto improvement, Pareto improvement incorporating distributional weighting system, and social welfare function.

Conventional CBA adopts potential Pareto improvement. Non-conventional CBA adopts Pareto improvement incorporating distributional weighting system. Social welfare function approach is theoretically accepted but is seldom used in practice.

Some theoretical and empirical aspects of the above two issues remain unresolved. A detailed discussion of the issues is provided in Chapter III.

Criticisms of CBA

Criticisms of CBA are centered on the problems of securing information, the immorality of valuing unique assets such as human life, and the ease of manipulation for political purposes (Pearse and Nash, 1981). Four systematic criticisms against the underlying philosophy of CBA are summarized by Pearce and Nash (1981) and discussed below: the liberal attack, the political science attack, the radical critique, and the management science approach.

Two major criticisms are distinguished from the liberal thought. The first is that the Paretian criterion is not consistent with liberal values based on the preservation of "negative freedoms" (Sen, 1970). The second is that Paretian welfare economics is not compatible with liberal welfare economics which is unwilling to pursue income redistribution objectives that involve the suppression or the destruction of markets (Peacock and Rowley, 1972).

Political science criticism of CBA stems from replacing political decision-making with a "mechanistic calculus" that is frequently incompatible with political philosophies. The political system must not only deal with the allocative CBA but also with the distributional impacts (Wildavsky, 1966; and Self, 1977).

Criticism from the radical thought stems from the use of market prices as an appropriate expression of individual values (Hunt and Schwartz, 1972). Hunt and Schwartz criticize CBA because it proceeded from welfare economics and unresolved issues such as the Scitovsky reversal test; second best theory which seeks pricing rules for the controllable sectors of an economy, but given market distortion elsewhere; absence of risk and uncertainty; Arrow's impossibility theorem which states no social welfare function exists under certain conditions; and so on. Another criticism from the radicals is that CBA assumes that the prevailing income distribution is optimal.

The suggestion from management science is that the basic value judgement concerning individual preference should be reconsidered. If decision-makers themselves provide the valuations for costs and benefits then the gap between CBA and political decision-making would be largely removed.

These criticisms as summarized by Pearce and Nash (1981) deal mostly with an underlying philosophy of CBA. How the criticisms can be accomodated are debatable and beyond the scope of this study.

Use of CBA in This Study

Public subsidy to rural water systems (STRWS) is one form of government intervention in the rural household water market. Intervention is justified for the correction of market failure in a society where perfectly competitive market norm is considered to maximize social welfare. Policy makers want to know whether the subsidy policy to rural water systems actually increases social welfare and, if so, by how much.

CBA is frequently used in ex-post evaluation of on-going programs to determine whether such programs should be extended, contracted, replaced, or redesigned. CBA is used in this study to evaluate on-going subsidy programs for rural water systems and to investigate to what extent the programs achieve social objectives as defined in welfare economics. Information generated from the CBA should suggest improved strategies for subsidizing rural water systems in attaining defined social objectives.

CHAPTER III

COST-BENEFIT ANALYSIS OF PUBLIC SUBSIDY

This Chapter presents the theoretical framework for cost-benefit analysis (CBA) and subsidy benefit distributions among groups of individuals in rural areas. Major theoretical components of CBA are outlined. Models for estimating costs and benefits are proposed. Finally, methods for subsidy benefit distribution measurement are presented.

Major Components of CBA

Determination of Social Preferences

CBA has social preferences as its objective function. CBA generates economic information that aids the decision-makers in determining which policies are consistent with social preferences. The question is, how are social preferences defined and identified. Three possible approaches are discussed.

Conventional Approach (Dasgupta and Pearce, 1972)

In CBA each individual is assumed to weigh the advantages and disadvantages of a particular policy, whether the individual is a selfish rationalist or a pure altruist (Pearce and Nash, 1981). After weighing the advantages and disadvantages, the individual may show his preferences between alternative states facing him. Suppose he has two alternative states, A and B. He may prefer A to B, or B to A, or he may be indifferent between them.

The individual may obtain different levels of utility at each alternative state. Then, his preferences are revealed in a form of utility function as follows:

$$A \; p \; B \quad ====> \quad U(A) > U(B)$$

$$A \; i \; B \quad ====> \quad U(A) = U(B) \qquad (3.1)$$

$$A \; w \; B \quad ====> \quad U(A) \geq U(B)$$

where A and B are alternative states, and p, i, and w represent preferred, indifferent, and at least indifferent with possible preference for A, respectively. U(A) and U(B) represent utility derived from state A and state B.

The individual ranks several states in terms of his preferences which are incorporated in his utility function. That is, his utility function or utility level would dictate his choice of preferred state.

Measurement of utility is controversial. However, two approaches to the utility measurement are widely recognized: the cardinal measure and the ordinal measure. The cardinal measure of utility assumes that each individual is capable of assigning to every good or combination of goods a specific number representing the amount or degree of utility to be generated from it. Although there exist cardinalists, the dominant view is on the side of the ordinal measurement which states that utility is greater or lesser in one situation than in another. Thus ordinal utility is measurable in markets which eventually is linked to "benefits" in CBA.

Consider a two commodity space, x and y, and indifference curves U and U_1 for an individual in Figure 2. His budget is represented with MM_1. Then, the utility maximizing individual will move to the highest indifference curve tangent to his budget line which is at Z and choose y* and x* for his consumption bundle. At utility maximizing point Z the slope of U is $dU_y/dU_x = MU_y/MU_x$. However, the slope of the budget line, MM_1, is P_y/P_x which is the relative prices of P_x and P_y. Thus, the utility maximization condition for the individual is

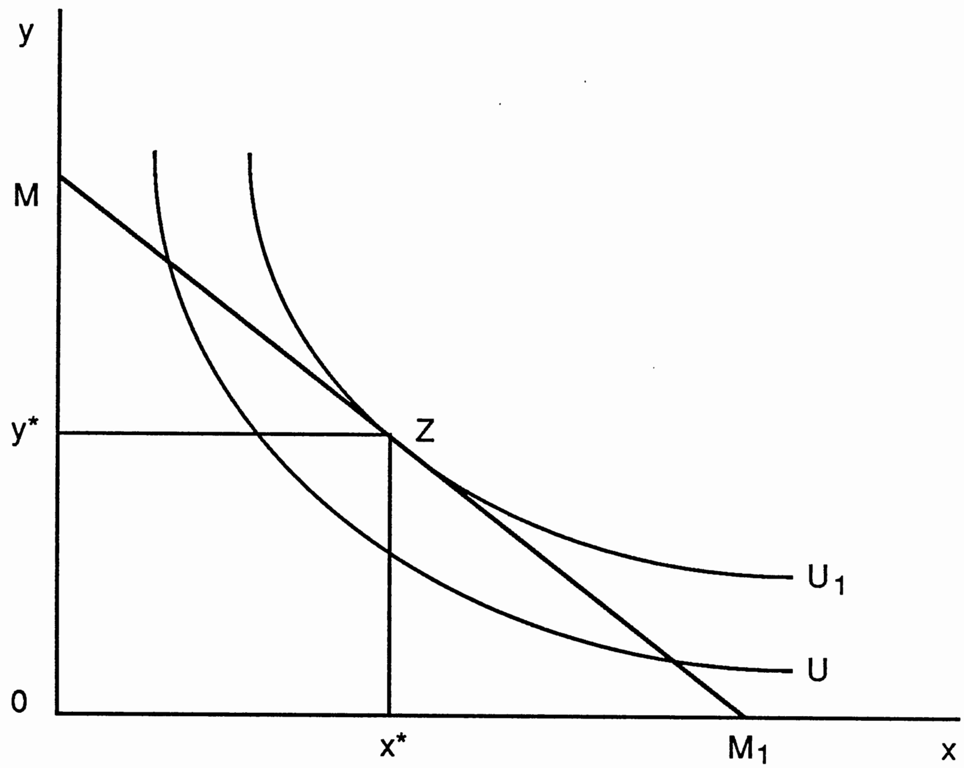


Figure 2. Price and Utility

$MU_y/MU_x = P_y/P_x$. By rearrangement, $MU_y/P_y = MU_x/P_x$. If we set $MU_x/P_x = 2$ for convenience, $MU_x = 2P_x$. This indicates that prices reflect the worth or utility of the commodities for the individual. If the individual pays P_x for x^* then he must be "willing to pay" this price for utility generated from x^*, which defines "benefit" in CBA. Thus, a relationship is obtained as follows:

marginal utility = price = willingness to pay = benefit (3.2)

However, CBA is concerned with social preferences. Simple aggregation of individual preferences does not necessarily represent preferences of society as a whole. Suppose there are three individuals, 1, 2, and 3, and two situations, A and B. One set of individual preferences could be:

$A \; p_1 \; B$

$A \; p_2 \; B$ (3.3)

$B \; p_3 \; A$

The majority prefer situation A to B. Then, the social preference would generate social welfare, SW, in a three person society, which can be expressed as $SW = sw[R_1 (A), R_2 (A), R_3 (A)]$, where $R(\cdot)$ indicates individual preference rankings. However each individual may have a different level of preference intensity thus generating different utility levels. If the preference intensity of individual 3 is more than the aggregate of preference intensity of individuals 1 and 2, then society could prefer B to A since $| -U_3 (A) | > | U_1 (A) + U_2 (A)|$ or $U_3(B) > U_1(A) + U_2(A)$. This approach weighs individual preferences and adds them up. Thus, SW is expressed as $SW = sw [(\alpha_1 \times R_1(A) + \alpha_2 \times R_2(A) + \alpha_3 \times R_3(A)]$ where the α's represent weights. This approach is based on the assumption of interpersonal comparison of utility. A difficulty arises, however, that there exists no single definitive unit of utility measurement. Thus, it is necessary to transform utility into willingness to pay. Then, from (3.1), (3.2) and (3.3):

$$A\ p_1\ B \Longrightarrow U_1(A) > U_1(B) \Longrightarrow WTP_1(A) > WTP_1(B)$$

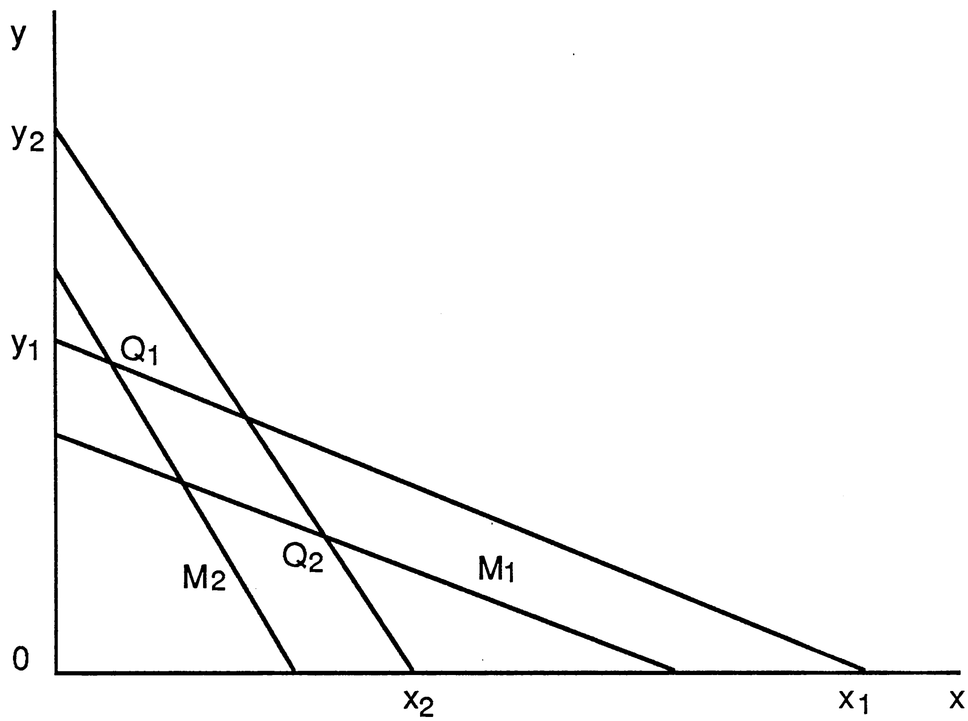
$$A\ p_2\ B \Longrightarrow U_2(A) > U_2(B) \Longrightarrow WTP_2(A) > WTP_2(B) \qquad (3.4)$$

$$B\ p_3\ A \Longrightarrow U_3(B) > U_3(A) \Longrightarrow WTP_3(B) > WTP_3(A)$$

The aggregation of the WTP may give social preferences of A over B or B over A, depending on the magnitudes of WTP for each individual. However, WTP does not fully reflect individual intensities of preferences since WTP depends partially on individual income.

In this approach some individuals may lose while others gain from a situation preferred by society. This approach contains the concept of compensation, which originated from Pareto welfare criteria. The Pareto criteria in determining social preferences of public policies states that policy should be made such that some people are made better off and no one is made worse off. Pareto argues that policy could be made if everybody prefers it on the "unanimity" basis. However, this criteria has been criticized because it is doubtful there is any policy that satisfies the unanimity rule. To overcome this problem Kaldor (1939) and Hicks (1939) suggested the "compensation principle" by which a policy is socially preferred if those who gain can compensate those who lose and still have some gains left over. This compensation principle revives the Pareto principle since it leaves the losers no worse off and others better off. This compensation principle suffers, however, from the case where two policies are preferable under the same criteria (Scitovsky, 1941).

This case can be illustrated with price lines on two commodity space as in Figure 3 (Dasgupta and Pearce, 1972) rather than with the Edgeworth diagram as done by Scitovsky. The Scitovsky paradox arises because the change in income distribution between situations alters the set of relative prices at different situations. In Figure 3, y_1x_1 and y_2x_2 represent price lines in situations 1 and 2,



SOURCE: Dasgupta, Ajit K. and D. W. Pearce. Cost-Benefit Analysis. Harper & Row Publishers, Inc., Britain, 1972.

Figure 3. The Scitovsky Paradox

respectively. The real income M_1 represents situation 2 quantity valued at situation 1 price and real income M_2 represents situation 1 quantity valued at situation 2 price.

Suppose quantity moves from Q_1 to Q_2. Then, change in real income valued at situation 1 price is $P_1Q_2 - P_1Q_1 < 0$, resulting in the preference of Q_1 over Q_2. However, if the move is valued at situation 2 price, the real income change is $P_2Q_2 - P_2Q_1 > 0$, resulting in preference of Q_2 over Q_1. This reversal leads to the double criterion suggested by Scitovsky, which states one policy is preferred to another policy only if the gainers from the change can compensate the losers and the losers can not bribe the gainers for not making the policy change. Arrow (1963) criticized that Scitovsky's double criterion contradicted the collective rationality, and restated that society is indifferent to two policies if reverses are possible. At any rate, this double criterion preserves the Pareto principle in that some people are made better off and nobody is worse off when compensation is made to losers.

The discussion so far has been based on the value judgement that individual preferences should be counted in identifying social preferences in an objective function. This implies that social preference is an aggregation of individual preferences. And the social preference is identified with Pareto principle (or potential Pareto improvement) regardless of whether actual compensation is made to losers or not. This approach has been the position of the "conventional" CBA.

<u>Non-Conventional Approach</u>

Conventional CBA has ignored the distributional effects of policy change in identifying social preferences and simply measured all gains and losses to society regardless of to whom they accrue. This approach has been justified by the use of the potential compensation test as a welfare criterion.

Some arguments are offered against this approach. If losers are not actually compensated then income will be redistributed, which destabilizes the link between the CBA maximand and social maximization (Dasgupta and Pearce, 1972). Another problem is that the aggregate of monetary gains and losses is not an accurate indicator of the satisfaction of compensation test (Boadway, 1976). And validity of the compensation test depends on whether ordinal utility curves before and after the policy intersect or not (Pearce and Nash, 1981). Due to political and economic structural reasons actual compensation can not be made in many developing countries, which may be inconsistent with Pareto optimality principle (Squire and van der Tak, 1984).

To complement the conventional approach, three options are possible (Dasgupta and Pearce, 1972). The first option is to prove that the income redistribution effect of a policy is not significant, thus ignoring the welfare effect of redistribution (Kurtillia, 1961; Eckstein, 1958). This argument ignores cumulative effects of policy and implicitly assumes optimality of existing income distribution. Furthermore, public policies in reality seldom have no distributional effects. The second option is to argue that the incorporation of income distribution would involve value judgement. The argument against this option would be that CBA itself involves one major value judgement, the count of individual preferences. The third option is to develop ways to allow for the distributional consequences of a policy either by trying to observe social preferences concerning distribution, or by other means. This third option is the non-conventional approach.

Social Welfare Function Approach

The concept of a social welfare function is the result of the continuous search for a rule that ranks all the alternatives and thus determines which first-best alternative represents the social optimum or preference (Just, Hueth and Schmitz, 1982). The social welfare function was first introduced by Bergson (1938). The Bergsonian social welfare function in a society of n individuals may be defined as $SW = sw(U_1, U_2, U_3, \ldots, U_n)$, where U_n denotes the utility index of the nth individual. The function simply means that the social welfare function is a function of the utility levels of all individuals in a society such that a higher value of the function is preferred to a lower one.

The concept of a social welfare function was criticized by Arrow (1963). Arrow specified five axioms required for a meaningful and valid social welfare function: the free triple condition, independence of irrelevant alternatives, non-negative association, non-imposition, and non-dictatorship. Then, he argued that no social welfare function which simultaneously satisfies the five axioms can exist, which is called Arrow's Impossibility Theorem. He concluded that there exists no general rule that can rank social states based only on the way these states are ranked by individual preferences and which satisfies some intuitively plausible criterion of reasonableness for social choice.

The social welfare function has been regarded illusory in its practicality for identifying social preferences, although the concept is theoretically desirable (Just, Heuth, and Schmitz, 1982).

Measurements of Change in Social Welfare

Decision makers must figure out the impact of certain policies on social welfare. In welfare economics measures of individual welfare are money measures where money reflects willingness to pay on the part of individuals, which in turn is related to the utility function of the individuals. Thus, when measuring individual welfare changes individual utility serves as a criterion. Since utility is not observable and thus can not be measured, it is measured indirectly by estimating a revealed willingness to pay in terms of money. In this regard three measures are discussed in the literature.

In the context of willingness to pay two measures have been suggested by Hicks (1943); compensating variation (CV) and equivalent variation (EV). The third measure is the Marshallian consumer surplus which is shown to be a good approximation of CV and EV under certain conditions.

Compensating Variation

Compensating variation (CV) is generally defined as the maximum amount of money an individual is willing to pay and still be no worse off compared with the welfare situation that would have prevailed without the price change. This concept can be explicitly illustrated as in Figure 4. Consider an individual having preference for good Q at price P, and the good Y (a composite of all other commodities) with a price of 1. Suppose he is faced with budget constraint, $M_1 = P_1 Q + Y$, where M_1 is initial income. The utility maximizing individual chooses the optimum consumption point A with commodity bundle of q_1 and Y_1. He enjoys utility level, U_1. Now, suppose the price of Q decreases from P_1 to P_2. Then, the individual increases consumption of Q from q_1 to q_2, and decreases Y from Y_1 to Y_2, hence moving to consumption point B. He is now on the higher utility level, U_2. The CV associated with the price fall of Q uses new price as a basis and measures what income change would be necessary to compensate the individual for the price change to restore the

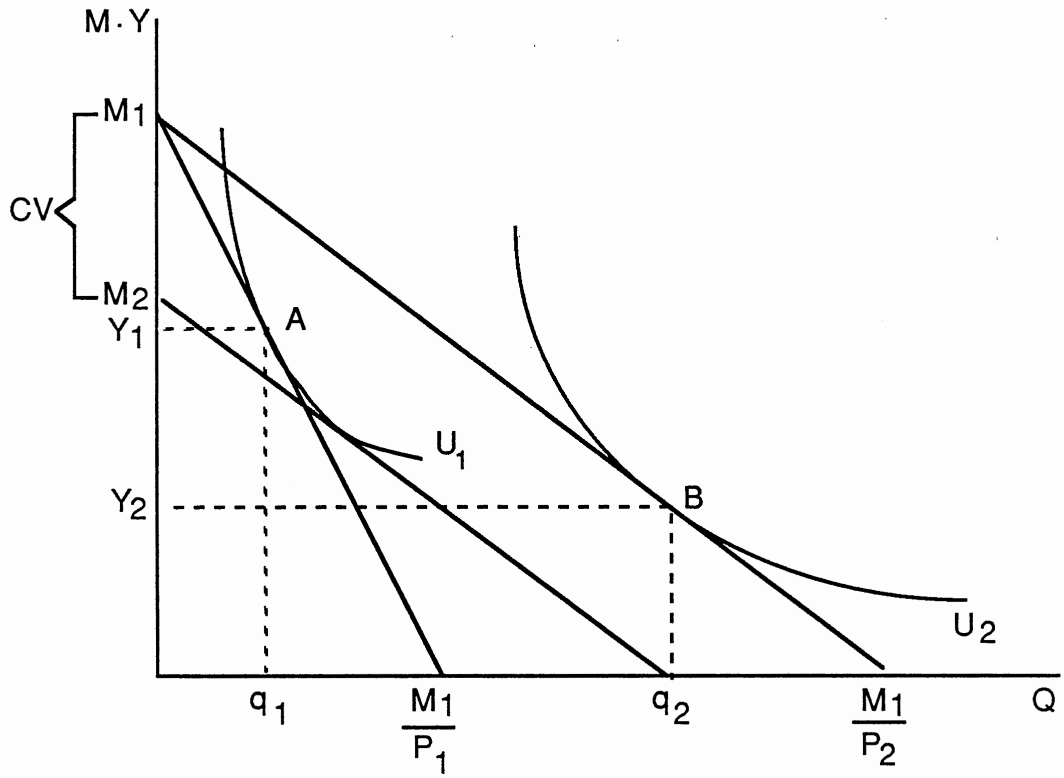


Figure 4. Compensating Variation

individual's original welfare level. To find the measure of CV the budget line M_1 through point B is shifted downward until it is tangent to the original utility level, U_1. Then the amount $M_1 - M_2$ is the measure of compensating variation which is the amount of money that needs to be taken away from the consumer to leave him as well off as before.

Equivalent Variation

Equivalent variation is defined as the amount of money that must be given to an individual in place of price and income changes to leave him as well off as if the change had occurred. This is illustrated in Figure 5. Due to the price fall of Q the consumer is at consumption point B on utility level, U_2. EV uses current price as the base and measures what income change would be equivalent to the new price change. Thus, the budget line M_1 passing through A is shifted upward until it is tangent to the utility level, U_2. Then, the equivalent variation is the amount $M_3 - M_1$, which is the amount of money that needs to be given to the individual to leave him just as well off as if the price change had occurred.

Consumer Surplus

Consumer surplus is commonly defined as the area under the demand curve and above the price line. This concept was coined by Dupuit (1884) who postulated that the price associated with any quantity on a consumer's demand curve is the maximum price the consumer is willing to pay for the last unit consumed. This concept was developed later by Marshall (1930).

Consider a consumer in initial equilibrium consuming q_0 at price p_0 on the demand curve in Figure 6. Over the quantity range of Q from 0 to q_0 he pays less for the good Q than the maximum amount that he would pay rather than

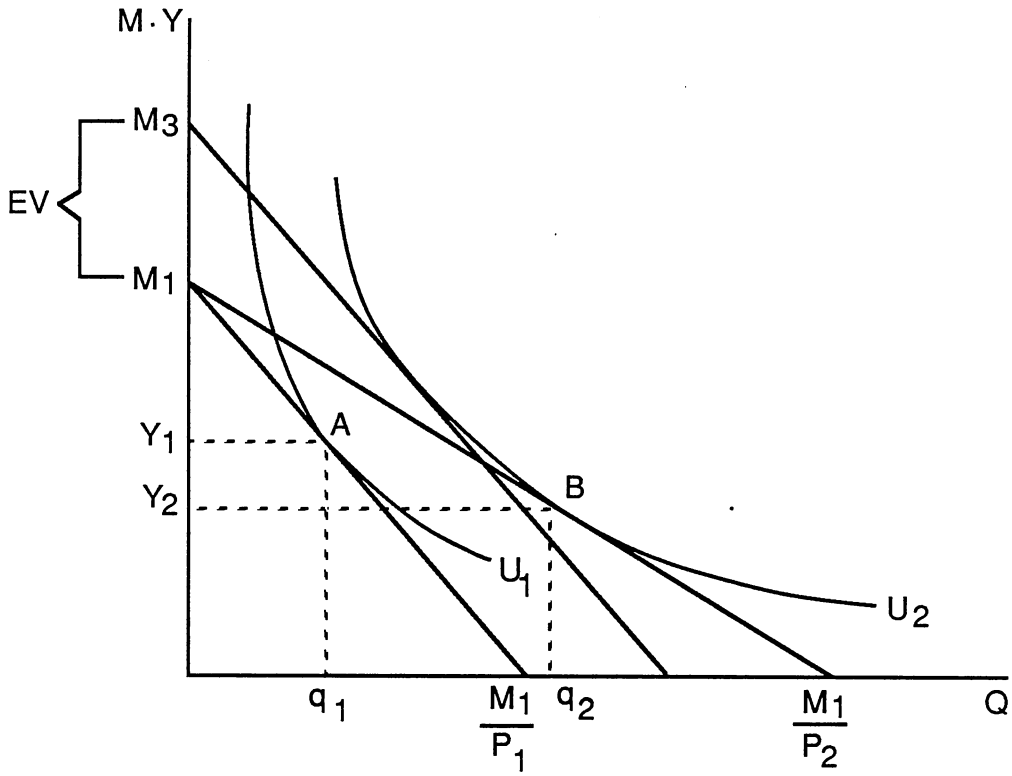


Figure 5. Equivalent Variation

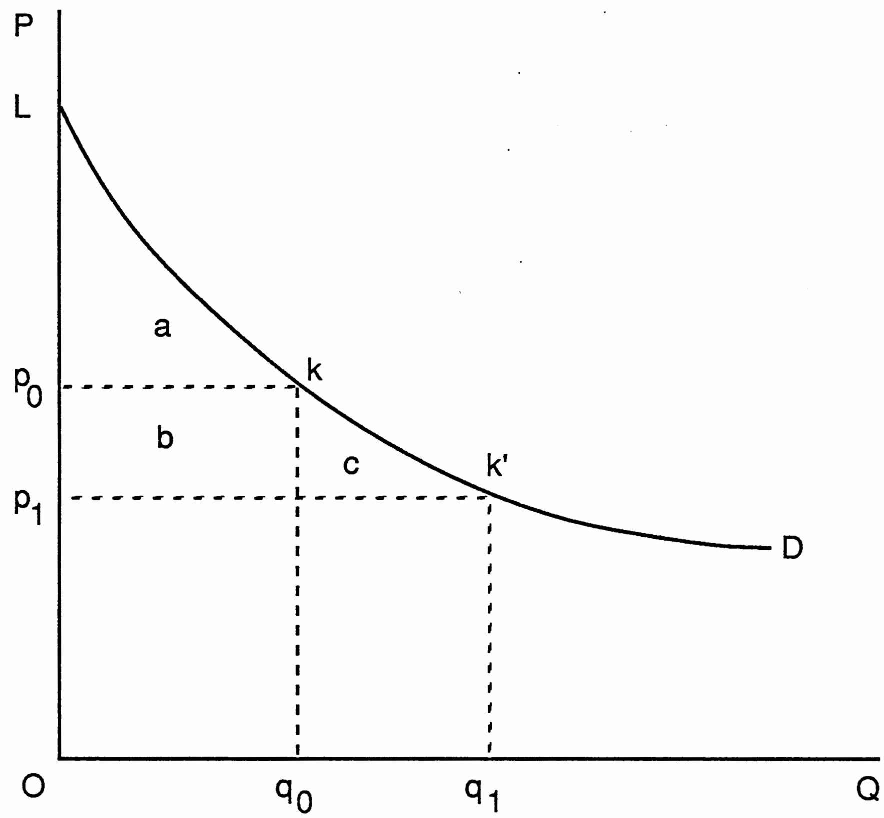


Figure 6. Consumer Surplus

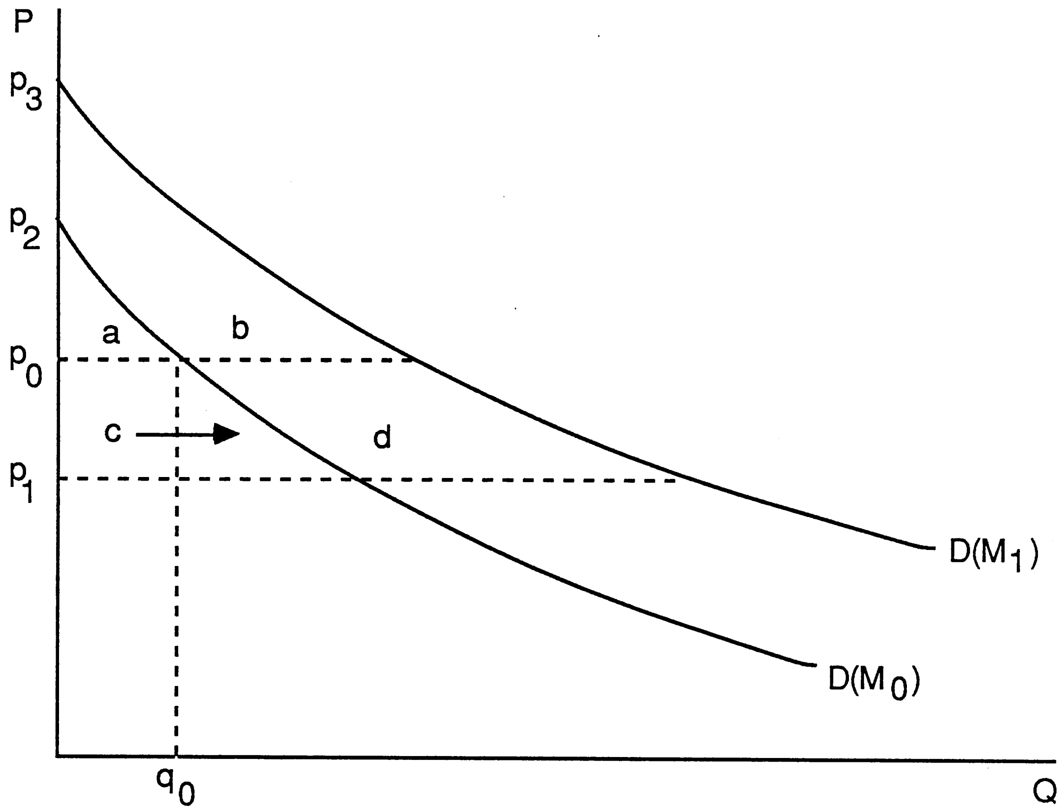
forego its consumption. Then the consumer surplus is measured as the area $Lp_0k = a$.

Suppose the price of Q decreases to p_1, moving to consumption point k'. Due to the price change consumer welfare is influenced. He pays only p_1 which is again less for the good Q than the maximum amount that he would pay rather than forego its consumption. Now the consumer surplus is measured as the area $Lp_1k' = a + b + c$. Thus the change in consumer surplus caused by the price fall is $Lp_1k' - Lp_0k = a + b + c - a = b + c$. Thus the consumer gains in consumer surplus with lower price.

However, this approach to the measurement of consumer welfare change has several problems which are discussed below (Just, Hueth, and Schmitz, 1982).

Path Dependence. The change in consumer surplus is not defined uniquely when several prices change simultaneously or when income changes together with price. The change in consumer surplus in these situations depends on the order in which price or income changes are considered. This is called the path-dependence problem.

Consider a case where price and income change simultaneously. In Figure 7 a consumer with initial income M_0 is in equilibrium consuming q_0 at price p_0 on the demand function $D(M_0)$. Suppose price and income change to p_1 and M_1, respectively. The change in consumer surplus may be evaluated in two different path adjustments; price adjustment followed by income adjustment or income adjustment followed by price adjustment. When the former case is considered the change in consumer surplus is $M_1 - M_0 + c$. When the latter case is considered the change in consumer surplus is $M_1 - M_0 + c + d$. With the same amount of income and price change the change in consumer surplus



SOURCE: Just, Richard E., Darrel L. Hueth and Andrew W. Schmitz. Applied Welfare Economics and Public Policy. Prentice-Hall, Inc., Englewood Cliffs, N.J. 1982.

Figure 7. Path Dependence of Consumer Surplus (Price and Income Change)

is quite different as the path of adjustment is considered differently. The same path dependence problem arises in the case of simultaneous multiple price changes.

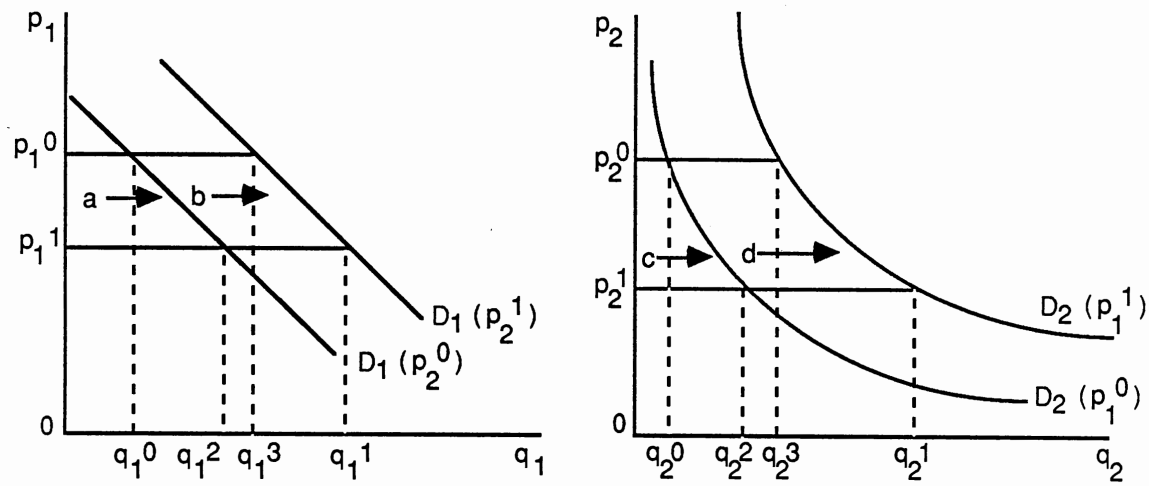
Consider a case where two prices change simultaneously with income held constant as in Figure 8. Suppose initial prices of q_1 and q_2 are p_1^0 and p_2^0, and initial demand curves for q_1 and q_2 are D_1 (p_2^0) and D_2 (p_1^0) respectively. Two path adjustments are illustrated; change of p_1 followed by change of p_2, and change of p_2 followed by change of p_1. In the former case, gain in consumer surplus is a + c + d and in the latter case the gain in consumer surplus is c + a + b. The two areas will not be equal in general except in some special cases.

Uniqueness of Consumer Surplus. In Figure 7 the same change in consumer surplus is obtained for any price change regardless of path adjustment if and only if the two demand curves, $D(M_0)$ and $D(M_1)$ coincide. Such coincidence can happen when the demand curve is not influenced by income changes. Thus, when both price and income change simultaneously, the consumer surplus change is unique if and only if the income effect $(\Delta q/\Delta M)$ is zero or income elasticity is zero.

In Figure 8 the same change in consumer surplus is obtained regardless of path orders if and only if area b is equal to area d. When price changes from p_1^0 to p_1^1 and p_2^0 to p_2^1 are very small then the shapes of b and d become parallelograms. Then each area is calculated by the product of $dp_1 \times dq_1$ and $dp_2 \times dq_2$. For path independence

$$dp_1 \times dq_1 = dp_2 \times dq_2 \text{ or } dq_1/dq_2 = dp_2/dp_1 \quad (3.5)$$

Suppose that all prices change by the same proportion so that $p_1^1 = \alpha p_1^0$ and $p_2^1 = \alpha p_2^0$. Then,



SOURCE: Just, Richard E., Darrell L. Hueth, and Andrew W. Schmitz. Applied Welfare Economics and Public Policy. Prentice-Hall, Inc., Englewood Cliffs, N.J. 1982.

Figure 8. Path Dependence of Consumer Surplus (Multiple Price Changes)

$$dp_2/dp_1 = (\alpha - 1)\, p_2{}^0/(\alpha - 1)\, p_1{}^0 \quad (3.6)$$

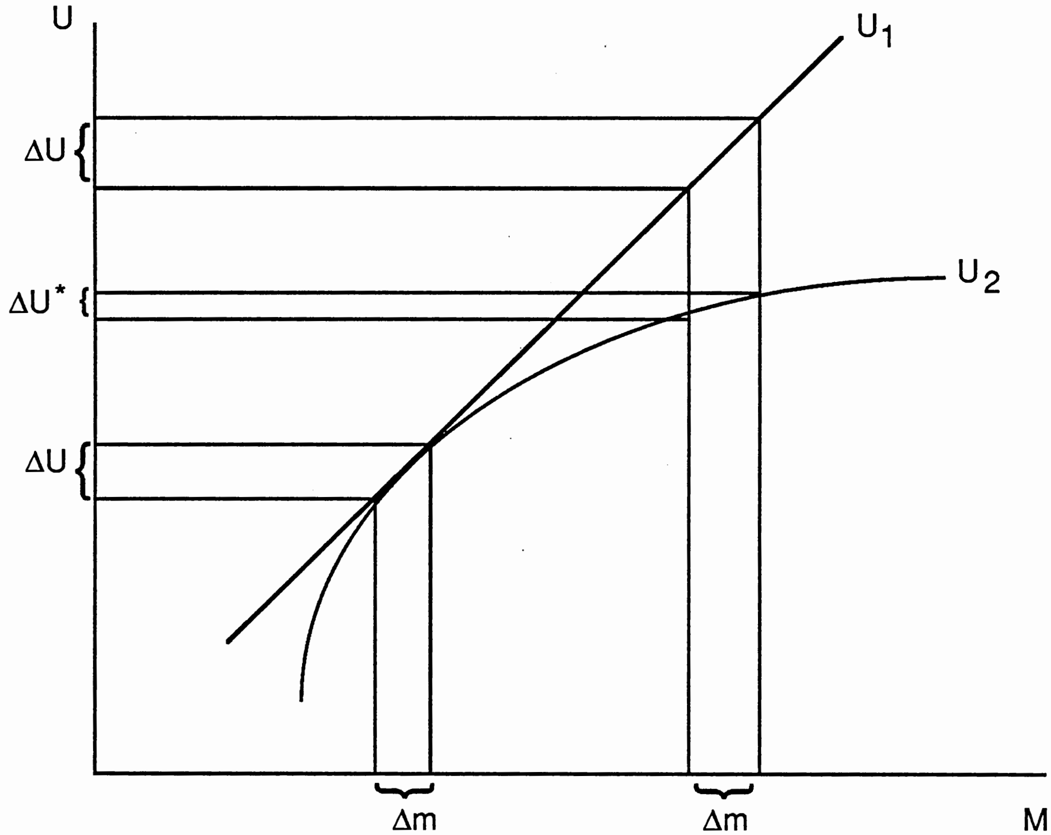
From (3.5) and (3.6)

$$dq_1/dq_2 = dp_2/dp_1 = p_2{}^0/p_1{}^0 \quad (3.7)$$

This equation implies that for path independence the ratio of quantity adjustments of q_1 and q_2 corresponding to any proportional changes in prices needs to be constant. Since the proportional change in prices are equivalent to an inversely proportional change in income under homogeneity of demand, the ratio of consumption adjustments in response to an income adjustment is a constant determined completely by prices regardless of income level. This result indicates consumer's indifference curves are tangent to the budget line, on which point straight-line income - consumption path emanating from the origin passes through. This is the case with homothetic utility indifference curves where any percentage change in income leads to an equal percentage change in all quantities consumed, hence all income elasticities of demand must be equal to one. Now it can be concluded that when all prices change simultaneously, the consumer surplus change is uniquely defined if and only if the consumer's indifference map is homothetic, which occurs if and only if all income elasticities of demand are unity. These uniqueness conditions are quite restrictive in empirical work.

Constancy of Marginal Utility of Income. Another difficulty in the use of consumer surplus for measuring consumer welfare change lies in the question whether the consumer surplus change provides a reasonable money measure of utility change. This problem is illustrated in Figure 9.

When a consumer has a utility curve U_1 the utility change ΔU corresponding to income change Δm is constant over any range since the marginal utility with U_1 is constant. However, when a consumer has a utility



SOURCE: Just, Richard E., Darrell L. Hueth, and Andrew W. Schmitz. Applied Welfare Economics and Public Policy. Prentice-Hall, Inc., Englewood, N.J. 1982.

Figure 9. Constancy of Marginal Utility of Income

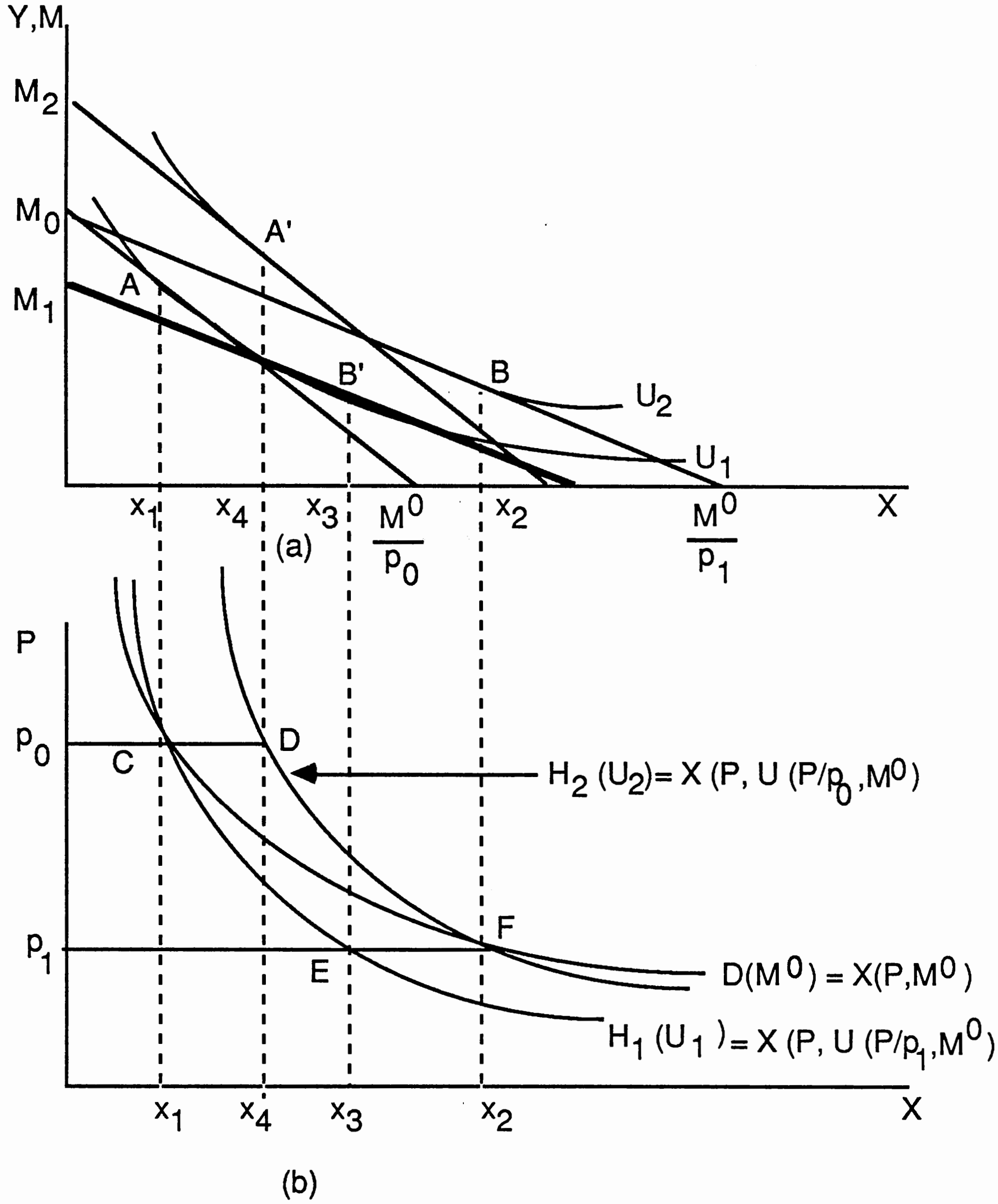
curve U_2 the utility changes due to the same income change is different depending on the initial income. This result implies that consumer surplus measures utility change when the marginal utility of income is constant.

In summary, to obtain the unique measure of utility change consumer surplus must meet certain conditions: (1) income elasticities must be the same and equal to one for all goods for which prices change, and income elasticities must be zero if income changes and (2) marginal utility of income must be constant with respect to prices and/or income changes.

Willig's Approximation. Compensating and equivalent variation have been discussed as theoretical measures of the welfare impact of changes in prices and income for an individual. However, it is difficult to determine the variations empirically since actual utility levels are not observable. It also has been discussed that Marshallian consumer surplus does not provide unique measure of utility except under restrictive conditions.

Willig (1976), however, validated the use of consumer surplus in welfare analysis and thus allows measurable estimates of the unobservable compensating and equivalent variations.

Consider three measurements of welfare changes as illustrated in Figure 10. Suppose a consumer faces choice of two goods, X with price P, and the composite of all other goods, Y, with a price of 1 subject to initial income constraint, M_0. Then, the consumer having an initial utility curve U_1 maximizes his utility at point A at the initial price p_0 in Figure 10 (a). This would give one consumption point C at p_0 in price-quantity space of Figure 10 (b). Now suppose the price of X has decreased from p_0 to p_1. With no change in income the new utility maximum point for the consumer would move to B for a normal good in Figure 10 (a). This would again give another consumption point F in



SOURCE: Just, Richard E., Darrell L. Hueth and Andrew W. Schmitz. Applied Economics and Public Policy. Prentice-Hall, Inc., Englewood Cliffs, N.J. 1982.

Figure 10. Measurements of Welfare Change

Figure 10 (b). By varying the price with income constant the Marshallian demand curve could be derived as D (M_0) = X (P, M_0) in Figure 10 (b). Then the change of consumer surplus is represented as the area of p_0CFp_1.

With the same price change, if the consumer wants to stay on the initial utility level before the price change then his consumption amount should be determined at B' with income being adjusted to M_1 in Figure 10 (a) and point E in Figure 10 (b). Then the Hicksian compensated demand curve is derived as $H_1(U_1) = x\ (P, U(P/p_1, M_0)$. Thus, by definition, compensating variation is M_0-M_1 in Figure 10 (a) and the area p_0CEp_1.

However, when there was no price reduction and if he wants to stay on the higher utility curve U_2 as if there had been a price reduction he would select point A' with income adjustments to M_2 at the consumption of X at x_4, which would give one consumption point D in Figure 10 (b). At the same price reduction from p_0 and p_1 he would select B to attain higher utility level U_2 in Figure 10 (a). This would give a consumption point F in Figure 10 (b), which is the same point on the Marshallian curve. By varying prices and adjusting income the Hicksian demand curve is derived as $H_2(U_2) = X\ (P, U(P/p_0, M_0))$. By definition, the equivalent variation is represented as $M_2 - M_0$ in Figure 10 (a) and the area p_0 DFp_1.

When price increases the reverse is true. For example, if the initial price is p_1, and increases to p_0, then Marshallian consumer surplus is p_0CFp_1, compensating variation is p_0DFp_1 and equivalent variation is p_0 CEp_1.

As shown above there exist some differences in values among the three welfare measures. When price increases the relationship among the three is $C \geq A \geq E$, and $C \leq A \leq E$ in reverse change in price where C = compensating variation, A = consumer surplus, and E = equivalent variation. Thus, employing consumer surplus as the relevant measure of change in social welfare may not be justified.

However, Willig (1976) removed doubt in its use by proving that consumer surplus is a good approximation of the variations in welfare analysis. He derived the relationships between the three welfare measurements as the following:

$C = A + \eta A^2/2M_0$ and (3.8)

$E = A - \eta A^2/2M_0$ (3-9)

Thus, $(C - A)/A = \eta A/2M_0$ and $(A - E)/A = \eta A/2M_0$ where η denotes income elasticity. These equations show the percentage error of approximating C and E with A. Then he proved that if $\eta A/2M_0 \leq 0.05$ no more than a five percent error is made by using consumer surplus as a measure of either compensating or equivalent variation. Consequently, he argued that Marshallian consumer surplus can be used "unapologetically" in approximating compensating or equivalent variation in welfare analysis regardless of whether the marginal utility of income is constant or not.

Attempts to Measure Hicksian Welfare Changes

There have been some attempts to measure the unobservable compensating and equivalent variations. Hurwicz and Uzawa (1971) showed that the Hicksian variations can be obtained using information from the ordinary demand functions. However, complex calculations and the lack of an operational algorithm have made the necessary computations impossible in most practical applications (Bergson, 1975; Chipman and Moore, 1980; and Just, Hueth and Schmitz, 1982). Hausman (1981) and Bowden (1984) showed the procedure to solve the Hurwicz-Uzawa systems for the two good case in differential equations. Utilizing the duality relationship between direct and indirect utility functions, Vartia (1983) presented an algorithm in the form of an ordinary first-order differential equation for calculating expenditure function and the Hicksian variations. Bergland (1985) suggested an algorithm with the use of optimal control approach for calculating Hicksian welfare change, which included changes in income and prices.

Shadow Pricing

The term shadow price originates from mathematical programming, where it means a marginal valuation imputed to an input or an output at the location of the optimum (Pearce and Nash, 1981). However, it has been extended to estimates of social benefits or social losses in CBA.

A shadow or accounting price, which is used interchangably in CBA, is defined as the price the economist attributes to a good or factor on the argument that it is more appropriate for the purpose of economic calculation than its existing market price (Mishan, 1976).

In CBA the analyst faces valuing inputs and outputs as results of certain policies and programs. In a perfectly competitive economy market prices are regarded to reflect the values of inputs and outputs where the output prices are equated with marginal costs, and input prices are equated with marginal value. Two major difficulties arise in valuing inputs and outputs which are required to be consistent with shadow prices implicit in Pareto optimality: (1) when market prices are inappropriate, and (2) when no market exists for the inputs and outputs.

The first difficulty comes from situations where market prices are not equal to marginal cost, and marginal cost does not reflect the true social cost of relevant resources. These situations are due to imperfect competition in the input and output markets, unemployment of resources, increasing returns to scale, subsidy and taxation, the existence of externality and public goods, and non-marginal change in price. The second difficulty comes when the inputs and outputs are characterized by intangibles such as human lives, noise, pollution, good health, good education, recreation, etc. These difficulties require shadow pricing of inputs and outputs in CBA. The technique of shadow pricing may depend on the characteristics of inputs and outputs to be valued. It may be noted that in general equilibrium the shadow pricing with respect to social marginal cost or social marginal benefit could face "second-best" problem in achieving Pareto optimality (Lipsey and Lancaster, 1956). That is, where prices are not equal to marginal costs elsewhere in an economy marginal cost pricing in the controllable sector may not guarantee Pareto optimality.

Social Discount Rate (Social Time Preference)

An individual may have time preference in consumption, a preference of present benefits over future benefits. Society as an integrate of individuals may have social time preference, a preference society exhibits for present benefits over future benefits. Public expenditure and investment programs involve the sacrifice of present benefits for future benefits. To society the sacrifice of present benefits would not be worth while unless the future gains are greater. Thus, the social discount rate can be defined as an accounting price which reflects society's "trade-off" of present benefits against future benefits (Dasgupta and Pearce, 1972).

Several concepts or approaches are outlined in the determination of a social discount rate for public expenditure or investment programs (Pearce and Nash, 1981). The problem lies in operationalizing the discount rate.

First is the social opportunity cost (SOC) approach. The social discount rate is determined where a return from the program is equal to and/or greater than what could have been achieved if the sacrificed expenditure for the program had been used in other best alternatives. The difficulties lie in the fact that the return from other best alternative is not observable and empirical estimation is not easy.

Second is the utilitarian approach or social time preference rate (STPR) which is based on diminishing marginal utility of consumption. The rate is determined by the formula, $S = (1 + c)^{-b} - 1$ where S represents the social discount rate, c and b represent the rate of growth of consumption per person and the elasticity of the marginal utility of consumption per person, respectively. However, there exists no concensus on the measurability of the utility function.

Third is an approach proposed by Scott (1977) which attempts to avoid the problems caused by the discrepancies between STPR and SOC. The formula is $W = \eta(b'/b) + d$ where W = the social discount rate, η = the elasticity of the marginal utility of income, b = base level of income, b' = change in income over time, and d = pure time preference rate. This approach looks at the balance between investment and consumption in the public sector only.

Fourth is a synthetic discount rate approach which operates as an average of the STPR and SOC rates. This approach differentiates the sources of finance for a program and types of benefits. It operates with the STPR.

In determining social discount rate no single approach has obtained general concensus from economists. The selection of a discount rate may depend on specific economic circumstances of programs to be analyzed.

However, it may be important to consider what alternatives are foregone and what reinvestment possibilities still exist in the world where the first-best conditions do not prevail (Pearce and Nash, 1981).

Distributional Weights

Distributional weights are used in the non-conventional approach in CBA where incorporation of income distribution is believed to be more consistent with Pareto optimality. In this approach CBA is carried out in two stages. The first stage involves evaluation of the gains and losses in money units accruing to or borne by each of the individuals affected by a policy. Then, the analyst combines these gains and losses into a single measure of change in social welfare. In this second stage distributional judgements are injected into assessing the gains and losses in welfare. For example, when net money gains to each individual in a society are $G_1, G_2, \ldots, G_n$ then the net gain to society in money terms only is represented as $SG = G_1 + G_2 + \ldots G_n$ where SG is total social gain and n is number of individuals. When distributional judgement is considered $SG = d_1G_1 + d_2G_2 + \ldots + d_nG_n$ where the d's are distributional weights.

In distributional weighting four approaches are offered (Dasgupta and Pearce, 1972). First is where the CBA analysis indicates the consequences of distribution but allows the decision maker to apply his own weights to the gains and losses of the various groups in society.

Second is where the CBA analyst observes weights implicit in past government decisions and uses those weights in the distributional analysis, assuming the weights reflect the decision makers current value judgements for society.

Third is where an explicit value judgement is imposed on the social utility function, such as scaling down higher incomes and scaling up lower incomes.

Finally, weights are determined by estimating the likely shape and elasticity of a marginal utility of income function.

Decision Criteria

A policy or project is regarded socially worth while in CBA if the benefits exceed the costs it generates. The appropriate formula expressing the social worth of a policy or project to aid the decision making is the decision criteria. The decision makers frequently face decision choices such as accept or reject. Major decision criteria are briefly summarized below.

Net Present Value (NPV) discounts costs and benefits occurring over time and express them all in a single common value at any one point of time. When the discounted value of the benefits exceeds the discounted value of the costs, that is, net present value generated from a program is positive, it is accepted. If the reverse is true, the project or policy is rejected.

Internal Rate of Return (IRR) is the discount rate that makes the NPV of a program equal to zero. The IRR is the maximum interest rate that the program can pay for the resources used if the program is to recover its costs and still just break even (Gittinger, 1982). If the IRR for a program is greater than some predetermined level which is generally the social opportunity cost, the program is considered acceptable.

Benefit-Cost Ratio (B/C Ratio) compares benefits with costs discounted at social opportunity cost. If the ratio of the two is greater than one a program or a project is considered acceptable. This rule frequently serves as an efficient criterion in public policy or program analysis. If the benefit-cost ratio is greater or equal to one then the policy or program is considered efficient and recommendable.

Other decision rules include annual value, cut-off period, pay-back period, net average rate of return, terminal value, optimal time-phasing, maximum average cost, net benefit investment ratio, etc. (See Sassone and Schaffer, 1978; Gittinger, 1982).

Model Formulation

General Framework

This study analyzes the impact of public subsidy programs to rural residents in water consumption (STRWS) on social welfare in Oklahoma. Following the discussion on the major components of CBA in public policy or program the general framework is set as follows.

The welfare foundation of STRWS is identified by improvement in economic efficiency and equity. Economic efficiency in STRWS is whether social benefits exceed social resource costs. Equity concerns finding how STRWS benefits are distributed to target groups of rural residents. That is, the value judgement recognizes it is desirable when subsidy benefits are provided to groups whose average income is lower than average income of taxpayers and whose settlement motivation in rural areas is dependent upon employment.

Although there have been some attempts in calculating the Hicksian welfare measure (Hurwicz and Uzawa, 1971; Hausman, 1981; Bowden, 1984; Varita, 1983; and Bergland, 1985), the social benefit or welfare changes will be measured with the use of Marshallian consumer surplus. It is justified in the current application for several reasons.

First, it is reasonable to assume that STRWS falls within the framework of Willig's justification for using Marshallian consumer surplus as an approximation of compensating and equivalent variations with less than a five percent error. This assumption is based on the result that the product of change in consumer surplus and income elasticity of water demand is small since the income share of water consumption costs is low and the income elasticity is less than one (Dellenbarger, 1985).

Second, there would be no path dependence problem associated with multiple price changes since only one price (water) changes and water is assumed to be a final consumption good.

Third, the concept of Marshallian consumer surplus is easily understood, simply calculated, and widely accepted under certain conditions in welfare analysis.

Shadow pricing through willingness to pay by rural households is assumed to reflect the value of water to society. The social discount rate is approximated by the social opportunity cost of the subsidy and assumed equal to long-term U.S. Treasury bond rates. Subsidy benefit distribution will be analyzed between recipient groups in rural areas, not between rural residents and the rest of the society. Cost allocation among groups in a society as a whole is not considered.

Two types of distributional weights are considered. The first is based on income and is expressed as $W_i = \bar{Y}/Y_i$, where $\bar{Y}$ denotes national reference level household income and Y_i represents income of household i in STRWS. The second is based on water consumption and is expressed as $\theta_i = (\bar{C}/C_i)^r$ where $\bar{C}$ denotes national reference level of household water consumption, C_i represents water consumption of household i in STRWS, and r is a parameter of the household utility function. The subsidy benefit distribution between different groups of rural households will be measured with the use of consumer surplus under separate demand functions.

The decision rule or efficient criterion is marginal social benefit cost ratio (MSBCR) with STRWS.

Analytical Models

Scope of Costs and Benefits

Subsidies are provided indirectly to rural households through lump sum grants and low interest long-term loans to rural water systems. Social costs and benefits are generated to society which may change social welfare in the form of economic efficiency and equity.

Some costs incurred in STRWS are intangible and unobservable. There may be negative externality in the form of displeasure to some taxpayers who do not agree with STRWS, say, low income urban households. Measurement of this displeasure is technically infeasible, thus not considered in this study.

Observable costs are classified into two major categories, public or government costs and private or recipient costs. Public costs consist of lump sum grants, long-term low interest loans, and administrative costs. Recipient costs are increased water bills due to higher consumption encouraged by lower water prices under subsidy.

Benefits to society of STRWS are in two major forms, direct benefits and indirect benefits. The direct benefits are decrease in water price and increased water consumption by rural households. These benefits are summarized by the change in consumer surplus. Indirect benefits may be in different forms. Benefits could be a reduction in health risks of rural residents due to increased safe water consumption under STRWS. Some altruistic or paternalistic taxpayers may obtain psychic satisfaction or positive utility by providing subsidy to rural residents. These indirect benefits are generally unobservable and difficult, if not impossible, to measure. Thus, in this study, only direct benefits to rural households are considered, that is, changes in consumer surplus.

Measurement of Social Costs and Benefits

The analytical model is based on the "with" and "without" concept. Social benefits and costs "without STRWS" in rural water consumption are measured and social benefits and costs "with STRWS" are measured. Change in social benefits and costs between the two states give the marginal social benefits and costs.

Consider a representative rural water system characterized as a decreasing cost firm in Figure 11 (a). The system has long-run marginal cost (LMC), long-run average cost (LAC), and faces aggregate water demand (D_A). It is assumed that the monopolistic rural water system does marginal cost pricing and adopts second degree price discrimination or decreasing block rate schedules to maintain financial feasibility through equating total revenue with total cost. It is also assumed that the rural water system is operating at its maximum technical efficiency.

In Figure 11 (b), D_I represents an individual household water demand function. Since potable water is not an inferior good, price and quantity will vary inversely and thus have a negatively sloped demand (Dellenbarger, Kang, and Schreiner, 1986).

Since water price is affected by the rural water system cost structure it is necessary to identify how the STRWS influences cost. Construction and

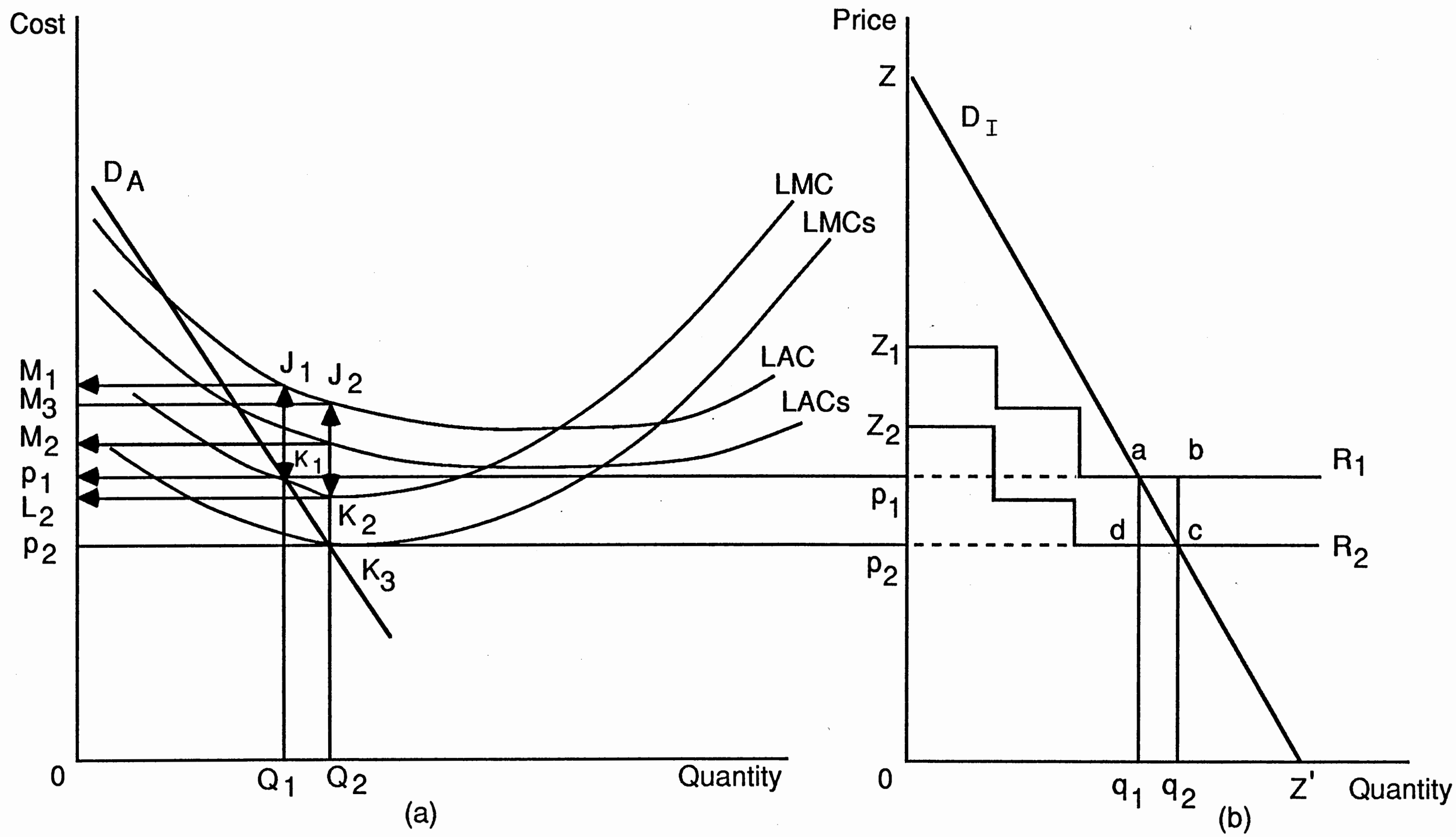


Figure 11. Public Subsidies and Change in Social Welfare.

expansion of rural water system facilities requires fixed capital investment. To recover costs, capital investment is annualized and incorporated into water pricing or monthly water bills. Let C = f [K(q), M(q), W(q)] where C is annual total cost, K(q) is annualized fixed capital investment, M(q) is annual operation and maintenance cost of water distribution facilities, and W(q) is annual water purchase or annual cost of water source at the water supply of q. Then marginal cost is represented as LMC = f' [K(q), M(q), W(q)]. When lump sum subsidy is provided to rural water system then the new cost function is given as $C_S = f_S$ [K(q) - S(q), M(q), W(q)] where S(q) is annualized amount of subsidy. Even though the subsidy is a lump sum it generally varies by size of system (number of households). Small systems receive small lump sum subsidies, large systems receive large lump sum subsidies. The new marginal cost under subsidy is represented as $LMC_S = f'_S$ [K(q) - S(q), M(q), W(q)].

Suppose the rural water system is provided a lump sum subsidy in the amount of S(q). According to the above results the public subsidy decreases LMC and LAC by spreading the subsidy over the supply of water and thus giving the LMCs and LACs as shown in Figure 11 (a). Marginal cost pricing with no profit sets the marginal price for the last unit of water consumed at p_2 and determines water system supply at Q_2 where D_A intersects LMCs. The marginal price for an individual household within the system is p_2 in Figure 11(b). With this pricing the rural water system will lose $(M_2 - p_2)Q_2$ and public cost will be $(M_3 - L_2)Q_2$. Social loss because of too many resources delivering too much water under STRWS is equal to the area $K_1K_2J_2J_1$. To compensate for lost revenue, management will resort to block rate schedule and thus extract some consumer surplus. Thus, a water rate schedule similar to R_2 is set up as shown in Figure 11(b).

Suppose no public subsidy is provided to the rural water system. Then for marginal cost pricing with no profit the marginal price for the last unit of water consumed would be set at p_1 and with water supply at Q_1. Marginal price for an individual household within the system is also p_1 in Figure 11(b). At this pricing the rural water system will lose revenue equal to $(M_1 - p_1)Q_1$. To compensate for lost revenue, management will use a block rate schedule similar to R_1 which will be above the rate schedule R_2 under STRWS.

These situations of "with STRWS" and "without STRWS" give different social benefits and costs. Social costs consist of private and public costs and social benefits consist of private and public benefits.

First, consider the social benefits and costs without STRWS. Private benefits are represented by the area under the individual demand curve, Zaq_1O in Figure 11(b). Public benefits are assumed zero. Private costs are represented by Z_1aq_1O and equals the household water bill. Public costs are not incurred in this situation. Then social benefits equal Zaq_1O and social costs equal Z_1aq_1O, resulting in net social benefits of $Zaq_1O - Z_1aq_10 = ZaZ_1$.

Now consider the social benefits and costs with STRWS. Private benefits have changed to the area represented by Zcq_2O. Public benefits are assumed zero. Private costs are the area represented by Z_2cq_2O, which is the household water bill. Public costs are the amount of public subsidies represented by Z_1bcZ_2. Then the social benefits are Zcq_2O and social costs are $Z_2cq_2O + Z_1bcZ_2 = Z_1bq_2O$, resulting in net social benefits of $Zcq_2O - Z_1bq_2O = ZaZ_1 - abc$[1].

Now the marginal social benefit-cost ratio (MSBCR) is the ratio between the added social benefits and the added social costs with public subsidy. The

[1]Because of a declining LMC, social costs are slightly less than the area abc for any individual household.

added social benefits are $Zcq_20 - Zaq_10 = acq_2q_1$. The added social costs are $Z_1bq_20 - Z_1aq_10 = abq_2q_1$. Then MSBCR is given by acq_2q_1/abq_2q_1 which will always be less than one.

Two problems arise in empirical measurements with this approach. First, only R_2, q_2, D_I and D_A are known but R_1 and q_1 are not. Second, block rate schedules can be set in numerous forms with various block lengths. These two problems make the measurement of social welfare change difficult. To overcome the problems a modified approach is considered using average price as surrogate for rate schedule. Water bill under a decreasing block rate schedule is defined as $WB = p_1q_1 + \sum_i p_i (q_i - q_{i-1})$ where WB denotes water bill, and p_1 and q_1 are the price and quantity consumed at the first block respectively, and p_i and q_i represent the price and quantity consumed at the ith block. Then the average price per unit of water consumption becomes $AP = WB/q_n = [p_1q_1 + \sum_i p_i (q_i - q_{i-1})]/q_n$. Conversely, WB is obtained from $AP \times q_n$. Since $WB = AP \times q_n$ the consumer surplus when calculated with WB is equal to the consumer surplus when calculated with $AP \times q_n$.

Measurement of social welfare change with the use of average price is illustrated in Figure 12. D_I is the same household demand curve as in Figure 11(b). Price p_{2a} is the average price when the system, with STRWS, sets the marginal price at p_2 and gives water supply of Q_2 in Figure 11(a). This in turn gives the individual household within the system a marginal price of p_2 and rate schedule similar to R_2 in Figure 11(b). The water bill for the individual household under R_2 is the area represented by Z_2cq_20 in Figure 11(b). Then the average price p_{2a} at q_2 in Figure 12 is given by the water bill Z_2cq_20 divided

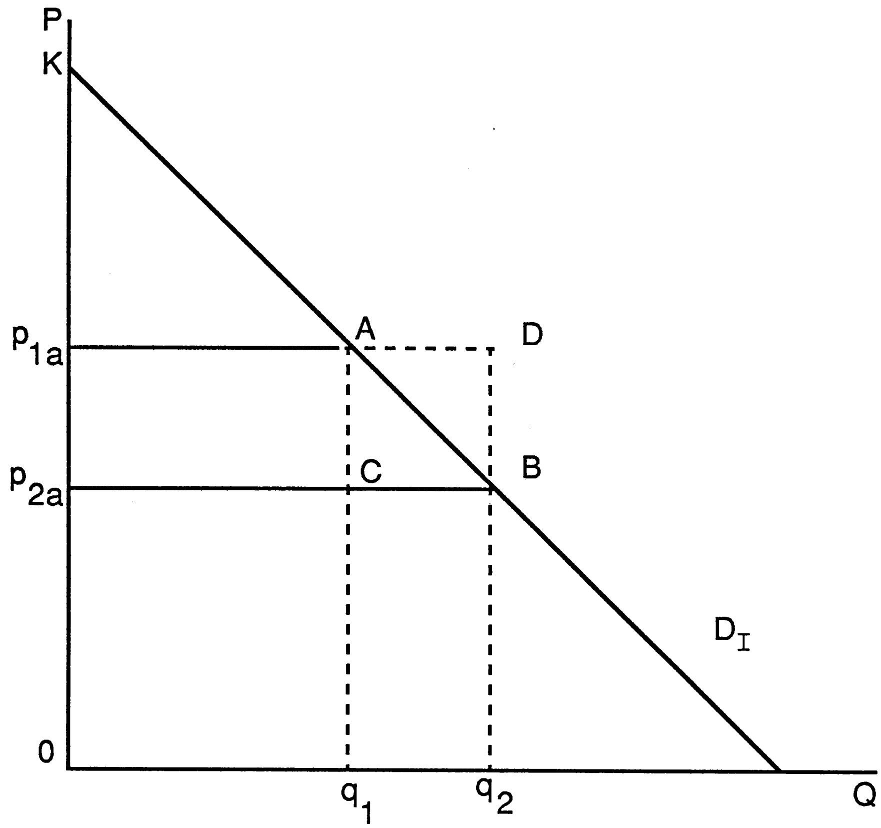


Figure 12. Price Change and Social Welfare.

by the quantity demanded, q_2 , in Figure 11(b). Similarly, p_{1a} at q_1 in Figure 12 is the average price when the system, without public STRWS, sets the marginal price at p_1 for the water supply of Q_1 in Figure 11(a). This in turn gives the individual household within the system marginal price of p_1 with rate schedule R_1 in Figure 11(b). The water bill for the individual household under R_1 is the area represented by Z_1aq_10 in Figure 11(b). Then the average price p_{1a} at q_1 in Figure 12 is given by the water bill Z_1aq_10 divided by the quantity demanded, q_1 in Figure 11(b).

Social benefits and costs without STRWS are simply private benefits and costs. With STRWS the social benefits are private benefits, KBq_20 and social costs are private costs $p_{2a}Bq_20$ plus public costs $p_{1a}DBp_{2a}$ in Figure 12. MSBCR is the change in social benefits, KBq_20 - KAq_10 = ABq_2q_1, over the change in social costs, $p_{1a}Dq_20$ - $p_{1a}Aq_10$ = ADq_2q_1.

However, unresolved is the problem of no observable information on p_{1a} and q_1, the average price and quantity without STRWS. Thus, computation of p_{1a} and q_1 is necessary. Price p_{1a} can be obtained by adding the subsidy amount per thousand gallons to p_{2a}. The subsidy amount is calculated by dividing the annualized subsidy amount by annual water supply of the system. Then, q_1 is obtained by substituting p_{1a} into individual household water demand functions. The size of q_1 will depend on the subsidy and the price elasticity of water demand.

The change in social benefits resulting from STRWS is calculated by integrating the individual household demand function D_I at the interval between q_1 and q_2 in Figure 12, that is,

$$MSB = \int_{q_1}^{q_2} D_I(p)dq \qquad (3\text{-}10)$$

where MSB denotes change in social benefits. The change in social costs from STRWS is calculated as

$$MSC = p_{1a} (q_2 - q_1) \tag{3-11}$$

where MSC denotes change in social costs. Then the marginal social benefit cost ratio (MSBCR) is measured by

$$MSB/MSC = \int_{q_1}^{q_2} D_I(p)dq / p_{1a}(q_2 - q_1) \tag{3-12}$$

This process can be completed for the average household in the sample of rural water systems and for the average household belonging to a socio-economic group. Then for the average household in each socio-economic group in the sample of rural water systems, the MSBCR is expressed as:

$$\frac{MSB_i}{MSC_i} = \frac{\int_{q_{i1}}^{q_{i2}} D_i(p)\, dq}{(q_{i2} - q_{i1})\, p_{i1}} \tag{3-13}$$

Where:

MSB_i = marginal benefit to society from STRWS for the average household belonging to socio-economic group i.

$D_i(p)$ = monthly water demand function for the average household belonging to socio-economic group i.

MSC_i = marginal cost to society incurred from STRWS for the average household belonging to socio-economic group i.

q_{i1} = monthly water consumption for the average household belonging to socio-economic group i without STRWS.

q_{i2} = monthly water consumption for the average household belonging to socio-economic group i under STRWS.

p_{i1} = price of water per thousand gallons at the monthly water consumption q_{i1} for the average household belonging to socio-economic group i.

Since the MSBCR will always be less than one, STRWS will be considered inefficient under the conventional approach. However, MSBCRs by socio-economic group will allow comparisons of relative efficiencies of STRWS.

Social Costs and Benefits Under Distributional Weights

The value judgements of decision makers in providing public subsidy to rural water systems are explicitly and implicitly contained in government documents (FmHA, 1982; and FmHA, 1985). Priority of public subsidy is given to "rural water systems serving low-income communities". The subsidies are provided "to reduce (water) user costs". These statements imply that STRWS has low income residents as a target group and it is designed to serve water needs. Thus it would be important for the decision makers to know how the benefits are distributed to targeted groups of people and whether the subsidies are used to serve water needs.

To incorporate decision maker's value judgements non-conventional approach or decision maker's approach in CBA uses distributional weighting systems. Two types of weighting systems are considered here: income distribution weights and consumption distribution weights.

Income Distribution Weights. Weights in this system, following Foster (1966), are derived from the ratio of a reference household income in the economy to the income of the consumer concerned, that is $W_i = (\bar{Y}/Y_i)$ where W_i is the distributional weight for household i, $\bar{Y}$ is the national mean income, and

Y_i is the income level of household i in the area surveyed by the rural water system. Then the weighted marginal social benefit of the average household belonging to socio-economic group i, MSB_{wi}, becomes W_i*MSB_i or $(\bar{Y}/Y_i)$*MSB_i where MSB_i is the unweighted marginal social benefit for the average household belonging to socio-economic group i from STRWS. The value judgement with this weighting system is that equal weights are given to preferences for all consumers. This weighting adjusts benefits to the value households would place on water if they had mean income and devoted the same proportion of their income to water consumption. The MSBCR is expressed as:

$$\frac{W_i * MSB_i}{MSC_i} = \frac{W_i * \int_{q_{i1}}^{q_{i2}} D_i(p)\, dq}{(q_{i2} - q_{i1})\, p_{i1}} \tag{3-14}$$

where W_i denotes distributional weight for the average household belonging to socio-economic group i and other notations are the same as specified in the conventional approach. If MSBCR is greater or equal to one then the subsidy program is considered efficient. If MSBCR is less than one then the subsidy program is considered inefficient.

Consumption Distribution Weights. This weighting system is based on the assumption that the marginal utility of consumption to a consumer decreases as the level of consumption increases (Squire and van der Tak, 1984). One form of the marginal utility function that represents this characteristic is formed as $U_c = C^{-r}$ where U_c is marginal utility of water consumption, C is the level of water consumption and r is a parameter of the utility function. Thus the distributional weights that distinguish the value of consumption to different households is derived as $\theta_i = U_i/U = (C_i/\bar{C})^{-r} = (\bar{C}/C_i)^r$ where θ_i is a consumption distribution weight for the average household belonging to socio-economic group i; U_i and $\bar{U}$ are marginal utility of water consumption for the average household and marginal utility at national reference level of water consumption for the average household, respectively; and $\bar{C}$ and C_i are national reference level of water consumption and water consumption level of the average household belonging to socio-economic group i. Squire and van der Tak (1984) suggest that in most cases r would center around 1. The weighted benefits for the average household belonging to socio-economic group i becomes $MSB_{wi} = \theta_i * MSB_i = (\bar{C}/C_i)^r * MSB_i$ where MSB_i is the unweighted marginal social benefit for the average household belonging to socio-economic group i. When expecting difficulties in deriving values for r one can parametrically evaluate results.

The MSBCR is expressed as:

$$\frac{\theta_i * MSB_i}{MSC_i} = \frac{\theta_i * \int_{q_{i1}}^{q_{i2}} D_i(p)\, dq}{(q_{i2} - q_{i1})\, p_{i1}} \qquad (3\text{-}15)$$

where θ_i denotes distributional weight for the average household belonging to socio-economic group i and other notations are the same as specified in the conventional approach. If MSBCR is greater than or equal to one the subsidy program is considered efficient. If the ratio is less than one the subsidy program is considered inefficient.

Subsidy Distribution by Socio-economic Group

This approach is based on the assumption that a decision maker wishes to classify recipients of public policy by socio-economic characteristics and measure subsidy distribution between the interested groups.

There exist two typical motivations for settlement in rural areas. The one is for purposes of employment or making a living. Farmers, people in rural employment, or small businessmen in rural areas belong to this category. They may not have any locational alternatives. The other is for purposes of exploiting locational advantages. They may be part of a low income group who prefer rural living for exploiting low rent while working at some other location. They may be part of a high income group who prefer rural living because of psychic earning from a rural environment despite time and transportation costs in commuting to the work place. Taxpayers may not wish to subsidize the high income group for psychic satisfaction of rural living.

Rural residents can also be grouped by income level. Some farmers and local businessmen have higher incomes than the average taxpayer. The average taxpayer may not want to subsidize any group of rural residents who have higher incomes than they do. Thus policy makers may want to know how subsidy benefits are distributed to income groups and to socio-economic groups seeking psychic satisfaction.

Measurement of subsidy distribution between groups is illustrated in Figure 13. Suppose there exist household groups A and B within a rural water system. Let the household monthly water demand be D_A for group A and D_B for group B. Suppose the water rate schedule without subsidy is R_1. Then the consumer surplus for group A is the area bounded by D_A, R_1 and price axis, and for group B is the area bounded by D_B, R_1 and price axis. Suppose also the rate schedule with subsidy is R_2. Then, the consumer surplus for group A is the area bounded by D_A, R_2 and price axis, and the consumer surplus for Group B is the area bounded by D_B, R_2 and price axis. The net change in consumer surplus (equal to subsidy amount) for groups A and B are the areas bounded by R_1, D_A, R_2 and price axis, and R_1, D_B, R_2 and price axis, respectively.

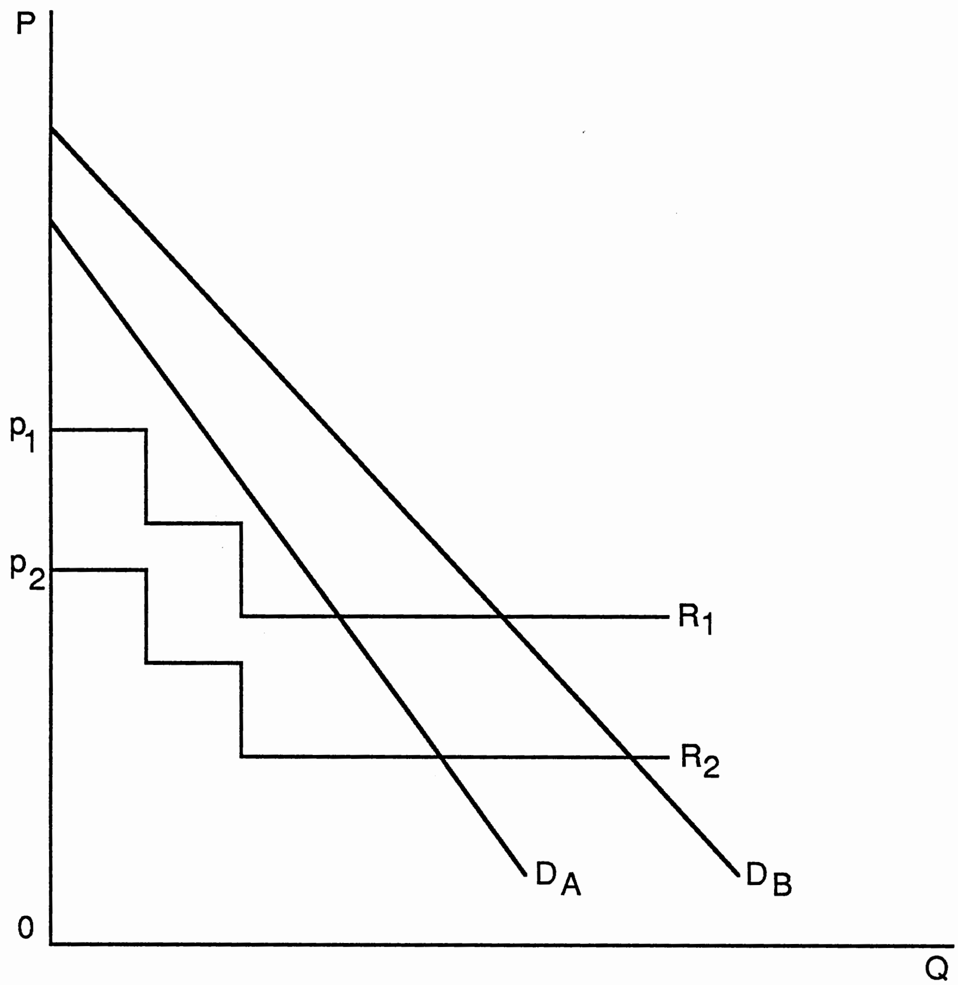


Figure 13. Distribution of Benefits Under Subsidy for Alternative Socio-Economic Groups (Decreasing Block Rate)

Calculation of Subsidy Costs

The subsidy costs are divided into three categories: lump sum grants, low interest long-term loans, and administrative costs. All costs are calculated on an annual basis and converted to cost per thousand gallons of water supplied.

Lump Sum Grant (LSG). LSG is provided to rural water systems at the time of construction, capacity expansion, or purchase of water facilities. Grant amount is a resource cost to society in that it represents foregone funds for alternative uses. If we assume that facilities constructed or purchased from grants are in use for n years and the opportunity cost or social discount rate is i then the annual subsidy cost equals the amount of the grant times the capital recovery factor where this factor is defined as:

$$\beta = i(1+i)^n/(1+i)^n - 1 \qquad (3\text{-}16)$$

Then annualized subsidy grant cost per thousand gallons of water (AGC_{wj}), supplied by rural water system j is equal to:

$$AGC_{wj} = \beta\ (LSG_j / Q_j) \qquad (3\text{-}17)$$

where LSG_j is the amount of lump sum grant and Q_j is the amount of water supplied annually by rural water system j.

Similarly, the annualized subsidy grant cost per household within rural water system j (AGC_{nj}) is estimated as:

$$AGC_{nj} = \beta\ (LSG_j / N_j) \qquad (3\text{-}18)$$

where N_j represents total number of households within rural water system j.

Low Interest Loan (LIL). Cost to society of low interest loans is the difference between the opportunity cost represented by the social discount rate and the subsidized interest rate over the loan period. The annualized subsidy cost of the low interest loan per thousand gallons of water to rural water system j (ALC_j) is the following:

$$ALC_{wj} = LIL_j (\beta - \alpha)/Q_j \qquad (3\text{-}19)$$

where β and α are capital recovery factors at i social discount rate and r subsidized interest rate, respectively; LIL_j is the amount of low interest loan; and Q_j is the amount of water supplied annually.

Similarly, the annualized subsidy cost of low interest loans per household within rural water system j (ALC_{nj}) is the following:

$$ALC_{nj} = LIL_j (\beta - \alpha)/N_j \qquad (3\text{-}20)$$

where N_j denotes number of households within rural water system j and other notations are the same as in equation (3-18).

Administrative Costs. Lump sum grants and low interest loans are administered by FmHA or other special federal agencies. Loan guarantees through bond issues are administered by State government. These administrative costs are indirect subsidy costs since they are borne by the public through taxpayer money. These costs could be obtained by identifying the budgets allocated for administering the STRWS. However, because these costs are presumed minor compared to the AGC and ALC costs, and due to expected difficulties in obtaining data on these costs, administrative costs are not considered in this study.

Summary

The theoretical foundation of cost-benefit analysis of public subsidy was outlined in this Chapter. Methods for measuring benefits and costs of public subsidy to rural water systems were presented. Distributional weighting systems were introduced to incorporate the decision-maker's value judgements in the objectives of public subsidy programs. Models for measuring subsidy distributions between groups of rural households from STRWS were suggested. Finally, methods for calculating subsidy costs of STRWS were outlined.

CHAPTER IV

RURAL COMMUNITY WATER DEMAND

This Chapter provides the basis for estimating water demand for rural communities in Oklahoma. The theoretical and practical issues associated with rural water demand estimation are discussed. Then a rural water demand model is proposed. Empirical results of water demand estimation follow.

Major Issues in Water Demand Estimation

A well defined rural water demand function is important for investment planning of rural water systems, water systems management, and welfare analysis of public subsidy to water systems. A large body of literature on water demand has developed over the last two decades. However, major issues still remain with respect to specification of the price variable and to the appropriate estimation technique. A further issue for rural water systems is that of locational preference. To what extent is the demand for rural water a reflection also of the demand for rural living? These issues are discussed below.

Water demand is defined as the various quantities of water a consumer is willing and able to buy as the water rate (price) varies, ceteris paribus (Dellenbarger, Kang, and Schreiner, 1986). The major problem in modelling water demand lies in the fact that consumers do not face a single price but a multipart price schedule set by monopolistic water systems. Houthakker (1951) discussed economic implications of the presence of a price schedule, focusing on which price, marginal or average, should be included in the demand function.

The conventional view for commodity demand functions under multipart rate schedules focuses on the marginal price. This view argues that consumers respond to the price represented by the marginal step on the rate structure where the consumer is observed to be. Howe and Linaweaver (1967) used marginal price in estimating residential water demand for the U.S. Since then, however, the economic theory of consumer behavior in the face of multipart rate structure has advanced considerably (Howe, 1982).

Taylor (1975) pointed out that marginal price alone does not represent the effects of the rate structure on consumer response. He argued that a single marginal price governs consumer behavior while the consumer is in that block, but it does not explain why consumption occurs in that block as opposed to some other block. He then showed that both block marginal and average price are the correct specification of consumer behavior for multipart rate schedules of a commodity (electricity) and account for differences in intramarginal rate steps.

Nordin (1976) modified Taylor's demand analysis and demonstrated that the theoretically correct specification of demand under block rate schedule is to include, in addition to marginal price, "a variable equivalent to a lump-sum payment the consumer must make before buying as many units as he wants at the marginal price." This lump-sum payment represents the difference between what a consumer actually pays and what would have been paid if all units were purchased at the marginal price. This payment is known as the difference variable or the rate structure premium. Billings and Agthe (1980) theoretically reinforced Nordin's modified specification of demand and empirically estimated residential water demand for Tucson, Arizona. Howe (1982) also applied

Nordin's specification to estimate residential water demand with statistically reasonable results.

However, other studies have used average price for residential water demand under block rate schedules (Gottlieb, 1963; Wong, 1972; Young, 1973; Foster and Beatie, 1979; and Cochran and Cotton, 1985). Specifically, Foster and Beatie (1981a, 1981b) advocated the use of average price as a proper specification of demand under block rate schedule. They questioned the perfect knowledge postulate implicit in the marginal price model, that is, the likelihood that consumers are aware of the detailed block pricing rate structure. Thus, they believed that consumers may not respond to marginal price or the change in lump-sum payment but are more likely to respond to their total water expenditure and thus perceive average price as a proxy for the unknown marginal block price. However, they conceded that the price to which consumers actually respond is an empirical question (Foster and Beatie, 1981a). Their empirical study showed that parameter estimates from the Nordin specification were not significantly different from an average price specification (Foster and Beatie, 1981b). Based on statistical criteria, comparisons of empirical performance between Nordin's specification and average price specification favor the average price model for water and electricity demand (Stevens and Kesisoglou, 1984; and Adams, Stevens, and Wills, 1985).

Opaluch (1982) proposed two hypothesis tests to determine whether consumers respond to average price or Nordin's modification of Taylor's model. For the consumer on the second block in a two block rate schedule average price can be expressed as $[P_1 Q_1 + P_2 (Q - Q_1)]/Q$ where Q represents total purchase of a good subject to block rate schedule, P_2 represents the price of Q in the second block or marginal price, Q_1 represents quantity of the initial block, and P_1 represents the price corresponding to Q_1. Then the average price can be expressed as $P_2 + \frac{(P_1 - P2)\ Q_1}{Q}$ which implies AP = MP + D/Q where AP and MP represent average price and marginal price respectively, and D represents Nordin's difference variable. This measure of average price may be defined in the demand function as follows:

$$Q = \beta_0 + \beta_1 P_x + \beta_2 P_2 + \beta_3 [(P_1 - P_2)\ Q_1 / Q] + \beta_4 [Y - (P_1 - P_2)Q_1] \qquad (4\text{-}1)$$

where P_x represents a price index for other relevant goods, Y represents total income of the consumer, and the ßs are coefficients.

If well informed consumers respond to marginal price, then $\beta_3 = 0$. Thus the demand function is given by:

$$Q = \beta_0 + \beta_1 P_x + \beta_2 P_2 + \beta_4 [Y - (P_1 - P_2)Q_1] \qquad (4\text{-}2)$$

That is, equation (4-1) reduces to Nordin's specification.

If consumers respond to average price, then $\beta_2 = \beta_3 \neq 0$. Thus the demand function is given as:

$$Q = \beta_0 + \beta_1 P_x + \beta_2 P_A + \beta_4 [Y - (P_1 - P_2)Q_1] \qquad (4\text{-}3)$$

where P_A represents average price.

The hypotheses to be tested are the following:

Test 1	Test 2
H_o : $\beta_3 = 0$	H_o : $\beta_2 = \beta_3$
H_A : $\beta_3 \neq 0$	H_A : $\beta_2 \neq \beta_3$

If the null hypothesis of both tests are rejected then the data are inconsistent with the demand functions (4-2) and (4-3). If the null hypothesis of test 1 fails to be rejected while that of test 2 is rejected, then the demand function is specified as (4-2). If the null hypothesis of test 1 is rejected while that of test 2 fails to be rejected then the demand function is specified as (4-3). If both null hypotheses fail to be rejected then (1) $\beta_2 = \beta_3 = 0$, or (2) $\beta_2 \neq 0$ with $\beta_3 = 0$, or $\beta_2 \neq 0$ with $\beta_2 = \beta_3$. Results of (1) indicate that consumers do not respond to price at all and results of (2) may indicate data weakness or different responsiveness of consumers, some to marginal and others to average price.

The Opaluch test was applied in an empirical study under a declining block rate schedule by Chicoine, Deller and Ramamurthy (1986). Results indicated that the decomposed variables of average price were determined as the appropriate price specification.

The issue associated with estimation technique focuses on the appropriateness of ordinary least squares (OLS) in the presence of block rate schedules. This issue is due to 1) nonlinear nature of the pricing structure where price depends on discontinuous quantities consumed; 2) measurement error in water consumption near the boundary of the discrete rate schedule which assigns wrong marginal price and thus introduces errors in the price variables; and 3) quantity dependent price and thus simultaneity bias (Chicoine, Deller, and Ramamurthy, 1986). Nonlinearity in quantities consumed may cause biased estimates of the demand parameters; measurement errors may result in both biased and inconsistent estimates; and simultaneity may give both biased and inconsistent estimates.

For the first problem there is little theoretical knowledge (Chicoine, Deller, and Ramamurthy, 1986). Kelejian (1971) theoretically demonstrates that two-stage least squares can be used to estimate the parameters of a nonlinear model. Terza and Welch (1982) propose a two-stage Probit approach that is applicable only for increasing block rate schedules. For the second problem, an instrumental variable approach has been applied in several studies (Billings, 1982; Hensen, 1984; Jones and Morris, 1984; Deller, Chicoine, and

Ramamurthy, 1986). For the third problem, simultaneous equation models have been applied by Adams, Stevens and Wills (1985); Agthe, Billings, Dobra and Raffiee (1986); and Chicoine, Deller and Ramamurthy (1986). Most empirical studies indicate that alternative estimation techniques (instrumental variable approach and simultaneous equation models), do not differ significantly from OLS results (Jones and Morris, 1984; Adams, Stevens and Wills, 1985; Chicoine, Deller and Ramamurthy, 1986; and Deller, Chicoine and Ramamurthy, 1986).

The issues associated with locational preference are concerned with the interrelationships between rural residence location and water demand behavior of rural households.

Rural areas may generate gross locational income in the form of lower cost of living or higher psychic earnings from a perceived improved environment. However, rural areas also incur locational costs such as commuting from residence to work place, higher insurance costs, unpaved access roads, lower police and fire protection, and higher water connection cost. Net locational income would be equal to gross locational income less locational costs. If rural households behave rationally they would prefer a rural location only if net locational income is positive, ceteris paribus. A positive net locational income may influence water demand behavior of rural households similar to household income. When gross locational income and other locational costs are assumed constant across different rural locations, water demand is influenced by water cost and commuting cost since net locational income is dependent upon these factors.

Water costs can be divided between daily water usage cost which is billed to rural households monthly and water access or connection cost. Daily water usage cost is reflected as a price variable in water demand. Water access or connection cost may explain, in part, locational demand behavior of rural households. This water access or connection cost also may be capitalized in property values since it is paid only once when rural households are connected to the water system.

Some households settle in rural areas specifically for the purpose of exploiting net locational income. They have locational preference for rural living (Dellenbarger, 1985). This group of rural households may show different water demand behavior due to net locational income or locational demand. The interrelationships between rural residence location and rural household water demand need to be tested since policy makers may want to know if the public is subsidizing locational preference or water usage.

Previous Studies of Rural Water Demand in Oklahoma

There have been several studies on rural community water demand in Oklahoma. Slogett and Badger (1974) estimated monthly water use of rural customers within 57 rural water systems in Oklahoma. Goodwin, Doeksen, and Nelson (1979) estimated monthly and annual water use with information obtained from state and county FmHA offices and from system managers. However, these studies were not intended to identify the systematic relationship between quantity of water consumed and factors such as price of water, price of alternative goods and services, and income. Dellenbarger, Myoung, and Schreiner (1984) estimated rural water demand with two different sets of aggregate data, one from secondary data covering 203 systems for the year 1977, and the other from survey data covering 69 systems collected by the Oklahoma Water Resources Board for the year 1981. They used average price for price specification with other socio-economic variables, and OLS was used for demand estimation. Functional forms were linear and log-linear. Estimation of seasonal and regional water demand were included in the study. The estimated demand function was for the aggregate water system.

Similar attempts have been made by Doeksen, Goodwin, and Oehrtman (1984) to estimate rural water demand. They used marginal cost for each customer as a price variable (probably marginal price) with other socio-economic variables. OLS was used as an estimation technique. Unlike the study of Dellenbarger, Myoung, and Schreiner, this study used cross-sectional household data.

A more recent study (Dellenbarger, Kang, and Schreiner, 1986) used household survey data and included Nordin's marginal price and difference variables under decreasing block rate schedules. A quadratic functional form was used with OLS estimation. Seasonality of rural water demand was examined using the Bonferroni inequality test. However, it was not tested whether rural consumer response is better explained with average price or with Nordin's specification.

None of the above studies included analysis of locational preference in estimating demand for rural water.

Rural Water Demand Estimation

Although Nordin's specification of water demand is considered theoretically reasonable it is also accepted in this study that the price variable specification may depend on empirical data. It is based on the argument that consumers may be "well informed" or "uninformed" on complicated rate schedules and rate premiums. Thus, Opaluch's test is used in determining the price variable to which consumers respond. Water demand is further specified for different consumer characteristics and different seasons.

Test for Appropriate Price Variable

The general model used in testing for the appropriate price variable is the following:

$$Q_{it} = \beta_0 + \beta_1 MP_{it} + \beta_2 DP_{it} + \beta_3 YD_{it} + \beta_4 FAMS_i + \beta_5 NRS_i + \beta_6 MILE_i + e_{it} \quad (4\text{-}4)$$

where:

Q_{it} = the quantity of water (1,000 gal.) consumed by household i in month t.

MP_{it} = marginal price ($) per 1,000 gallons for household i in month t.

DP_{it} = Opaluch's decomposed price variable for household i in month t and is obtained from Nordin's difference variable divided by the quantity consumed.

YD_{it} = monthly income ($1,000) of household i in month t and is equal to annual household income divided by 12 less Nordin's difference variable or rate premium in month t.

$FAMS_i$ = family size (number of persons) in household i.

NRS_i = percentage (%) of nonhousehold water from alternative sources for household i.

$MILE_i$ = distance (miles) from residence to work place for household i.

MP, DP, and YD are used for the Opaluch test in determining the appropriate price variable. Since rural areas have access to alternative sources of water such as ponds and wells, NRS is used to test the importance of these water sources. Distance from residence to work place, MILE, is used as a surrogate for commuting cost. Water access cost data are not available for this study. However, a locational preference variable is identified for a later water demand model.

Data were obtained from a survey conducted in 1984 by the Department of Agricultural Economics at Oklahoma State University on Oklahoma rural water systems and households within the rural water systems. The survey procedure is explained in Dellenbarger (1985). A random sample of Oklahoma rural water systems was drawn and a ten percent random sample of households within each system was surveyed. Actual 1983 monthly water consumption and water billings data were obtained from water system records and a mail questionnaire was sent to each household in the ten percent sample to obtain data on family income, family size, alternative sources of water, and other household characteristics. A total of 347 households responded representing 14 different rural water systems. Of these, a total of 571 usable monthly observations representing 11 systems resulted. Lack of information on household income and distance to place of work accounted for the major reduction in usable observations.

Ordinary least squares (OLS) regression was used as estimation technique. The two sets of hypotheses as proposed by Opaluch are:

Test 1	Test 2
H_o : $\beta_1 = 0$	H_o : $\beta_1 = \beta_2$
H_A : $\beta_1 \neq 0$	H_A : $\beta_1 \neq \beta_2$

The estimated water demand function is the following:

$$Q = 5.583 - 1.416\ MP - 1.760\ DP + 1.386\ YD + 1.513\ FAMS$$
$$(4.77) \quad (-3.44) \quad (-10.01) \quad (7.25) \quad (8.17)$$
$$-0.011\ NRS - 0.054\ MILE \qquad (4\text{-}5)$$
$$(-1.96) \quad (-2.44) \quad \bar{R}^2 = 0.40$$

The signs of all variables are as expected. The t values as shown in parentheses below the coefficients are significant at the five percent level. These results show the null hypothesis of test 1 is rejected, that is, $\beta_1 \neq 0$. For Test 2 the F statistic is 0.56 and is not significant at the 5 percent probability level. Therefore, the null hypothesis $\beta_1 = \beta_2$ is not rejected. Results of the hypothesis testing indicate that consumers more likely respond to "average price". Thus, the appropriate water demand model is specified as:

$$Q = f(AP, S) \qquad (4\text{-}6)$$

where AP is average price and S is a vector of other socio-economic variables.

Empirical Water Demand Models and Results

Evaluation of STRWS in this study requires estimation of rural water demand by (1) season and (2) season, income level, and locational preference as shown in Figure 14. The models specified for water demand estimation are the following:

Model I

$$Q_{it} = \beta_0 + \beta_1\ AP_{it} + \beta_2\ FAMS_i + \beta_3\ YD_{it} + \beta_4\ NRS_i$$
$$+ \beta_5\ MILE_i + \beta_6\ DM_1 + \beta_7 APD + e_{it} \qquad (4\text{-}7)$$

Model II

$$Q_{it} = \beta_0 + \beta_1\ AP_{it} + \beta_2\ FAMS_i + \beta_3\ YD_{it} + \beta_4\ NRS_i$$
$$+ \beta_5\ MILE_i + \beta_6\ DM_1 + \beta_7\ INDP + \beta_8\ INDM + \beta_9\ LPD$$
$$+ \beta_{10}\ APD + \beta_{11}\ APYP + \beta_{12}\ APYM + \beta_{13}\ APL + e_{it} \qquad (4\text{-}8)$$

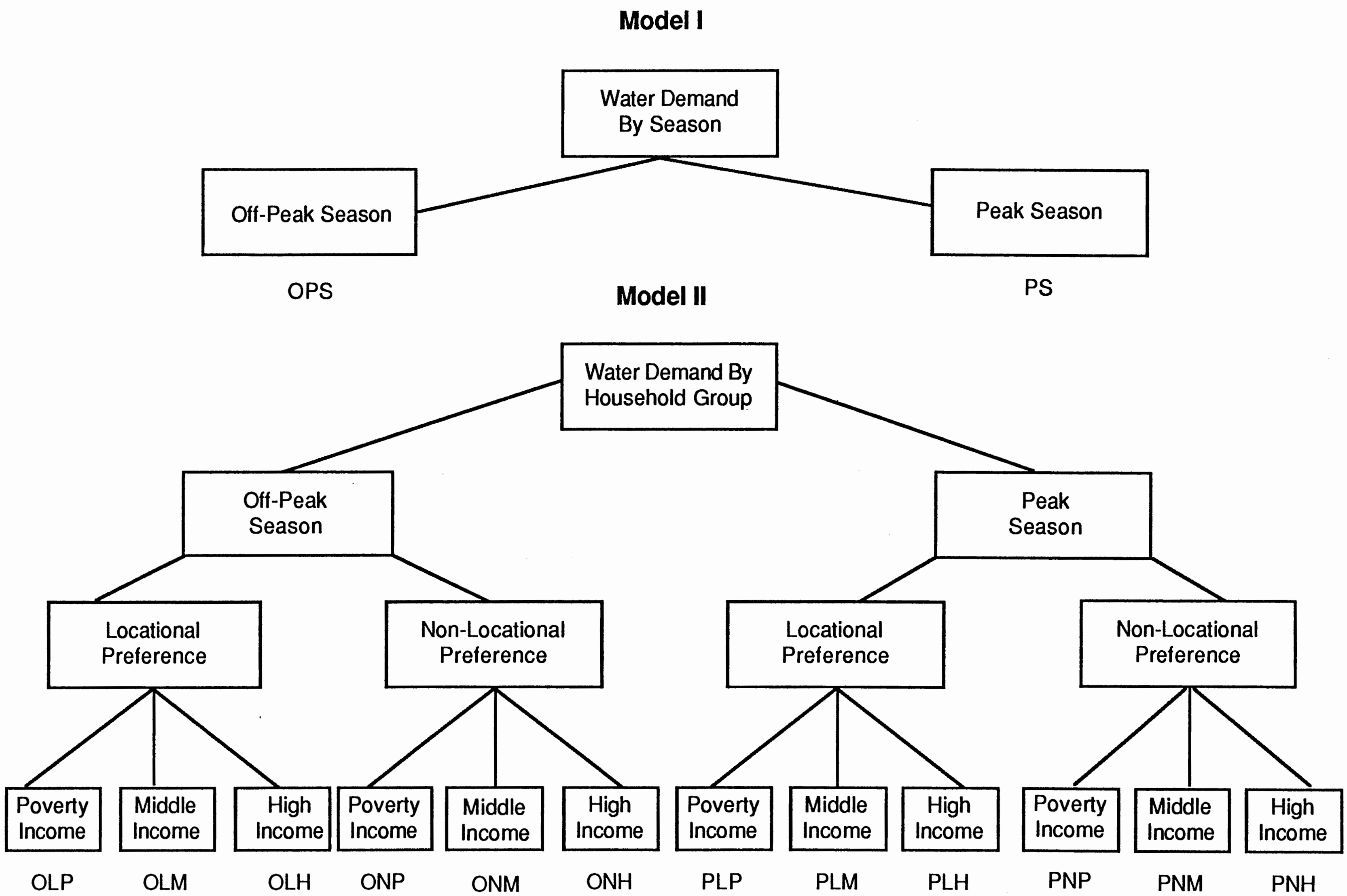


Figure 14. Water Demand by Season and Household Group

where

Q_{it} = the quantity of water (1,000 gal.) consumption by household i in month t.

AP_{it} = average price ($) per 1,000 gallons of water for household i in month t.

$FAMS_i$ = family size (number of persons) in household i.

YD_{it} = monthly income ($1,000) of household i in month t and is equal to annual household income divided by 12 less Nordin's difference variable or rate premium in month t.

NRS_i = percentage (%) of nonhousehold water from alternative sources for household i.

$MILE_i$ = distance (miles) from residence to work place in household i.

DM1 = dummy variable for season where

DM1 = 1 if (January-June, October-December)

DM1 = 0 if (July-September)

INDP = dummy variable for poverty family household income group

INDP = 1 if annual household income is less than or equal to $7,938.

INDP = 0 if other.

INDM = dummy variable for median family household income group

INDM = 1 if annual household income is greater than $7,938 but less than or equal to $25,701.

INDM = 0 if other.

LPD = dummy variable for locational preference.

LPD = 1 if the residents express locational preference.

LPD = 0 otherwise.

APD = AP * DM1

APYP = AP * INDP

APYM = AP * INDM

APL = AP * LPD

Seasonality identification on rural water demand in Oklahoma was obtained from Dellenbarger, Kang, and Schreiner (1986). Data on locational preference were obtained by asking rural households about their settlement motivation (desire for rural living). Locational preference is thus expressed by a dummy variable. Dummy variables were also used to distinguish water demand behavior of different household income groups; poverty income level (less than $7,938), median income level (greater than $7,938 but less than $25,701), and high income level (greater than $25,701) for the year 1983. The poverty income level is reported by the U.S. Department of Commerce and is based on Social Security Administration poverty index of 1964 and revised by Federal Interagency Committee in 1969 and 1980 (U.S. Department of Commerce, 1984).

The two estimated water demand equations using OLS are shown in Table I. In Model I, the coefficients for all variables are significant at the 5% probability level and signs of all variables are as expected. The negative sign of MILE indicates that demand for water decreases as distance from residence to work place increases thus reducing net locational income. Adjusted $\bar{R}^2$ is 0.46. This equation gives two seasonal water demands as presented in Table II. Structural stability test for the equivalence of intercept and slope for the two seasons gives F statistic of 30.09 which is significant at the 5 percent probability level, indicating difference between the two seasons in intercept and slope. Price elasticities for the two seasons are calculated for Model I and presented in Table III. Because these are linear demand functions, the point

TABLE I

ESTIMATED WATER DEMAND FOR RURAL COMMUNITIES IN OKLAHOMA, 1983[a]

	MODEL I		MODEL II	
Variable	Mean Values	Regression Coefficient and t Values	Mean Values	Regression Coefficient and t Values
INTERCEPT		10.806		19.329
		(8.83)		(8.25)
AP	3.36	-2.659	3.34	-5.654
		(-9.91)		(-12.34)
FAMS	3	1.587	3	1.166
		(8.90)		(5.83)
YD	2.14	1.468	2.18	1.852
		(8.45)		(4.59)
NRS	26	-0.010	27	0.003
		(-1.91)		(0.56)
MILE	7.5	-0.057	7.8	-0.065
		(-2.72)		(-2.81)
DM1		-7.545		-6.848
		(-7.17)		(-6.38)
APD		1.487		1.283
		(4.99)		(4.23)
INDP				-6.864
				(-3.03)
INDM				-5.843
				(-3.28)
LPD				-4.892
				(-4.02)
APYP				2.699
				(6.42)
APYM				2.389
				(5.72)
APL				1.356
				(3.68)
n[b]			571	511
$\bar{R}^2$			0.46	0.50

[a]Mean of dependent variable $\bar{Q}$ was 7,394 gallons for Model I and 7,579 gallons for Model II.

[b]The difference in sample size is due to missing data on locational preference.

TABLE II

ESTIMATED MONTHLY WATER DEMAND BY SEASON AND SOCIO-ECONOMIC GROUP FOR RURAL COMMUNITIES IN OKLAHOMA, 1983

Variable	Intercept	AP	FAMS	YD	NRS	MILE
MODEL I						
Off-Peak Season (OPS)	3.261	-1.172	1.587	1.468	-0.010	-0.057
Peak Season (PS)	10.806	-2.659	1.587	1.468	-0.010	-0.057
MODEL II						
Off-Peak Season						
Locational Preference						
Poverty Income (OLP)	0.725	-0.316	1.166	1.852	0.003	-0.065
Middle Income (OLM)	1.746	-0.626	1.166	1.852	0.003	-0.065
High Income (OLH)	7.589	-3.015	1.166	1.852	0.003	-0.065
Non-Locational Preference						
Poverty Income (ONP)	5.617	-1.672	1.166	1.852	0.003	-0.065
Middle Income (ONM)	6.638	-1.982	1.166	1.852	0.003	-0.065
High Income (ONH)	12.481	-4.371	1.166	1.852	0.003	-0.065
Peak Season						
Locational Preference						
Poverty Income (PLP)	7.573	-1.599	1.166	1.852	0.003	-0.065
Middle Income (PLM)	8.594	-1.909	1.166	1.852	0.003	-0.065
High Income (PLH)	14.437	-4.298	1.166	1.852	0.003	-0.065
Non-Locational Preference						
Poverty Income (PNP)	12.465	-2.955	1.166	1.852	0.003	-0.065
Middle Income (PNM)	13.486	-3.265	1.166	1.852	0 003	-0.065
High Income (PNH)	19.329	-5.564	1.166	1.852	0.003	-0.065

SOURCE: Based on Table I.

TABLE III

PRICE ELASTICITIES OF WATER DEMAND BY SEASON AND HOUSEHOLD GROUP FOR RURAL COMMUNITIES IN OKLAHOMA, 1983[a]

	Mean Quantity for All Households and All Seasons	Mean Price for All Households and All Seasons	Mean Quantity for Each Season for All Households	Mean Quantity and Mean Price for Each Season and Each Group
MODEL I				
Off-Peak Season (OPS)	-0.47	-0.74	-0.78	-0.78
	(6,767)	(3.605)	(5,587)	(5,587)
Peak Season (PS)	-1.56	-1.24	-0.91	-0.91
	(6,767)	(3.605)	(9,084)	(9,084)
MODEL II				
Off-Peak Season				
Locational Preference				
Poverty Income (OLP)	b	-0.38	b	-0.26
	(6,767)	(3.605)	(5,587)	(3,311)
Middle Income (OLM)	-0.06	-0.46	-0.28	-0.35
	(6,767)	(3.605)	(5,587)	(5,311)
High Income (OLH)	-1.54	-1.72	-2.08	-1.87
	(6,767)	(3.605)	(5,587)	(5,988)
Non-Locational Preference				
Poverty Income (ONP)	-0.31	-2.12	-0.59	-0.73
	(6,767)	(3.605)	(5,587)	(5,142)
Middle Income (ONM)	-0.92	-1.22	-1.32	-1.25
	(6,767)	(3.605)	(5,587)	(5,784)
High Income (ONH)	-2.27	-2.47	-2.96	-1.48
	(6,767)	(3.605)	(5,587)	(8,938)

TABLE III (Continued)

	Mean Quantity for All Households and All Seasons	Mean Price for All Households and All Seasons	Mean Quantity for Each Season for All Households	Mean Quantity and Mean Price for Each Season and Each Group
Off-Peak Season				
Locational Preference				
Poverty Income (PLP)	-0.63	-1.10	-0.21	-0.54
	(6,767)	(3.605)	(9,084)	(7,145)
Middle Income (PLM)	-1.08	-0.96	-0.55	-0.72
	(6,767)	(3.605)	(9,084)	(8,171)
High Income (PLH)	-2.53	-1.84	-1.63	-1.16
	(6,767)	(3.605)	(9,084)	(11,066)
Non-Locational Preference				
Poverty Income (PNP)	-1.33	-2.08	-0.74	-0.82
	(6,767)	(3.605)	(9,084)	(8,665)
Middle Income (PNM)	-1.92	-1.47	-1.18	-1.37
	(6,767)	(3.605)	(9,084)	(8,343)
High Income (PNH)	-3.24	-2.45	-2.16	-0.88
	(6,767)	(3.605)	(9,084)	(15,308)

[a]Numbers in the parenthesis indicate the points where elasticities are measured.

[b]Elasticity is not calculated due to extension of the demand equation to the negative price quadrant.

elasticities vary depending on quantity of water demanded (see Figure 15). The elasticity in off-peak season as estimated at the overall monthly mean of water consumption for all households is -0.47 versus -1.56 in peak season. The elasticities at overall average price is -0.74 in off-peak season and -1.24 in peak season. However, when calculated at the mean seasonal quantity and price the elasticities are -0.78 for off-peak season and -0.91 for peak season.

In Model II (Table I) coefficients of all variables are significant at the 5 percent probability level except NRS and signs of all variables other than NRS are as expected. Adjusted $\bar{R}^2$ is 0.50. Seasonal water demands by household income level and locational preference are presented in Table II. Price elasticities by the household group are presented in Table III. Structural stability test for the equivalence of intercept and slope across household groups gives F statistic of 2.04 which is significant at the 5 percent probability level, indicating difference in intercept and slope between household groups. Elasticities are calculated for the following quantities and prices: mean monthly water consumption for all households, mean price for all households and all seasons, mean monthy water consumption by season for all households, and mean monthly water consumption and mean price for each group.

Although price elasticities vary depending on quantity of water demanded, in general, low income groups are less price elastic than high income groups. This is consistent with low income groups being at water consumption levels closer to the basic requirement. Groups with locational preference are less price elastic than groups with no locational preference. The reasoning is that groups with locational preference are compensated by net locational income for the loss due to a change in price. Peak season water demand is more price elastic than for the off-peak season. The extent of influence of weather factors

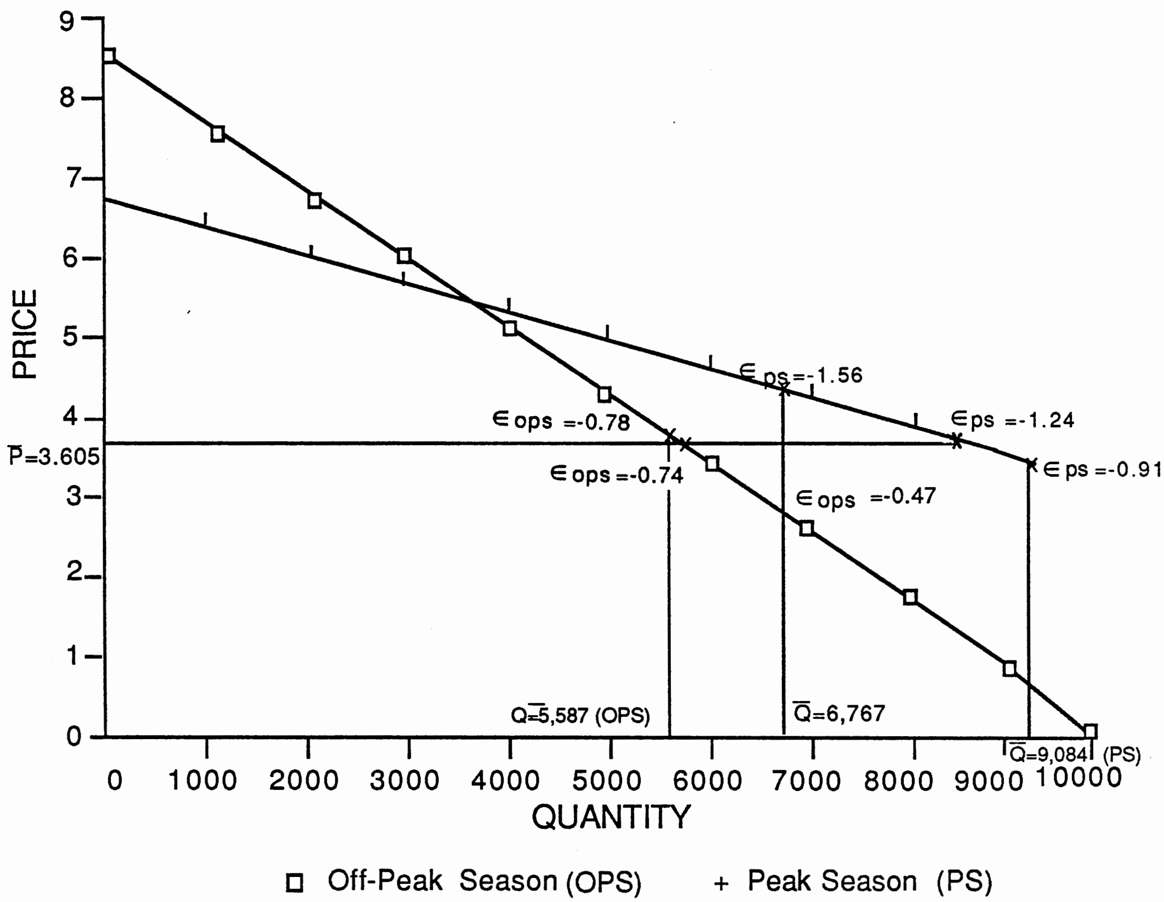


Figure 15. Water Demand by Season and Computed Price Elasticities for Rural Communities in Oklahoma, 1983.

such as rainfall and temperature on water demand for the 1983 period in Oklahoma may be different from that for other years.

Computed elasticities for some groups in Table III should be interpreted with care since the implied quantity and price data may extend beyond the observed data for such groups.

Summary

This Chapter discussed water demand for rural communities in Oklahoma. Major theoretical issues influencing water demand and water demand estimation were reviewed. Average price was selected as the appropriate price variable using Opaluch's test.

Water demand functions by season, income level, and locational preference were estimated. These demand functions are used for cost-benefit analysis in Chapter V.

CHAPTER V

EMPIRICAL RESULTS OF PUBLIC SUBSIDY TO RURAL WATER SYSTEMS IN OKLAHOMA

This Chapter discusses empirical results of the analysis of public subsidies to rural water systems in Oklahoma. The cost of public subsidies are calculated on an annual basis per thousand gallons of water supply and per household served. Marginal Social Benefit-Cost Ratios (MSBCR) of public subsidy to rural water systems (STRWS) are calculated under the conventional and non-conventional approaches and under conditions of seasonality of water demand, income level of rural households, and settlement motivation. Subsidy distribution among income groups of rural households are analyzed.

Sample Description of Rural Water Systems in Oklahoma

Sample Survey Data

The Department of Agricultural Economics at Oklahoma State University in 1984 carried out a random sample of rural water systems in Oklahoma and of rural households within those systems. Those data were used in Chapter IV to estimate rural community water demand. A complementary survey of 11 systems used in the demand estimation was conducted in 1987 to collect data on subsidies received by the rural water systems through the Farmers Home Administration (FmHA) or other public agencies. The 11 systems represent all of the FmHA district offices except district 2 (see Appendix A). Data on subsidies (grants and low interest loans) administered by the FmHA were collected from the permanent records of the district offices. Data on subsidies provided by agencies other than the FmHA were collected from the individual rural water system. Survey questionnaires and cover letters are shown in the Appendix.

Characteristics of the Sample of Rural Water Systems

The sample of rural water systems were mostly incorporated from 1950 to 1970 (Table IV). The oldest rural water system was incorporated in 1924 and the latest was incorporated in 1974. The number of connections varied widely. The smallest had 110 connections and the largest had 2,938. The miles of distribution lines varied from 5 to 380 with two systems not reporting. Water supplied (amount billed to household customers) on an annual basis ranged from 6,055 thousand gallons to 275,338 thousand gallons. All systems priced water using a decreasing block rate schedule.

Grants and Loans Received by System

Public subsidies to the sample of rural water systems included grants and long-term low interest loans (Table V). All of the systems surveyed received low interest long-term loans and all but four received grants.

Grants were provided in lump sum payment and were used for initial construction of facilities, capacity expansion, and/or renovation of existing system. The major source of grants was FmHA although DECA (Department of Economic and Community Affairs) and RedArk (RedArk Development Authority) each made one grant. Six systems received more than one grant.

Loans were provided for the same purposes as were the grants. All of the loans were exclusively supplied from FmHA. Nine systems received more than one loan from FmHA. Interest rates ranged from a low of 3.75 percent to a high

TABLE IV

CHARACTERISTIC DATA OF SAMPLE OF RURAL WATER SYSTEMS IN OKLAHOMA

System Code	Year Incorporated	Number of Connections[a]	Miles of Lines[b]	Water (1,000 Gal.)[c]
A	1969	110	5	13,929
B	1958	183 (1985)	16	6,055 (1985)
C	1924	190	25	14,226 (1985)
D	1966	132	12	6,660 (1985)
E	1965	2,938 (1984)	-	275,338
F	1969	788	-	93,410
G	1959	1,219	24	84,269
H	1970	1,041	380	87,000
I	1966	242	8	16,654
J	1962	275	10	62,750
K	1974	370	76	29,800
AVERAGE		680	61	62,735

[a]Data are for 1983 to correspond with earlier survey unless otherwise noted.

[b]Two systems were unable to estimate the miles of distribution lines.

[c]Amount of water billed to rural households in 1983 unless otherwise noted.

TABLE V

GRANTS AND LOANS PROVIDED SAMPLE OF RURAL WATER SYSTEMS IN OKLAHOMA

System Code	Year Granted	Grant (G) or Loan (L)	Amount ($)	Purpose[a]	Source	Interest Rate of Loan (%)	Long-term Treasury Bond Rate (%)
A	1969	L	110,000	1	FmHA	5.000	6.10
B	1967	L	40,000	1	FmHA	4.000	4.85
	1980	L	190,000	2	FmHA	5.000	10.81
C	1968	G	29,930	3	DECA	-	5.26
	1968	L	100,000	3	FmHA	4.125	5.26
	1983	L	100,000	3	FmHA	5.000	11.18
	1983	G	83,222	2	DECA	-	11.18
D	1967	G	37,280	1	FmHA	-	4.85
	1971	G	60,000	2	FmHA	-	6.12
	1979	G	23,700	2	FmHA	-	9.29
	1967	L	83,720	1	FmHA	3.750	4.85
	1971	L	15,000	2	FmHA	5.000	6.12
	1979	L	23,700	2	FmHA	5.000	9.29
E	1965	L	833,840	1	FmHA	3.950	4.21
	1972	L	155,000	2	FmHA	5.000	6.01
	1982	L	5,500,000	2	FmHA	5.000	12.76
F	1975	G	100,000	2 and 3	FmHA	-	8.19
	1978	G	68,500	2	FmHA	-	8.49
	1971	L	870,000	1 and 2	FmHA	5.000	6.12
	1974	L	156,000	2	FmHA	5.000	8.05
	1978	L	71,500	2	FmHA	5.000	8.49
G	1979	G	29,400	3	FmHA	-	9.29
	1974	L	215,000	3	FmHA	5.000	8.05
	1979	L	29,400	3	FmHA	5.000	9.29
	1973	G	150,000	2	RedArk	-	7.12

TABLE V (Continued)

System Code	Year Granted	Grant (G) or Loan (L)	Amount ($)	Purpose[a]	Source	Interest Rate of Loan (%)	Long-term Treasury Bond Rate (%)
H	1981	G	309,300	2	FmHA	-	12.87
	1971	L	1,092,000	1	FmHA	5.000	6.12
	1975	L	86,000	2	FmHA	5.000	8.19
	1981	L	115,200	2	FmHA	5.000	12.87
I	1966	L	67,000	1	FmHA	3.750	4.66
J	1972	G	22,400	2	FmHA	-	6.01
	1977	G	34,000	2	FmHA	-	7.75
	1967	L	238,000	1	FmHA	3.750	4.85
	1972	L	22,400	2	FmHA	5.000	6.01
	1976	L	33,900	2	FmHA	5.000	7.86
K	1979	G	105,000	3	FmHA	-	9.29
	1981	G	50,000	3	FmHA	-	12.87
	1975	L	120,000	3	FmHA	5.000	8.19
	1979	L	106,000	3	FmHA	5.000	9.29
	1981	L	38,000	3	FmHA	5.000	12.87

[a]1: Initial construction of system facilities.
2: Capacity expansion.
3: Renovation of existing system.

of 5 percent per year. A five percent rate was dominant for the subsidized loans. Subsidized rate is compared with the long-term U.S. Treasury bond rate at the time of each loan. The latter interest rate can be presumed closer to the opportunity cost or social discount rate. Loans provided in the 1980s were more heavily subsidized than loans provided in the 1960s and the 1970s. Repayment period was 40 years for all loans.

Average amount of grant per system for the 11 systems was $100,248. The largest grant was $309,300 and the smallest grant was $29,930, at current prices. As indicated earlier, four systems did not receive any grants.

Average amount of loans per system for the 11 systems was $946,696 at current prices. The largest amount of loans received by a system was $6,488,840, and the smallest amount was $67,000.

Annualized Cost of STRWS at Opportunity Cost

Annualized cost of public subsidy to rural water systems in Oklahoma is calculated in this section based on the opportunity costs of resource use. The annualized cost is on the basis of 1,000 gallons of water supplied for the year 1983 to correspond with estimated water demand for the same year.

Opportunity Cost of Subsidy Through Grants (SG)

The social opportunity cost of public subsidies through grants is the economic sacrifice of those resources in the best alternative use. Then the annualized subsidy in grants provided in year y for a rural water system w (ASG_{wy}) is obtained from the following:

$$ASG_{wy} = \beta_{wy} (LSG_{wy}) \qquad (5\text{-}1)$$

where

ASG_{wy} = annualized cost of public subsidy in grant provide in year y to rural water system w,

$ß_{wy}$ = capital recovery factor for n years with discount rate i, and

LSG_{wy} = lump sum grant provided to rural water system w in year y.

The capital recovery factor is the following:

$$ß = \frac{i(1+i)^n}{(1+i)^n - 1} \tag{5-2}$$

where

i = interest rate or social discount rate and is assumed equal to the long-term U.S. Treasury bond rate at the time of the grant, and

n = number of years of expected life of the asset purchased with the grant and is assumed equal to 40, the repayment period of FmHA loans.

The average annualized cost of public subsidy provided through grants per thousand gallons of water supplied for the sample of 11 rural water systems (MASG) is the following:

$$MASG = \frac{\sum_{w=1}^{11} ß_{wy} * LSG_{wy}}{\sum_{w=1}^{11} Q_w} * 1{,}000 \text{ gallons} \tag{5-3}$$

where Q_w = the water supplied by rural water system w in 1983 and is taken as the amount of water actually billed to rural household customers.

The average annualized cost of public subsidy through grants per household of the sample of rural water systems (HASG) is the following:

$$HASG = \frac{\sum_{w=1}^{11} ß_{wy} * LSG_{wy}}{\sum_{w=1}^{11} N_w} \tag{5-4}$$

where N_w = the number of households within rural water system w.

The annualized cost of public subsidy through grants is shown in Table VI. The average amount of grants provided to the sample of 11 rural water systems was $100,248 at current prices, including the systems not receiving grants. The largest amount of grants received by a sample system was $309,300. The average amount of annualized grant subsidies was $9,948 with the largest amount for a single system of $40,123. The average amount of grant subsidy per 1000 gallons was $0.16 with the largest grant subsidy per thousand gallons of $1.27 for a single system. The average amount of annual grant subvsidy per household was $14.61. The highest grant subsidy per rural household was $63.96.

Opportunity Cost of Subsidy Through
Low Interest Loans (SL)

The social opportunity cost of public subsidy through low interest loans (SL) is the difference between the actual loan rate and the return from the best alternative use (social opportunity cost) of the same loan. Thus the annualized SL was calculated as the difference between annual repayment with social discount rate (assumed equal to long-term U.S. Treasury bond rate) and annual repayment with actual interest rate for the loan.

The capital recovery factor with actual interest rate is the following:

$$\alpha = \frac{r\,(1+r)^n}{(1+r)^n - 1} \qquad (5\text{-}5)$$

where

r = actual loan interest rate and

n = number of years in repayment period and equal to 40.

The annualized cost of SL for rural water system w (ASL_w) is the following:

TABLE VI

ANNUALIZED COST OF PUBLIC SUBSIDIES THROUGH GRANTS FOR SAMPLE OF RURAL WATER SYSTEMS IN OKLAHOMA

System Code	Year Granted	Grant Amount ($)	Social Discount Rate	Capital Recovery Factor (ß)	Annual Subsidy Per Grant ($)	Water Supplied in 1983 (1,000 gal.)
A	-	-	-	-	-	13,929
B	-	-	-	-	-	6,055
C	1968	29,930	0.0526	0.0604	1,806.79	14,226
	1983	83,222	0.1118	0.1134	9,440.34	
D	1967	37,280	0.0485	0.0571	2,128.17	6,660
	1971	60,000	0.0612	0.0675	4,048.16	
	1979	23,700	0.0929	0.0956	2,266.62	
E	-	-	-	-	-	275,338
F	1975	100,000	0.0819	0.0856	8,557.15	93,410
	1978	68,500	0.0849	0.0883	6,047.93	
G	1979	29,400	0.0929	0.0956	2,811.75	84,269
	1973	150,000	0.0712	0.0761	11,408.46	
H	1981	309,300	0.1287	0.1297	40,123.32	87,000
I	-	-	-	-	-	16,654
J	1972	22,400	0.0601	0.0665	1,490.62	62,750
	1977	34,000	0.0775	0.0816	2,775.15	
K	1979	105,000	0.0929	0.0956	10,041.98	29,800
	1981	50,000	0.1287	0.1297	6,486.15	
Total		1,102,732			109,432.58	690,091
Average		100,248	0.0847	0.088771	7,816.61	62,736

TABLE VI (Continued)

System Code	Year Granted	Annual Subsidy Per 1000 Gal. Per Grant ($)	Number of Households in 1983	Total Annual Subsidy Per Household ($)	Total Annual Subsidy Per System ($)	Annual Subsidy Per 1000 Gal. ($) Per System
A	-	-	110	-	-	-
B	-	-	183	-	-	-
C	1968	0.13	190	59.20	11,247.13	0.79
	1983	0.66				
D	1967	0.32	132	63.96	8,442.94	1.27
	1971	0.61				
	1979	0.34				
E	-	-	2,938	-	-	-
F	1975	0.09	788	18.53	14,605.08	0.16
	1978	0.06				
G	1979	0.03	1,219	11.67	14,220.21	0.17
	1973	0.14				
H	1981	0.46	1,041	38.54	40,123.32	0.46
I	-	-	242	-	-	-
J	1972	0.02	275	15.51	4,265.77	0.07
	1977	0.04				
K	1979	0.34	370	44.67	16,528.13	0.55
	1981	0.22				
Total			7,488		109,432.58	
Average		0.16	680	14.61	9,948.42	0.16

$$ASL_{wy} = \frac{(\beta_{wy} - \alpha_{wy}) * LSL_{wy}}{Q_w} \tag{5-6}$$

where LSL_{wy} is lump sum loan provided to rural water system w in year y and other notations are as previously specified.

Then the average annualized SL per thousand gallons of water supplied for the sample of rural water systems (MASL) is

$$MASL = \frac{\sum_{w=1}^{11} (\beta_{wy} - \alpha_{wy})^* LSL_{wy}}{\sum_{w=1}^{11} Q_w} * 1{,}000 \text{ gallons} \tag{5-7}$$

where Q_w is the water supplied by system w in 1983.

Similarly, the average annualized SL per rural household for the sample (HASG) is:

$$HASG = \frac{\sum_{w=1}^{11} (\beta_{wy} - L_{wy}) * LSL_{wy}}{\sum_{w=1}^{11} N_w} \tag{5-8}$$

where N_w is the number of households in system w for year 1983. The calculated subsidies are as shown in Table VII.

The average amount of loan provided the sample of rural water systems was $946,696 at current prices. The largest loan was for $5,500,000 and the smallest loan was $15,000 at current prices. However, the largest amount of total loans to a system was $6,488,840 and the smallest amount of total loans to a system was $67,000. The average annual subsidy per loan was $17,852 with the largest subsidy equal to $387,072 and the smallest subsidy equal to $138. The total average annual subsidy per system was $42,196 with the largest

TABLE VII

ANNUALIZED COST OF PUBLIC SUBSIDIES THROUGH LOANS FOR SAMPLE OF RURAL WATER SYSTEMS IN OKLAHOMA

System Code	Year Obtained	Loan Amount ($)	Loan Interest Rate	Capital Recovery Factor (α)	Social Discount Rate	Capital Recovery Factor (ß)	Water Supplied in 1983 (1,000 gal.)
A	1969	110,000	0.05000	0.0583	0.0610	0.0673	13,929
B	1967	40,000	0.04000	0.0505	0.0485	0.0571	6,055
	1980	190,000	0.05000	0.0583	0.1081	0.1099	
C	1968	102,000	0.04125	0.0515	0.0526	0.0604	14,226
	1983	100,000	0.05000	0.0583	0.1118	0.1134	
D	1967	83,720	0.03750	0.0487	0.0485	0.0571	6,660
	1971	15,000	0.05000	0.0583	0.0612	0.0675	
	1979	23,700	0.05000	0.0583	0.0929	0.0956	
E	1965	833,840	0.03950	0.0501	0.0421	0.0521	275,338
	1972	155,000	0.05000	0.0583	0.0601	0.0665	
	1982	5,500,000	0.05000	0.0583	0.1276	0.1287	
F	1971	870,000	0.05000	0.0583	0.0612	0.0675	93,410
	1974	156,000	0.05000	0.0583	0.0805	0.0843	
	1978	71,500	0.05000	0.0583	0.0849	0.0883	
G	1974	215,000	0.05000	0.0583	0.0805	0.0843	84,269
	1979	29,400	0.05000	0.0583	0.0929	0.0956	
H	1971	1,092,000	0.05000	0.0583	0.0612	0.0675	87,000
	1975	86,000	0.05000	0.0583	0.0819	0.0856	
	1981	115,200	0.05000	0.0583	0.1287	0.1297	
I	1966	67,000	0.03750	0.0487	0.0466	0.0556	16,654
J	1967	238,000	0.03750	0.0487	0.0485	0.0571	62,750
	1972	22,400	0.05000	0.0583	0.0601	0.0665	
	1976	33,900	0.05000	0.0583	0.0786	0.0826	
K	1975	120,000	0.05000	0.0583	0.0819	0.0856	29,800
	1979	106,000	0.05000	0.0583	0.0929	0.0956	
	1981	38,000	0.05000	0.0583	0.1287	0.1297	
Total		10,413,660					690,091
Average		400,525	0.0474	0.0563	0.0778	0.0827	62,736

TABLE VII (Continued)

System Code	Year Obtained	Annual Subsidy Per Loan ($)	Annual Subsidy Per 1,000 Gal. Per Loan ($)	Number of Households in 1983	Total Annual Subsidy Per Household ($)	Total Annual Subsidy Per System ($)	Annual Subsidy Per 1,000 gal. ($) Per System
A	1969	992.51	0.071	110	9.02	992.51	0.071
B	1967	262.50	0.043	183	55.04	10,072.71	1.664
	1980	9,810.21	1.620				
C	1968	907.81	0.064	190	33.81	6,423.56	0.452
	1983	5,515.75	0.388				
D	1967	705.47	0.106	132	13.10	1,728.76	0.260
	1971	137.87	0.021				
	1979	885.43	0.133				
E	1965	1,638.49	0.006	2,938	132.74	389,992.13	1.416
	1972	1,281.41	0.005				
	1982	387,072.23	1.406				
F	1971	7,996.26	0.086	788	18.02	14,203.09	0.152
	1974	4,060.91	0.043				
	1978	2,145.92	0.023				
G	1974	5,596.77	0.066	1,218	5.50	6,695.15	0.079
	1979	1,098.38	0.013				
H	1971	10,036.68	0.115	1,041	19.80	20,614.35	0.237
	1975	2,347.23	0.027				
	1981	8,230.45	0.095				
I	1966	464.36	0.028	242	1.92	464.36	0.028
J	1967	2,005.52	0.032	275	10.97	3,015.38	0.048
	1972	185.18	0.003				
	1976	824.68	0.013				
K	1975	3,275.20	0.110	370	26.89	9,950.23	0.334
	1979	2,960.13	0.133				
	1981	2,714.90	0.091				
Total		464,152.23		7,487	326.81	464,152.23	
Average		17,852.01	0.673	680	61.99	42,195.66	0.673

equal to $389,992 and the smallest equal to $464. The average annual subsidy per thousand gallons of water supplied by the sample of systems was $0.67 with the highest subsidy amount equal to $1.66 per thousand gallons and the lowest subsidy amount equal to $0.03 per thousand gallons. The average annual subsidy per household from low interest loans was $61.99 per household with the highest subsidy equal to $132.74 and the lowest subsidy equal to $1.92.

Total Annual Subsidy from STRWS

Total annual public subsidy provided to rural water system w is the sum of ASG_W and ASL_W. Results for the sample of systems are shown in Table VIII.

The total average annual subsidy provided to sample of rural water systems was $52,144 with the highest subsidy equal to $389,992 and the lowest subsidy equal to $464. Total average subsidy per thousand gallons of water supplied for the sample of the systems was $0.83 with the highest subsidy equal to $1.66 and the lowest subsidy equal to $0.03. Total average annual subsidy per household for the sample was $76.61 with the highest annual subsidy equal to $132.74 and the lowest annual subsidy equal to $1.92.

MSBCR Under Conventional Approach

Cost-benefit analysis (CBA) under the conventional approach ignores distributional effects of new policies or policy changes and simply measures all gains and losses to society regardless of to whom they accrue. This approach has been justified by the use of the potential compensation test as a welfare criterion (Chapter III).

Marginal social benefit-cost ratio (MSBCR) in general measures additional benefits to additional costs resulting at the margin from government policies or

TABLE VIII

TOTAL ANNUALIZED COST OF PUBLIC SUBSIDIES FOR SAMPLE OF RURAL WATER SYSTEMS IN OKLAHOMA

System Code	Annual Grant Subsidy ($)	Annual Loan Subsidy ($)	Total Annual Subsidies ($)	Water Supplied in 1983 (1,000 Gal.)	Number of Households in 1983	Total Annual Subsidy Per 1,000 Gal. ($)	Total Annual Subsidy Per Household ($)
A	-	992.51	992.51	13,929	110	0.07	9.02
B	-	10,072.71	10,072.71	6,055	183	1.66	55.04
C	11,247.13	6,423.56	17,670.69	14,226	190	1.24	93.00
D	8,442.94	1,728.76	10,171.70	6,660	132	1.53	77.06
E	-	389,992.13	38,992.13	275,338	2,938	1.42	132.74
F	14,605.08	14,203.09	28,808.17	93,410	788	0.31	36.56
G	14,220.21	6,695.15	20,915.36	84,269	1,218	0.25	17.17
H	40,123.32	20,614.35	60,737.67	87,000	1,041	0.70	58.35
I	-	464.36	464.36	16,654	242	0.03	1.92
J	4,265.77	3,015.38	7,281.15	62,750	275	0.12	26.48
K	16,528.13	9,950.23	26,478.36	29,800	370	0.89	71.56
Total	109,432.58	464,152.23	573,584.81	690,091	7,487		
Average	9,948	42,196	52,144	62,736	681	0.83	76.61

program. MSBCR in this study measures additional social benefits to additional social costs resulting from public subsidy to rural households through rural water systems (STRWS). The MSBCR is measured on the basis of average public subsidy provided rural households per thousand gallons of water supplied. Following the discussion presented in Chapter III on the analytical framework, social welfare analysis with the use of MSBCR is considered by season and by household socio-economic characteristics.

The two seasons as defined in Chapter IV are off-peak season (OPS) and peak season (PS) in water demand. Households are classifed into 12 groups according to socio-economic characteristics. Household groups are: (1) poverty income level with locational preference in off-peak season (OLP), (2) middle income level with locational preference in off-peak season (OLM), (3) high income level with locational preference in off-peak season (OLH), (4) poverty income level with non-locational preference in off-peak season (ONP), (5) middle income level with non-locational preference in off-peak season (ONM), (6) high income level with non-locational preference in off-peak season (OHN), (7) poverty income level with locational preference in peak season (PLP), (8) middle income level with locational preference in peak season (PLM), (9) high income level with locational preference in peak season (PLH), (10) poverty income level with non-locational preference in peak season (PNP), (11) middle income level with non-locational preference in peak season (PNM), and (12) high income level with non-locational preference in peak season (PNH). Poverty income level is published in the National Statistical Abstract, U.S. Department of Commerce (1984), and includes those rural households whose income in 1983 is less than $7,938 annually. Middle income level includes those rural households with income more than $7,938 but less than $25,701 annually. High income level includes those rural households with income more than \$25,701 annually. Whether a household has a locational preference or not was determined on the basis of the answers made by households in the administered survey questionnaire. Off-peak season includes January to June and October to December. Peak season includes July to September. The seasonality information was obtained from a previous study by Dellenbarger, Kang, and Schreiner (1986).

Following the theoretical framework in Chapter 3, MSBCRs for seasonal water demand is the following:

$$MSBCRs = \frac{\int_{q_{s1}}^{q_{s2}} D_s\,(p)dQ}{(q_{s2} - q_{s1})\, p_{s1}} \qquad (5\text{-}9)$$

where

$MSBCR_s$ = marginal social benefit cost ratio for subsidy to rural households in season s.

$D_s(p)$ = monthly water demand function for rural households in season s.

q_{s1} = monthly quantity of household water demand without STRWS.

q_{s2} = monthly quantity of household water demand with STRWS.

p_{s1} = price of water per 1000 gallons at quantity q_{s1}.

MSBCRs for water demand by socio-economic group is the following:

$$MSBCR_{si} = \frac{\int_{q_{i1}}^{q_{i2}} D_{si}\,(p)dQ}{(q_{i2} - q_{i1})\, p_{i1}} \qquad (5\text{-}10)$$

where

$MSBCR_{si}$ = marginal social benefit-cost ratio for subsidy to rural household belonging to group i in season s.

$D_{si}(p)$ = monthly water demand function for household group i in season s and other notations are the same as with MSBCR.

Following the analytical framework in Chapter III the calculated social benefits and costs, and MSBCRs for different seasons and household groups are shown in Table IX.

In the seasonal analysis, without public subsidy rural household off-peak season (OPS) monthly average water demand was 4,612 gallons and average price was $4.54 per thousand gallons. With public subsidy of $0.83 per thousand gallons, average price decreased to $3.71 and monthly water demand increased by 975 gallons to 5,587 gallons. Additional social benefits generated and additional social costs incurred to society from STRWS were $4.02 and $4.42, respectively, which gives a MSBCR for OPS of 0.91. Net additional private benefits generated was $0.40 which was obtained by subtracting additional private costs from additional private benefits which is the same with additional social benefit in this analysis (see Chapter III). Additional social costs consist of $3.61 of additional private costs and $0.81 of additional public costs. For $0.40 of net additional private benefits $0.81 of additional public costs are required. Additional net social benefits generated are $-0.40 which is the difference between additional social benefits and additional social costs. An average size rural water system with 680 household connections generates additional monthly benefits of $2,734 ($4.02*680) to society and incurs additional monthly costs of $3,006 ($4.42*680) to society with STRWS.

A public subsidy of $0.83 per thousand gallons of water supplied accounts for 18.3 percent of average price in off-peak season and 20.8 percent of average price in peak season paid by rural households with public subsidy.

Without public subsidy, rural household peak season (PS) monthly average water demand was 6,874 gallons and average price was $3.99 per

TABLE IX

SOCIAL BENEFITS AND COSTS OF PUBLIC SUBSIDY TO RURAL WATER SYSTEMS (STRWS) IN OKLAHOMA WITHOUT DISTRIBUTION EFFECTS

Households Groups	$\bar{P}$ With STRWS ($/1,000 Gal.)	$\bar{Q}$ With SRTWS (Gal./Month)	Total Annual Subsidy Per 1,000 Gal. ($)	$\bar{P}$ Without STRWS ($/1,000 Gal.)	$\bar{Q}$ Without STRWS (Gal./Month)	Marginal Change in Q (Gal./Month)	Marginal Social Benefit ($)
Off-Peak Season (OPS)	3.71	5,587	0.83	4.54	4,612	975	4.02
Peak Season (PS)	3.16	9,084	0.83	3.99	6,874	2,210	7.89
Off-Peak Season							
Locational Preference							
Poverty Income (OLP)	2.88	3,311	0.83	3.71	3,049	262	0.86
Middle Income (OLM)	3.10	5,311	0.83	3.93	4,790	521	1.83
High Income (OLH)	3.59	5,989	0.83	4.42	4,034	1,954	7.8281
Non-Locational Preference							
Poverty Income (ONP)	2.23	5,142	0.83	3.06	3,754	1,388	3.68
Middle Income (ONM)	3.68	5,785	0.83	4.51	4,146	1,639	6.72
High Income (ONH)	3.03	9,938	0.83	3.86	5,320	3,618	12.48
Peak Season							
Locational Preference							
Poverty Income (PLP)	2.53	7,145	0.83	3.36	5,814	1,331	3.92
Middle Income (PLM)	3.13	8,171	0.83	3.96	6,589	1,582	5.61
High Income (PLH)	3.02	11,066	0.83	3.85	7,515	3,551	12.20
Non-Locational Preference							
Poverty Income (PNP)	2.41	8,665	0.83	3.24	6,201	2,464	6.96
Middle Income (PNM)	3.53	8,343	0.83	4.36	5,625	2,718	10.72
High Income (PNH)	2.38	15,308	0.83	3.21	10,626	4,682	13.10

TABLE IX (Continued)

Households Groups	Marginal Costs: Private Cost ($)	Marginal Costs: Public Cost ($)	Marginal Costs: Social Cost ($)	Marginal Net Private Benefit ($)	Marginal Net Social Benefit ($)	MSBCR
Off-Peak Season (OPS)	3.61	0.81	4.42	0.40	-0.40	0.9095
Peak Season (PS)	6.98	1.83	8.81	0.92	-0.92	0.8956
Off-Peak Season						
Locational Preference						
Poverty Income (OLP)	0.75	0.22	0.97	0.11	-0.11	0.8866
Middle Income (OLM)	1.62	0.43	2.05	0.21	-0.22	0.8927
High Income (OLH)	7.01	1.62	8.63	0.81	-0.81	0.9061
Non-Locational Preference						
Poverty Income (ONP)	3.10	1.15	4.25	0.58	-0.58	0.8659
Middle Income (ONM)	6.04	1.36	7.40	0.68	-0.68	0.9081
High Income (ONH)	10.98	3.00	13.98	1.50	-1.50	0.8927
Peak Season						
Locational Preference						
Poverty Income (PLP)	3.37	1.11	4.48	0.55	-0.55	0.8750
Middle Income (PLM)	4.96	1.31	6.27	0.65	-0.66	0.8947
High Income (PLH)	10.73	2.95	13.68	1.47	-1.47	0.8918
Non-Locational Preference						
Poverty Income (PNP)	5.94	2.04	7.99	1.02	-1.02	0.8711
Middle Income (PNM)	9.59	2.26	11.85	1.13	-1.13	0.9046
High Income (PNH)	11.16	3.89	15.05	1.94	-1.94	0.8704

thousand gallons. With public subsidy of $0.83 per thousand gallons, average price decreased to $3.16 and monthly water demand increased by 2,210 gallons to 9,084 gallons. Additional benefits generated and additional costs incurred to society from STRWS were $7.89 and $8.81, respectively, which gives a MSBCR for PS of 0.90. Net additional private benefits generated was $0.92. Additional social cost consists of $6.98 of additional private cost and $1.83 of additional public cost. For $0.92 of net additional private benefits $1.83 of public cost was required. Additional net social benefits generated was $-0.92. An average size rural water system with 680 household connections generates additional monthly benefits of $5,365 ($7.89*680) to society and incurs additional monthly costs of $5,991 (7.89*680) to society with STRWS.

STRWS is inefficient under conventional CBA since the MSBCR is less than one. That is, additional costs incurred to society is more than additional benefits generated to society with STRWS. This result, however, was expected as discussed in Chapter III. Under STRWS society puts too many resources in rural water systems.

MSBCRs by rural household income level differ only marginally. For poverty income groups (OLP, ONP, PLP, and PNP) MSBCRs ranged from 0.89 to 0.91 and for high income groups MSBCRs ranged from 0.87 to 0.91. However, it is noted that the groups paying higher price per thousand gallons showed higher MSBCRs than the groups paying lower price per thousand gallons. This is due to relative smallness of marginal net social benefits over private costs. This result indicates that since low income groups generally demand lower levels of water consumption and average water price is higher at lower water demand in decreasing block rate schedules, subsidizing lower income groups would be more efficient.

Additional public costs are higher for higher income groups than lower income groups. Those additional public costs for poverty income groups (OLP, ONP, PLP, and PNP) ranged from $0.22 to $2.04 per month. Those costs for middle income groups (OLM, ONM, PLM, and PNM) ranged from $0.43 to $2.26. The same costs for high income groups (OLH, ONH, PLH, and PNH) ranged from $1.62 to $3.89. STRWS pays much higher additional public costs for higher income groups than lower income groups.

STRWS provides higher additional net private benefits for higher income groups than lower income groups. Poverty income groups obtain additional net monthly private benefits from a low of $0.11 (OLP) to a high of $1.02 (PNP). Middle income groups obtain additional net monthly private benefits from a low of $0.21 (OLM) to high of $1.13 (PNM). High income groups obtain additional net benefits from a low of $0.81 (OLH) to a high of $1.94 (PNH).

Net social loss (additional net social benefits) was smaller for lower income groups than with higher income groups under STRWS because of lower water demand.

MSBCRs for locational preference groups are marginally different from MSBCRs for non-locational preference groups. Additional public costs are higher for non-locational preference groups than for locational preference. However, it is noted that substantial public costs are incurred for those groups with locational preference. Additional net private benefits are also higher for non-locational preference groups than for locational preference groups. Whether locational preference groups need to be subsidized at all depends on decision-makers.

STRWS is inefficient as a whole under conventional CBA. The conventional CBA above does not consider decision-makers objectives to be achieved with STRWS.

MSBCR Under Non-Conventional Approach

CBA in non-conventional approach considers distribution of benefits generated from a government policy or program. In this approach a social objective is pursued by public decision-makers. The objective is social since it affects society as a whole. When decision-makers are selected by way of a socially approved political process they are considered to formulate objectives for society. Thus, the objectives duly chosen by decision-makers are considered consistent with Pareto improvement criterion.

In this study the objectives of decision-makers are to reduce water consumption cost for low income rural households as implied in grant and loan instructions of the FmHA. Benefit distribution results are evaluated using income and consumption weights.

MSBCR With Income Distribution Weights

Income weights have been derived from the ratio of median household family income in the U.S. to the mean family income of the sample of Oklahoma rural household groups in 1983. That is, $W_i = \bar{Y}/Y_i$ where W_i is the income distributional weight for a household belonging to socio-economic group i, $\bar{Y}$ is the national median family income of $25,707 in 1983, and Y_i is the mean income level of the average household belonging to socio-economic group i. Then the weighted benefits for the average household belonging to socio-economic group i, BYW_i, becomes $W_i{*}B_i$ or $(\bar{Y}/Y_i){*}B_i$ where B_i is the unweighted benefits of the average household belonging to socio-economic group i with STRWS. The value judgement assumed with this weighting system is that decision-makers give equal weight to preferences of all household customers. This weighting adjusts benefits to the values consumers would place on water if they had mean income and devoted the same proportion of their income to water consumption.

The marginal social benefit-cost ratio from subsidizing a rural household belonging to group i with income weighting is expressed as:

$$MSBCR_i = \frac{w_i \int_{q_{i2}}^{q_{i1}} D_i(p)dQ}{(q_{i2} - q_{i1})\, p_{i1}} \tag{5-11}$$

where W_i denotes income distributional weight for the average household belonging to socio-economic group i, D_i (p) is water demand function for household group i, and other notations are the same as specified in the conventional CBA approach.

The weighted benefits and MSBCRs for the sample of Oklahoma rural households by season and for different socio-economic groups are presented in Table X. MSBCRs weighted by income were 1.001 for the off-peak season and 0.985 for the peak season. Thus STRWS is marginally efficient in OPS and marginally inefficient in PS when income weights are used under non-conventional CBA. An important result is that STRWS is less efficient during peak season when there is more discretionary water demand and more efficient during off-peak season when water demand is more related to basic requirements.

MSBCRs were higher for lower income groups than higher income groups. MSBCRs for poverty level income groups ranged from 3.41 to 3.45. MSBCRs for middle income level groups ranged from 1.12 to 1.33. Subsidizing rural households belonging to these income groups under income weighting is efficient, especially the poverty income groups. Subsidizing high income level groups is quite inefficient with MSBCRs ranging from 0.49 and 0.53.

TABLE X

SOCIAL BENEFITS AND COSTS OF PUBLIC SUBSIDY TO RURAL WATER SYSTEMS (STRWS) IN OKLAHOMA USING INCOME DISTRIBUTION WEIGHTS

Household Group	Unweighted Social Benefit ($)	Social Cost ($)	Unweighted MSBCR	Household Mean Income ($)	Income Weight	Weighted Social Benefits ($)	MSBCR Weighted by Income
Off-Peak Season (OPS)	4.02	4.42	0.9095	22,452	1.1002	4.42	1.0006
Peak Season (PS)	7.89	8.81	0.8956	22,452	1.1002	8.68	0.9853
Off-Peak Season							
Locational Preference							
Poverty Income (OLP)	0.86	0.97	0.8866	6,346	3.8924	3.35	3.4510
Middle Income (OLM)	1.83	2.05	0.8927	16,565	1.4912	2.73	1.3311
High Income (OLH)	7.82	8.63	0.9061	45,416	0.5439	4.25	0.4928
Non-Locational Preference							
Poverty Income (ONP)	3.68	4.25	0.8659	6,250	3.9522	14.54	3.4221
Middle Income (ONM)	6.72	7.40	0.9081	20,000	1.2351	8.30	1.1216
High Income (ONH)	12.48	13.98	0.8927	41,944	0.5889	7.35	0.5257
Peak Season							
Locational Preference							
Poverty Income (PLP)	3.92	4.48	0.8750	6,346	3.8924	15.26	3.4058
Middle Income (PLM)	5.61	6.27	0.8947	16,565	1.4912	8.37	1.3342
High Income (PLH)	12.20	13.68	0.8918	45,416	0.5439	6.64	0.4850
Non-Locational Preference							
Poverty Income (PNP)	6.96	7.99	0.8711	6,250	3.9522	27.51	3.4427
Middle Income (PNM)	10.72	11.85	0.9046	20,000	1.2351	13.24	1.1173
High Income (PNH)	13.10	15.05	0.8704	41,944	0.5889	7.71	0.5126

MSBCRs for locational preference are only marginally different from MSBCRs for non-locational preference. Poverty income group OLP has a marginally higher MSBCR than ONP which may indicate more justification for subsidy to poverty income groups if they choose rural location on the basis of lower cost of living. For locational preference high income groups' (OLH and PLH) MSBCRs are marginally lower than for non-locational preference high income groups (ONH and PNH). This would further indicate less of a need to subsidize high income groups if they choose rural location on the basis of psychic income.

Little difference occurs between MSBCRs of different socio-economic groups for peak and off-peak seasons. However, in general, the off-peak season has marginally higher MSBCRs indicating less of a need to subsidize discretionary water consumption during the peak season.

In general, weighted marginal social benefits for lower income groups were substantially higher than weighted marginal social benefits for higher income groups. The exceptions are OLP and OLM for which the weighted marginal social benefits are very low relative to that of OLH. The highest income weighted marginal social benefit was for group PNP and equalled \$27.51. The lowest income weighted marginal social benefit was for group OLM and equalled \$2.73. In general, income weighted benefits were higher for lower income groups than for higher income groups, and they were higher for with non-locational preference groups.

In summary, the MSBCR weighted by income was greater than1.0 for OPS but less than 1.0 for PS. For rural household groups, the poverty income and middle income groups had MSBCRs greater than 1.0 but the high income groups had MSBCRs less than 1.0 and about 0.5. Under income weighting, subsidizing lower income groups is socially more efficient than subsidizing higher income groups. Similarly, subsidizing off-peak seasonal demand and locational preference for poverty and middle income groups is more socially efficient than subsidizing peak seasonal demand and locational preference for high income groups.

MSBCR with Consumption Distribution Weights

This weighting system is based on the assumption that the marginal utility of consumption to a consumer decreases as the level of consumption increases. As discussed in Chapter III consumption distribution weight is expressed as $\theta_i = (\bar{C}/C_i)^r$ where θ_i is consumption weight, $\bar{C}$ is a reference level of water consumption, C_i is the level of water consumption for rural household group i and r is a parameter of the utility function. This is based on the assumption that the marginal utility of water consumption to a consumer decreases as the level of water consumption increases over a reference level that may be associated with a basic requirements consumption level. The weight θ_i changes both with different value of r and with different water consumption level of a household C_i.

The national average monthly water consumption of rural households in 1978 was reported at 6,518 gallons for a three person household (Francis, 1983). It was estimated at 6,636 gallons in 1980 (Solley, Chase, and Mann, 1983). The sample survey completed by the Department of Agricultural Economics at Oklahoma State University in 1984 gave the monthly water consumption at 6,767 gallons for 1983. It was 5,587 gallons in off-peak season and 9,084 gallons in peak season.

The parameter of the utility function, r, was used parametically. When r is zero additional water consumption is considered equally valuable regardless of the existing level of water consumption. As r is increased the household with lower rate consumption level is weighted more heavily than the household with higher water consumption level. For most policy makers, r ranges from 0 to 2, centering around 1 (Squire and Van der Tak, 1984).

Social benefits weighted by consumption becomes θ_i*Bi or $(\bar{C}/C)^r * B_i$ where B_i is the unweighted marginal social benefits from STRWS for the average household belonging to socio-economic group i. The marginal social benefit-cost ratio for household group i with consumption weighting is:

$$MSBCR_i = \frac{\theta_i \int_{q_{i2}}^{q_{i1}} D_i(p)dQ}{(q_{i2} - q_{i1})\, p_{i1}} \tag{5-12}$$

where θ_i denotes consumption distribution weight for the average household belonging to socio-economic group i, D_i (p) is water demand function for the average household belonging to socio-economic group i, and other notations are the same as specified in the conventional CBA. The weighted benefits and MSBCRs by season and for the different household groups are presented in Table XI.

MSBCRs of OPS and PS remain the same as in unweighted MSBCRs since average water consumption for the sample of Oklahoma households does not differ significantly from the U.S. average. When r is 0.5, subsidizing water only of group OLP is efficient with a MSBCR of 1.15. Subsidizing all other household groups is inefficient with group PNH giving the lowest MSBCR of 0.67. With r increased to 1, subsidizing OLP and PLP is efficient. As r increases further to 1.5, subsidizing PLM and PNM also becomes efficient. When r is 2.0 subsidizing ONP becomes efficient and OLM has a MSBCR close to 1.

TABLE XI

SOCIAL BENEFITS AND COSTS OF PUBLIC SUBSIDY TO RURAL WATER SYSTEMS (STRWS) IN OKLAHOMA USING CONSUMPTION DISTRIBUTION WEIGHTS

Household Groups	Unweighted Marginal Social Benefit ($)	Marginal Social Cost ($)	Unweighted MSBCR	Household Mean Consumption (Gal./Month)	Weighted Marginal Social Benefits (r=0.5)	Weighted Marginal Social Benefits (r=1.0)
Off-Peak Season (OPS)	4.02	4.42	0.9095	5,587	4.02	4.02
Peak Season (PS)	7.89	8.81	0.8956	9,084	7.89	7.89
Off-Peak Season						
Locational Preference						
Poverty Income (OLP)	0.86	0.97	0.8866	3,311	1.12	1.45
Middle Income (OLM)	1.83	2.05	0.8927	5,311	1.88	1.93
High Income (OLH)	7.82	8.63	0.9061	5,988	7.55	7.30
Non-Locational Preference						
Poverty Income (ONP)	3.68	4.25	0.8659	5,142	3.84	4.00
Middle Income (ONM)	6.72	7.40	0.9081	5,785	6.60	6.49
High Income (ONH)	12.48	13.98	0.8927	8,938	9.87	7.80
Peak Season						
Locational Preference						
Poverty Income (PLP)	3.92	4.48	0.8750	7,145	4.42	4.98
Middle Income (PLM)	5.61	6.27	0.8947	8,171	5.92	6.24
High Income (PLH)	12.20	13.68	0.8918	11,066	11.05	10.01
Non-Locational Preference						
Poverty Income (PNP)	6.96	7.99	0.8711	8,665	7.13	7.30
Middle Income (PNM)	10.72	11.85	0.9046	8,343	11.19	11.67
High Income (PNH)	13.10	15.05	0.8704	15,308	10.09	7.77

TABLE XI (Continued)

Household Groups	Weighted Marginal Social Benefits (r=1.5)	Weighted Marginal Social Benefits (r=2.0)	MSBCR Weighted by Consumption (r=.05)	MSBCR Weighted by Consumption (r=1.0)	MSBCR Weighted by Consumption (r=1.5)	MSBCR Weighted by Consumption (r=2.0)
Off-Peak Season (OPS)	4.02	4.02	0.90956	0.9095	0.9095	0.9095
Peak Season (PS)	7.89	7.89	0.8956	0.8956	0.8956	0.8956
Off-Peak Season						
Locational Preference						
Poverty Income (OLP)	1.89	2.45	1.1517	1.4961	1.9434	2.5244
Middle Income (OLM)	1.97	2.03	0.9156	0.9391	0.9632	0.9879
High Income (OLH)	7.05	6.81	0.8753	0.8455	0.8167	0.7888
Non-Locational Preference						
Poverty Income (ONP)	4.17	4.34	0.9026	0.9408	0.9807	1.0222
Middle Income (ONM)	6.38	6.27	0.8924	0.8770	0.8619	0.8470
High Income (ONH)	6.17	4.88	0.7058	0.5580	0.4412	0.3488
Peak Season						
Locational Preference						
Poverty Income (PLP)	5.62	6.34	0.9866	1.1125	1.2544	1.4144
Middle Income (PLM)	6.58	6.93	0.9434	0.9947	1.0488	1.1059
High Income (PLH)	9.07	8.22	0.8080	0.7321	0.6633	0.6010
Non-Locational Preference						
Poverty Income (PNP)	7.47	7.65	0.8919	0.9132	0.9350	0.9574
Middle Income (PNM)	12.18	12.71	0.9449	0.9850	1.0278	1.0725
High Income (PNH)	5.99	4.61	0.6705	0.5165	0.3979	0.3065

However, subsidizing ONH and PNH is very inefficient and gives MSBCRs of 0.35 and 0.31.

In general, regardless of the size of r, subsidizing the lower income groups gives higher MSBCRs than subsidizing higher income groups and subsidizing groups with locational preference gives higher MSBCR than subsidizing groups with non-locational preference. However, the absolute magnitude of social benefits generated with STRWS was larger when subsidizing the groups with non-locational preference than subsidizing the groups with locational preference. These results are due to lower water consumption levels by groups with locational preference than by groups with non-locational preference.

In summary, when r is 1 which is generally considered reasonable by government policy makers, only subsidizing OLP and PLP is efficient. However, MSBCRs for PLM and PNM are close to 1, and those for OLM, ONP and PNP are above 0.9. Finally, MSBCRs for ONH and PNH are low and only around 0.5.

Subsidy Distribution by Socio-Economic Group

This approach is based on the assumption that decision makers wish to have information on how subsidies are currently distributed to target groups so that policy may be used to improve efficiency in use of the subsidy program in attaining policy objectives. Policy objectives of STRWS were identified in Chapter I as to reduce water use cost of low income rural households which are considered as target groups. Target groups are identified by income level and settlement motivation or preference for location as discussed in Chapter IV.

Following the analytical framework of Chapter III using average price rather than block rate, and assuming a linear demand function the amount of subsidy paid to a rural household belongoing to socio-economic group i is the :

$$S_i = q_{i1} * (p_{i1} - p_{i2}) + 0.5 * (q_{i2} - q_{i1}) * (p_{i1} - p_{i2}) \qquad (5\text{-}13)$$

where

S_i = total amount of subsidy paid to a rural household belonging to group i.

q_{i1} = quantity of water demand without subsidy for a rural household belonging to group i.

q_{i2} = quantity of water demand with subsidy for a rural household belonging to group i.

p_{i1} = price of water per thousand gallons at consumption level q_{i1}.

p_{i2} = price of water per thousand gallons with subsidy and results in consumption q_{i2}.

The subsidy distributions by rural household groups are presented in Table XII. In off-peak season average monthly subsidy per househjold is $4.23 and in peak season average monthly subsidy per household is $6.62 for an annual subidy of $57.93. Among the different household groups OLP received the lowest monthly subsidy of $2.64 and PNH received the highest monthly subsidy of $10.76. Subsidy amounts were higher in peak season than in off-peak season and were higher for non-locational preference than for locational preference except in the case of middle income groups.

Subsidy cost is greater than equation (5-13) by the amount $0.5*(q_{i2} - q_{i1}) * (p_{i1} - p_{i2})$ since this represents welfare loss from STRWS. Monthly subsidy cost per rural household in off-peak season is $4.64 and in peak season is $7.54 for a total annual cost of $64.38. The lowest montly subsidy cost is $2.75 for OLP and the highest monthly subsidy cost is $12.71 for PNH.

TABLE XII

SUBSIDY DISTRIBUTION AMONG RURAL HOUSEHOLD GROUPS IN OKLAHOMA

Household Group	$\bar{Q}$ With STRWS (Gal./Month)	$\bar{P}$ With SRTWS ($/1,000 Gal.)	Subsidy Per 1,000 Gal. ($)	$\bar{P}$ Without STRWS ($/1,000 Gal.)	$\bar{Q}$ Without STRWS (Gal./Month)	Subsidy Distribution Per Household ($)	Subsidy Cost Per Household ($)
Off-Peak Season (OPS)	5,587	3.71	0.83	4.54	4,612	4.23	4.64
Peak Season (PS)	9,084	3.16	0.83	3.99	6,874	6.62	7.54
Off-Peak Season							
Locational Preference							
Poverty Income (OLP)	3,311	2.88	0.83	3.71	3,049	2.64	2.75
Middle Income (OLM)	5,311	3.10	0.83	3.93	4,790	4.19	4.41
High Income (OLH)	5,988	3.59	0.83	4.42	4,034	4.16	4.97
Non-Locational Preference							
Poverty Income (ONP)	5,142	2.23	0.83	3.06	3,754	3.69	4.27
Middle Income (ONM)	5,785	3.68	0.83	4.51	4,146	4.12	4.80
High Income (OLH)	8,938	3.03	0.83	3.86	5,320	5.92	7.42
Peak Season							
Locational Preference							
Poverty Income (PLP)	7,145	2.53	0.83	3.36	5,814	5.38	5.93
Middle Income (PLM)	8,171	3.13	0.83	3.96	6,589	6.13	6.78
High Income (PLH)	11,066	3.02	0.83	3.85	7,515	7.71	9.18
Non-Locational Preference							
Poverty Income (PNP)	8,665	2.41	0.83	3.24	6,201	6.17	7.19
Middle Income (PNM)	8,343	3.53	0.83	4.36	5,625	5.80	6.92
High Income (PNH)	15,308	2.38	0.83	3.21	10,626	10.76	12.71

In general, public subsidies in absolute amount are more heavily distributed to higher income groups and groups with non-locational preference.

Summary

In this Chapter social welfare implications of public subsidies to rural water systems (STRWS) in Oklahoma have been analyzed with the use of marginal social cost benefit analysis and subsidy distribution among different rural household groups.

Public subsidy for a sample of 11 rural systems in Oklahoma in 1983 averaged $0.83 per thousand gallons of water supplied which accounts for 18.3 percent of average price in off-peak season and 20.8 percent of average price in peak season paid by rural households with public subsidy. Total average annual subsidy per household was $76.61.

Under conventional CBA, STRWS turned out to be inefficient. MSBCRs were less than 1.0 for all socio-economic household groups. MSBCRs were higher for the groups paying higher prices for water regardless of locational preference and income level. However, the differences in magnitude of MSBCRs were negligible. With public subsidy of $0.83 per thousand gallons, additional social benefits generated and additional costs incurred to society were $4.02 and $4.42 in off-peak season, and were $7.89 and $8.84 in peak season, respectively. Net additional private benefits generated was $0.40 which required $0.81 of additional public costs in off-peak season, and was $0.92 which required $1.83 of additional public costs in peak season. An average size rural water system with 680 household connections generates additional monthly benefits of $2,734 with additional monthly costs of $3,006 to society in off-peak season, and additional monthly benefits of $5,365 with additional monthly costs of $5,991 to society in peak season.

Under non-conventional CBA, MSBCRs with income distribution weights are greater than 1.0 for the poverty and middle income groups, and MSBCRs were around 0.5 for the higher income groups. MSBCRs were higher for lower income level groups than for the middle income groups. MSBCRs for the poverty and middle income level groups with locational preference were higher for the groups with non-locational preference. However, the opposite was true for the higher income groups.

MSBCRs with consumption distribution weights were greater than 1.0 for the poverty income group with locational preference in off-peak season (OLP) when the parameter of utility function, r, was 0.5. However, MSBCRs were greater than 1.0 for OLP and PLP, and MSBCRs were close to 1.0 for PLM and PNM when r was 1.0 which is the value frequently chosen by government policy makers. MSBCRs were higher for the groups with lower income, and higher with non-locational preference.

In subsidy distribution monthly average subsidy paid households in off-peak season was $4.23 and in peak season was $6.62. Higher income groups received higher subsidies than lower income groups, and the groups with non-locational preference received higher subsidies than the groups with locational preference. However, groups with locational preference, meaning they have chosen to live in rural areas, received substantial subsidies for their locational preference choice. The high income group with non-locational preference received a monthly subsidy of $5.92 in off-peak season had $10.76 in peak season, for an annual subsidy of $85.56.

CHAPTER VI

ECONOMIC STRATEGIES FOR IMPROVEMENT IN PUBLIC SUBSIDY PROGRAMS FOR RURAL WATER SYSTEMS

This Chapter concerns economic strategies for improvement in public subsidy programs for rural water systems in Oklahoma. First, efficiency criterion in public policy is briefly described. Second, economic strategies are discussed to improve efficiency of public subsidy programs. Finally, a summary of the Chapter is provided.

Efficiency Criterion in Public Programs

Efficiency in economics is usually defined in terms of optimality conditions of resource use under norms of perfect competition (Pasour, 1981). If marginal rates of substitution between outputs or factors are the same under norms of perfect competition there is efficiency. However, it may be meaningless to define efficiency without considering goals of economic policy. Efficiency has meaning only when such goals have been set (Russel and Young, 1983). Thus, efficiency is defined as the combination of resource use that maximizes individual or social goals (Doll and Orazm, 1984). In this context, efficiency measurements require a comparison of an observed situation with a defined efficiency norm that is consistent with stated policy goals.

Efficiency in public policy or programs is generally defined in terms of Pareto optimality as discussed in Chapter III. If new policy is consistent with

Pareto optimality the policy is considered efficient. Efficiency measurement in public policy is based on the comparison between social benefits generated and social costs incurred from the policy. If social benefits are greater than social costs the policy is considered efficient. CBA frequently serves as a tool for making comparisons. The CBA may include decision makers' value judgements (non-conventional approach) or may include only potential economic gains over costs (conventional approach).

Three economic strategies are discussed for efficiency improvement of subsidy programs: (1) productive efficiency strategy, (2) water system size strategy, and (3) water rate strategy. These strategies are based on the fact that public subsidies are transfer payments and conditional on desired results or actions of the recipients. That is, rural water systems and their members may be required to complete certain actions for the taking of public subsidy.

Productive Efficiency Strategy

Productive efficiency is due to allocative and technical efficiency. When firms equate the marginal value products of all factors to their marginal costs then resources are said to be used with allocative efficiency. When firms produce maximum possible output from a given set of inputs then resources are said to be used with technical efficiency. The definitions and computational framework for both allocative and technical efficiency were first proposed by Farrel (1957).

Fox and Hofler (1986) have measured the allocative and technical efficiency for rural water systems in the United States. Their findings indicate that 15.7 percent of actual cost is ascribed to technical inefficiency, and 27.8 percent of actual cost is ascribed to allocative inefficiency for the average water system. Thus, 43.5 percent of actual cost on average is ascribed to productive inefficiency in rural water system operation. Although inefficiency was not measured in a dynamic environment, results shed light on the extent of potential productive inefficiency in rural water system operation.

Improvement of productive efficiency in rural water systems would improve efficiency of public subsidy programs for rural water systems as illustrated in the following.

Consider a rural water system facing rural household water demand D in Figure 16. Suppose p_s is price of water at water consumption quantity q_s in current productive efficiency level with STRWS, and p_n is price of water at water consumption level of q_n without STRWS. Suppose price is lowered by r to p_1 due to water supply cost reduction through improvement of productive efficiency and thus increasing water consumption to q_1.

MSBCR with STRWS before improved productive efficiency, $MSBCR_b$, is measured as NSq_sq_n/NKq_sq_n. Similarly, MSBCR with STRWS after improved productive efficiency, $MSBCR_a$, is measured as ASq_sq_1/ALq_sq_1. Since NSq_sq_n is equal to $NAq_1q_n + ASq_sq_1$ and NKq_sq_n is equal to $NKLAq_1q_n + ALq_sq_1$ with NKLA positive, $MSBCR_a$ is greater than $MSBCR_b$. Thus, efficiency of STRWS is increased after improved productive efficiency. Also, the improved productive efficiency reduces subsidy requirements.

Sources of productive inefficiency need to be identified. Guidelines on how to correct these sources of inefficiencies should be provided rural water systems to improve efficiency of public subsidy programs.

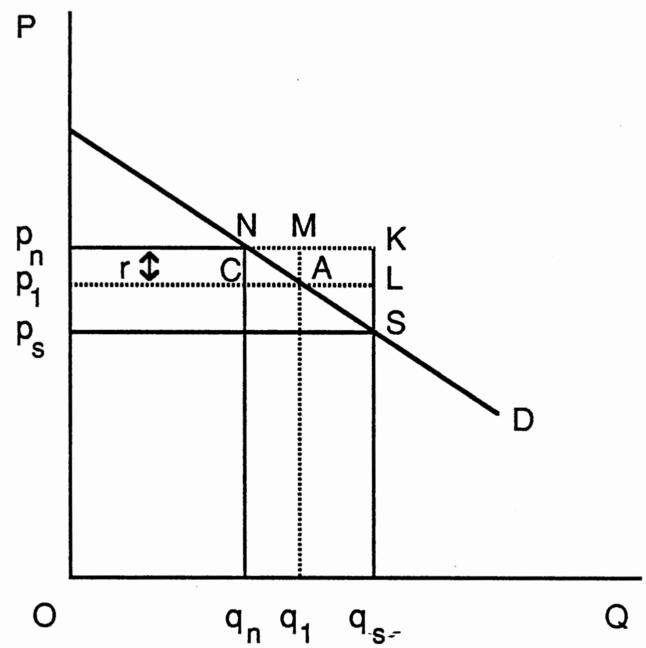


Figure 16. The Impact of Improved Productive Efficiency on Social Benefits and Costs.

System Size Strategy

Rural water systems show significant economies of scale (Sauerlender 1974; Myoung, 1982; Myoung and Shreiner, 1984; Fox and Hofler, 1986). Average cost in operation of rural water systems falls as the size of system increases. Rural water systems are also characterized as natural monopoly. Water demand in a given market is not large enough to bring about the most efficient size system.

These characteristics of rural water systems are illustrated in Figure 17. Suppose a rural water system faces long-run marginal cost (LMC), long-run average cost (LAC), and aggregate demand D_1. LAC decreases as system size increases through all economically feasible water supply ranges. D_1 meets LMC at the quantity level where LAC is greater than LMC. For the rural water system charging marginal cost price, revenue loss or negative cash flow is experienced equal to the amount of A_1JKM_1. This revenue loss may be compensated by public subsidy and/or by adoption of block rate schedule. As D_1 shifts upward to D_2 the revenue loss per unit of water supplied decreases from A_10 - M_10 to A_20 - M_20 and compensation requirement with public subsidy is reduced. When D_1 shifts to D_3, LMC meets LAC at quantity q_3 where LAC is at its minimum. Subsidy requirement to compensate revenue loss for rural water systems charging marginal cost price disappears at q_3. At this demand level, block rate schedule is not necessary and all rural households face the same marginal price regardless of the amount of water they consume. Thus, the subsidy policy that conditions rural water systems to take actions for shifting D_1 would increase efficiency of subsidy program by reducing subsidy requirement and decreasing water supply cost.

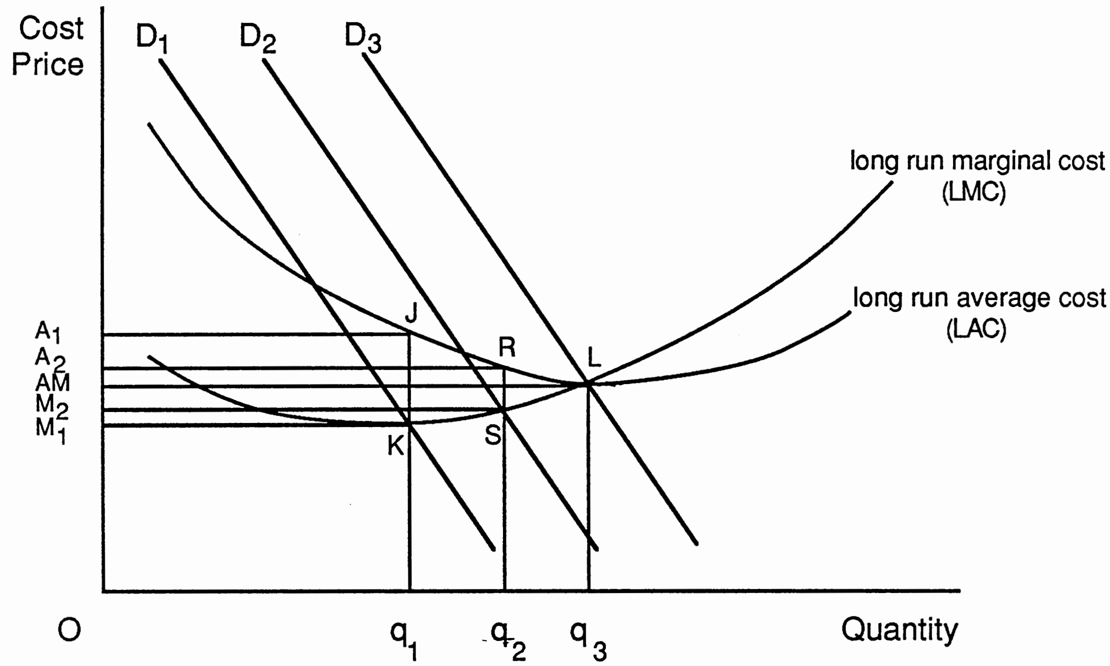


Figure 17. Economies of Size for Rural Water Systems

The major factors that cause shifts of rural water demand are rural population, household income, and existence or attraction of large volume water consuming industries. Changes in these factors occur over time and generally are beyond the control of decision makers providing public subsidy.

One alternative to waiting for demand shifts through normal population and income growth is the regionalization or consolidation of rural water systems. Regionalization or consolidation implies combining two or more rural water systems into one centralized regional unit. A few case studies show substantial cost decrease through regionalization (Sauerlender, 1974) or consolidation (Goodwin and Doeksen, 1984).

Cost decreases from consolidation occur mainly through (1) more efficient management (physical maintenance, financial operations, billing procedures), (2) elimination of duplicate services and office facilities, and (3) more efficient utilization of existing equipment (Goodwin and Doeksen, 1984). For example, per customer operation cost for one rural water system decreased by 50 percent after consolidation in the Goodwin and Doeksen study.

The reduction of water supply cost through consolidation or regionalization in rural water systems would enable government to reduce subsidy cost or enable rural households to obtain more benefits given current level of public subsidy. Thus, priority in public subsidy should be considered for augmenting system size and perhaps through system regionalization and consolidation. However, potential conflicts, if any, between rural water systems or communities may need to be resolved.

Water Rate Strategy

One policy objective in providing public subsidy to rural water systems is to assist target groups (low income households and rural fixed location residents) by reducing water use cost as implied in the FmHA grant and loan instructions. Thus, water rate schedules should incorporate strategies for improving efficiency of the subsidy program including the policy objective.

Water rate schedule determination in rural water systems is generally subject to three common criteria: financial, economic, and social. Financial criteria emphasize revenue requirements or cost recovery. Economic criteria emphasize economic efficiency in resource use and social criteria emphasize allocation of water service benefits and costs. The social criteria include the policy makers' objective concerning the distribution of subsidy costs and benefits since rural water systems are subsidized by the public. Marginal cost pricing is the starting point to meet all the criteria.

Consider a rural water system characterized with long-run marginal cost (LMC) and long-run average cost (LAC), and facing aggregate water demand (D_A) in Figure 18(c). Suppose the water system serves two households with water demands, D_L (low income) and D_H (high income) in Figure 18(a) and 18(b). Marginal cost pricing establishes water price P_m for the water system. Household L consumes q_1 and household H consumes q_2 at P_m, respectively. If pricing is other than P_m there will be underuse or overuse of resources and the economic efficiency criteria are not met. Each household faces the same marginal price (cost) for incremental capacity. However, under economically efficient marginal cost pricing, total revenue does not cover total cost for the rural water system characterized by decreasing unit costs. The rural water

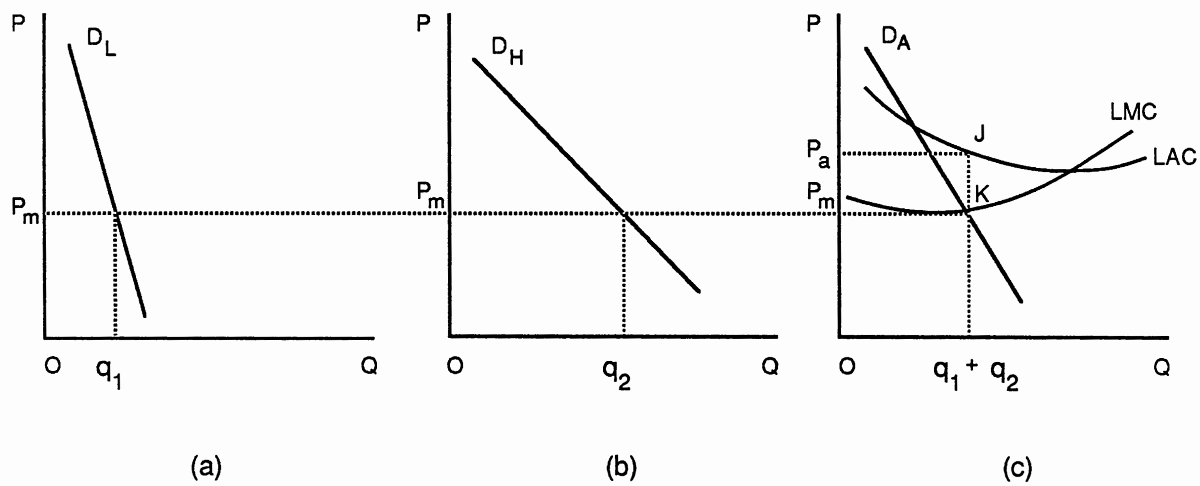


Figure 18. Efficient Water Pricing With Full Subsidy for Revenue Loss.

system experiences negative cash flow equal to the area P_aJKP_m and does not meet the financial criteria.

Two approaches may be considered to meet revenue requirement. The first approach is to make up all revenue loss, P_aJKP_m in Figure 18(c), out of public subsidy. In this case the financial and economic criteria are met but the policy objective (social) criteria may not be met since high income households with higher water consumption are subsidized more than low income households with lower water consumption and since public subsidy may come from taxpayers with lower income than the higher income households who are recipients of subsidized water.

The second approach is to use block rate schedules. This approach is used even when public subsidy is not large enough to cover all revenue loss. The most common schedule is a decreasing block rate. The block rate may be set with price discrimination or without price discrimination. These two block rates are illustrated in Figure 19.

Suppose D_A is aggregate water demand for a rural water system characterized with long-run average cost (LAC) and long-run marginal cost (LMC) in Figure 19(b). In Figure 19(a), D_L is the average water demand for low income households and D_H is the average water demand for high income households within the rural water system. Suppose the system sets a nondiscriminatory water rate schedule such as abcef so that the two household groups face the same marginal price (cost) MC_0 and the initial block rate is designed to meet revenue shortage at marginal cost pricing. At marginal cost price P_M, low income households demand q_L and high income households demand q_H. This rate schedule is economically efficient since pricing is marginal cost and is equitable since each household group pays the same marginal price. It meets revenue requirements by taking more consumer

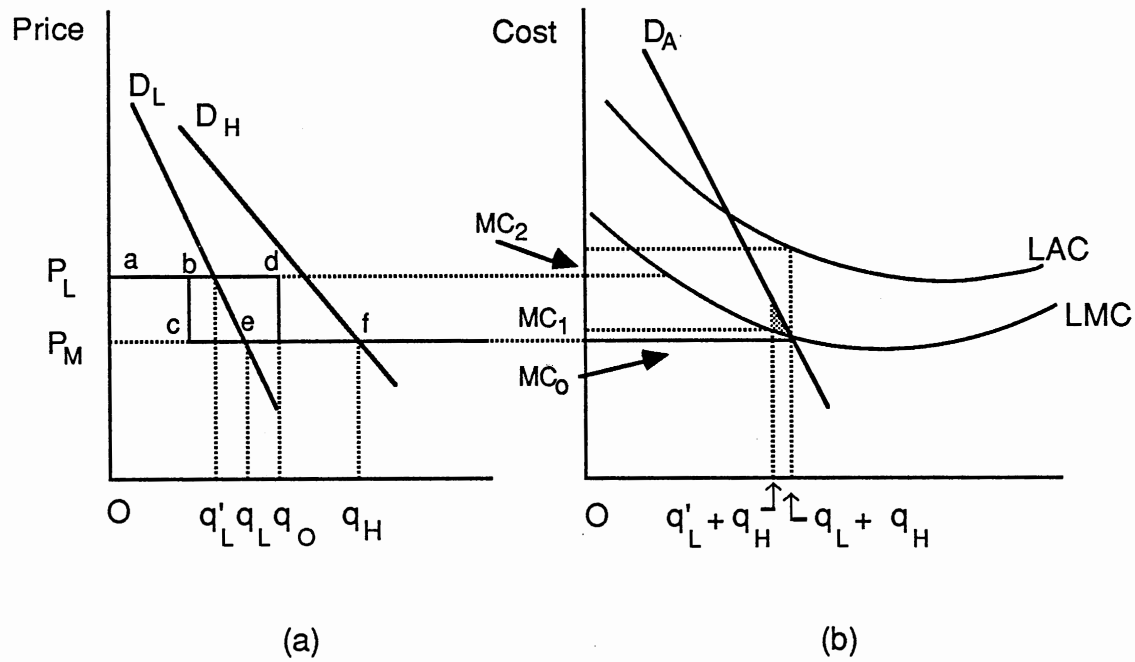


Figure 19. Block Rate Schedule With Price Discrimination and Without Price Discrimination.

surplus through the higher initial block rate. However, low income households pay higher average price which is not consistent with the public subsidy policy objective of reducing water use cost for low income households. Furthermore, if households respond to average price as hypothesized for water demand estimation in Chapter IV, low income households will consume less because of higher average price. A monthly subsidy rebate (perhaps through a lower fixed monthly service charge, i.e. lower initial block rate) will lower average price to low income households, increase their water demand, and lower water use cost which is consistent with the policy objectives of FmHA.

Next consider the price discriminatory rate schedule abdef which is a schedule all too frequently encountered with rural water systems. The financial objective is to encourage water consumption because of decreasing unit costs but to capture sufficient consumers surplus to equate total revenue with total cost. With this discriminatory rate schedule, water demand for low income households is q_L' and water demand for high income households is q_H. Water system demand is $q_L' + q_H$ and system marginal cost is MC_1. Under this rate schedule low income households pay higher marginal price, P_L, which is equal to system marginal cost MC_2, and high income households pay lower marginal price, P_M, which is equal to system marginal cost MC_0. This rate schedule causes underuse of resources, that is, marginal benefits in the aggregate are less than marginal costs and there is a loss in economic efficiency measured as the shaded area in Figure 19(b). Of course, this loss in the aggregate could be removed by lowering the marginal price to high income households so their consumption is equal to $q_H + (q_L - q_L')$. Price discriminatory block rate is not consistent with marginal cost pricing, and is not equitable since each household group pays a different marginal price. It is not consistent with decision makers' objective for STRWS since low income households pay an even higher average price than under nondiscriminatory water rate schedule.

Thus, to achieve economic efficiency, meet financial requirements, and obtain equitable distribution of STRWS, rural water systems should be encouraged to set nondiscriminatory water rate schedules. Rebate systems should be encouraged to more closely target subsidies to low income groups. If households respond to average price, monthly rebates will decrease average price and increase water demand. If households are assumed to respond to marginal price, an annual rebate based on income is preferable and will not influence monthly water consumption. In this case, the rebate becomes more a transfer payment rather than a subsidy.

Results of estimated water demand given in Chapter V show that socio-economic groups having locational preference are also substantially subsidized. Whether subsidy for low income groups with locational preference is removed or not depends upon policy objectives. One possibility to remove at least part of the subsidy for these groups may be to impose an extra monthly locational charge for those people working in the region but outside the rural water system boundary. However, whether this extra charge is socially feasible or not may need to be determined.

Summary

Three economic strategies were discussed for the improvement of public subsidy program for rural water systems. The strategies were productive efficiency strategy, system size strategy, and water rate strategy. Application of all strategies should lead to increased MSBCRs from STRWS. The strategies however, may require further research before they can be practically implemented.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Summary

The Consolidated Farm and Rural Development Act[1] authorizes FmHA to provide grants and long-term, low interest loans for the installation, repair, improvement, or expansion of rural water system facilities. The FmHA provides grant and loan funding up to 75 percent of an eligible project's cost. Through September, 1986 the FmHA and its predecessor agencies have nationally provided rural water systems $2,896 million in grant funds and $9,132 million in subsidized loans.

The goal of decision makers in the public subsidy program for rural water systems (STRWS) is implicitly stated in FmHA grant and loan instructions as to reduce water user cost for low income households in rural communities. However, implementation of STRWS has resulted in subsidies provided to household groups with high income, and to household groups exploiting locational benefits. The concern is whether all rural households should be subsidized since many households have higher income than the typical taxpayer providing such subsidies, and many households benefiting from subsidy are motivated to settle in rural areas for purposes of exploiting locational preference. Thus, policy makers need information on the distribution

[1]PL 92-419, 30 August, 1972, United States Statutes at Large 86, pp. 657-677.

of STRWS benefits and costs to establish strategies for improved efficiency of STRWS.

The major objectives in this study were to: (1) evaluate social benefits and costs of the subsidy program, (2) measure the distribution of public subsidy among major socio-economic groups within rural water systems, and (3) provide economic strategies for bringing about improved efficiency in the use of such public subsidies.

Social welfare criteria were used with cost-benefit analysis (CBA) as the analytical procedure. Conventional CBA was extended to non-conventioanl CBA by applying policy weights to the distribution of net benefits from STRWS.

Economic Rationale for Public Subsidy

A resource allocation is said to be Pareto optimal when resources are allocated such that production and consumption cannot be reorganized to increase utility of some individuals without decreasing the utility of others. Resource allocation in competitive markets is consistent with Pareto optimality and serves as the basis for much of welfare analysis. However, perfectly competitive markets rarely exist in reality. In the event of market failure, government frequently intervenes to improve the performance of the market system. Intervention may be intended to achieve efficiency of resource allocation judged ultimately by the Pareto optimality principle but with reference to social preference for distribution of net benefits. Intervention may take place in several forms such as taxation, regulation, government direct production, and subsidization through government expenditure.

Potential for market failure with rural household water markets stems mainly from the characteristic of a natural monopoly and from decreasing unit cost. Rural household water markets are intervened through government regulation, tax exemption, direct water supply, and subsidization. This study concerns welfare evaluation of government intervention in rural household water markets through public subsidy.

Cost-Benefit Analysis in Evaluation of Public Subsidy

CBA is an analytical technique based on welfare economics to aid policy makers in decision making for public policy. Since the technique is used to analyze social benefits and costs, it may incorporate implicit and explicit social objectives.

Welfare economics involves two major issues: (1) identification of social objectives or preferences to be satisfied by government policy or program, and (2) measurement of social welfare change due to the policy or program.

Social preferences or objectives are identified by three approaches: (1) potential Pareto improvement, (2) Pareto improvement incorporating a distributional weighting system, and (3) social welfare function. Conventional CBA adopts potential Pareto improvement. Non-conventional CBA adopts Pareto improvement incorporating a distributional weighting system. Social welfare function approach is theoretically accepted but is infrequently used in practice.

Theoretically correct measurements of social welfare change are the Hicksian compensating and equivalent variations. However, complex calculations and the lack of an operational algorithm have limited their use in most practical applications. Marshalian consumer surplus is another alternative for measurements of social welfare change. Although consumer surplus has some limitations such as path dependence, uniqueness conditions, and assumption of constancy of marginal utility of income, Willig (1976) validated the use of consumer surplus in welfare measurements as a good approximation of compensating and equivalent variations under certain conditions.

This study used both conventional and non-conventional CBA and used consumer surplus in measurement of social welfare change due to public subsidy for rural water systems.

Calculation of Social Benefits and Costs

The benefits to society of STRWS are in the two major forms, direct benefits and indirect benefits. The direct benefits are a reduction in water bill and an increase in water consumption by rural households. These benefits are summarized in the change in consumer surplus. The indirect benefits may be through a reduction in public health risks due to increased safe water consumption by rural households. Some altruistic or paternalistic taxpayers may obtain psychic satisfaction or positive utility by providing subsidy to rural households. Indirect benefits are frequently unobservable.

The costs to society of STRWS are also in the two major forms, direct costs and indirect costs. The direct costs include government subsidy and rural household recipient costs. The government subsidy costs consist of lump sum grants, long-term low interest loans, and administrative costs. The rural household recipient costs are increased water bills due to higher water consumption encouraged by lower water prices. Indirect costs may include negative externality in the form of displeasure to some taxpayers who may not agree with the subsidy program, plausibly low income people. Negative externalities may also be associated with increased urban sprawl and increased traffic on rural roads.

This study included analysis only of observable direct benefits and costs since unobservable benefits and costs were considered either technically infeasible to measure or of minor significance. Administrative costs of government were not included since these costs were presumed minor compared to total public subsidy and because of expected difficulties in obtaining data.

The government subsidy costs were computed on the basis of opportunity cost of resource use and equal to U.S. Treasury cost of lump sum grants and discount rates equal to U.S. Treasury long-term bond rates. All costs were calculated on an annual basis and then converted to cost per thousand gallons of water supplied.

Rural Community Water Demand in Oklahoma

Water demand estimation is required to measure welfare change due to public subsidy for rural water systems. The major problem in modelling rural water demand lies in the fact that rural households do not face a single price but a multipart price schedule set by rural water systems. This problem is associated with two major issues: (1) specification of the appropriate price variable and (2) appropriate estimation technique. A further issue for rural water demand is associated with locational preference.

The Department of Agricultural Economics at Oklahoma State University in 1984 carried out a random sample survey of rural water systems in Oklahoma and of rural households within those systems. Those data were used in Chapter IV to estimate rural community water demand.

Average price was selected as the appropriate price variable through use of the Opaluch test. OLS was used for the estimation technique since most empirical studies indicate OLS gives reasonable results based on statistical criteria. To incorporate locational preference of rural households in water demand, a dummy variable was used. Income measurements in water demand were also handled by dummy variables.

A total of 14 water demand equations were estimated by: (1) season, and (2) season, income group, and locational preference. Price elasticities of water demand for different groups were measured at different mean water consumption and price levels. Because water demand functions were linear, the point elasticities varied depending on quantity of water demanded. The elasticity in off-peak season as estimated at the overall monthly mean of water consumption for all households was -0.47 versus -1.56 in peak season. The elasticities at overall average price was -0.74 in off-peak season and -1.24 in peak season. However, when calculated at the mean seasonal quantity and price the elasticities were -0.78 for off-peak season and -0.91 for peak season.

Public Subsidy to Rural Water Systems in Oklahoma

A complementary survey of 11 systems used in the demand estimation was conducted in 1987 to collect data on subsidies received by the rural water systems through the Farmers Home Administration (FmHA) or other public agencies. Most of the systems were incorporated from 1950 to 1970. The number of household connections varied widely. The smallest had 110 connections and the largest had 2,938. The miles of distribution lines varied from 5 to 380 with two systems not reporting. Water supplied (amount billed to household customers) on an annual basis ranged from 6,055 thousand gallons to 275,338 thousand gallons. All systems priced water using a decreasing block rate schedule.

Public subsidies to the sample of rural water systems included grants and long-term low interest loans. The grants and loans were used for initial construction of facilities, capacity expansion, and/or renovation of existing system. The major source of grants and loans was FmHA. Interest rates for loans ranged from a low of 3.75 percent to a high of 5 percent per year and repayment period was 40 years for all loans. Average amount of grants per system for the sample was $100,248. The largest grant was $309,300 and the smallest was $29,930. Average amount of total loans per system for the sample was $946,696. The largest amount of loans received by a system was $6,488,840 and the smallest amount was $67,000.

The social opportunity cost of public subsidy through grants is the economic sacrifice of those resources in the best alternative use. It is assumed these funds would be available for other public programs and at a cost of U.S. Treasury long-term bond rates. The annualized average cost (40 year life) of public subsidy through grants per sample system was $9,948 with the largest amount for a single system equal to $40,123. The average amount of grant subsidy per thousand gallons was $0.16 with the largest grant subsidy of $1.27. The average amount of annual grant subsidy per household was $14.61. The highest annual grant subsidy per rural household was $63.96.

The social opportunity cost of public subsidy through low interest loans is the difference between the actual loan rate and the U.S. Treasury long-term bond rate. The annualized average cost (40 year life) of public subsidy through loans was $42,196 with the largest equal to $389,992 and the smallest equal to $464. The average amount of loan subsidy per thousand gallons was $0.67 with the highest subsidy amount equal to $1.66 and the lowest subsidy amount equal to $0.03. The average annual loan subsidy per household was $61.99

with the largest subsidy equal to $132.74 and the lowest subsidy equal to $1.92.

Total social opportunity cost of public subsidy is the sum of grant subsidy and loan subsidy. Total average annual subsidy provided to the sample of rural water systems was $52,144 with the highest subsidy equal to $389,992 and the lowest subsidy equal to $464. Total average subsidy per thousand gallons of water supplied was $0.83 with the highest subsidy equal to $1.66 and the lowest subsidy equal to $0.03. Total average annual subsidy per household for the sample was $76.61 with the highest annual subsidy equal to $132.74 and the lowest subsidy equal to $1.92.

Under conventional CBA, public subsidy to rural water systems (STRWS) is always inefficient with marginal social benefit-cost ratios (MSBCRs) less than 1.0. This is because subsidies are used to decrease costs to recipients and thus extend resources to rural water systems beyond the point where marginal social benefits equal marginal social costs. Because benefits under conventional CBA are weighted equally, net benefits to recipients of additional rural water will be less than net social cost of public subsidy plus welfare loss of too many resources allocated to rural water systems. MSBCRs were higher for the groups paying higher prices for water regardless of locational preference and income level. However, the difference in magnitude of MSBCRs were negligible.

With public subsidy of $0.83 per thousand gallons, average monthly water demand in off-peak season increased by 975 gallons from 4,612 gallons to 5,587 gallons. Additional monthly social benefits generated and additional monthly social costs incurred to society were $4.02 and $4.42, respectively. Net additional monthly private benefits generated was $0.40 and which required $0.81 of additional public costs. An average size rural water system with 680 household connections generates additional monthly benefits of about $2,734 to society and incurs additional monthly costs of about $3,006 to society with STRWS during off-peak season.

With public subsidy of $0.83 per thousand gallons, average monthly water demand in peak season increased by 2,210 from 6,874 to 9,084 gallons. Additional monthly social benefits generated and additional monthly social costs incurred to society were $7.89 and $8.81, respectively. Net additional private benefits generated was $0.92 which required $1.83 of additional public costs. An average size rural water system with 680 household connections generates additional monthly benefits of about $5,365 to society and incurs additional monthly costs of about $5,991 to society.

A public subsidy of $0.83 per thousand gallons of water supplied accounts for about 18.3 percent of average price in off-peak season and about 20.8 percent of average price in peak season paid by rural households.

Under non-conventional CBA, MSBCRs with income distribution weights were greater than 1.0 for the poverty and middle income groups, and MSBCRs were around 0.5 for the higher income groups. MSBCRs were higher for poverty income level groups than for the middle income level groups. MSBCRs for the poverty and middle income level groups with locational preference were higher than for the groups with non-locational preference. However, the opposite was true for the higher income groups.

MSBCR with consumption distribution weights was greater than 1.0 for the poverty income group with locational preference in off-peak season when the parameter of utility function, r, was 0.5. When r was increased to 2.0, MSBCRs were greater than 1.0 for poverty income groups in off-peak season, poverty and middle income groups in peak season with locational preference, and middle income groups in peak season with non-locational preference. When r is equal to 1.0, a value consistent with most policy makers, only poverty income groups with locational preference had MSBCRs greater than one. In general, MSBCRs with consumption weights were higher for groups with lower incomes than for groups with higher incomes, and were higher for groups with non-locational preference than for groups with locational preference.

In subsidy distribution, monthly average subsidy paid households in off-peak season was $4.23 and in peak season was $6.62. Higher income groups received higher subsidies than lower income groups, and the groups with non-locational preference received higher subsidies than the groups with locational preference. However, groups with locational preference, meaning they have chosen to live in rural areas, received substantial subsidies for their locational choice. The higher income group with non-locational preference received a monthly subsidy of $5.92 in off-peak season and $10.76 in peak season.

Strategies for Improved Efficiencies in STRWS

Three economic stragegies are proposed for the possible efficiency improvement of STRWS; productive efficiency strategy, system size strategy, and water rate strategy. Productive efficiency and system size strategy improve efficiency of STRWS through reducing unit water supply cost and also reducing subsidy requirements. Water rate strategy improves efficiency of STRWS through incorporating decision maker's objectives and efficiency water pricing.

Conclusions and Policy Implications

Conclusions drawn from the social cost-benefit analysis are summarized as follows:

1. public subsidy program for rural water systems (STRWS) is inefficient as a whole under conventional cost-benefit analysis;
2. a dollar of public cost is required to transfer $0.50 net private benefits from STRWS to rural households;
3. under non-conventional cost-benefit analysis, STRWS is efficient for low income and low consumption groups;
4. MSBCRs for non-locational preference groups differ slightly from MSBCRs for locational preference groups;
5. subsidy distribution was higher for high income groups, and lower for low income groups; and
6. substantial amounts of public subsidy are paid for locational preference.

Based upon analytical and empirical results of this study of STRWS, several policy implications are discussed. First, the inefficiency of public subsidy program under conventional CBA does not necessarily mean that STRWS should be eliminated. This study has provided policy makers additional information on the distribution of net benefits from STRWS. Results from this study should be compared with results of other subsidy programs including subsidy to urban dwellers for water consumption. Furthermore, non-convnetional CBA which incorporates net benefit distribution weights demonstrates that subsidizing low income and low consumption groups are efficient. A reorientation of subsidy to lower income groups would improve the overall efficiency of the subsidy program. This may be achieved through carefully designed water rate schedules. Rebate systems for target groups on monthly or annual basis and life line rates or target group rates may be possible alternatives.

Second, if rural water systems are encouraged to take measures to reduce water supply costs, efficiency of subsidy program would increase. This may be achieved thorugh productive efficiency improvement, and capturing more of the economies of size through consolidation or regionalization.

Third, existing subsidy program results may not be consistent with policy maker's objectives to reduce water use cost for low income groups since the program subsidizes higher income groups more than for lower income groups. Policy makers may want to solve this inconsistency through providing direct subsidy to target gorups and not to water systems for general reduction in water cost.

Fourth, subsidizing locational preference may not be consistent with policy maker's objectives since the general public may not want to subsidize groups who prefer rural living for psychic satisfaction or for increasing net locational income.

Finally, subsidizing discretionary water consumption in peak season may not be consistent with policy maker's objectives. Increased consumption through subsidy in peak season increases needed system capacity and reduces the overall efficiency of the system and efficiency of the subsidy.

For improved efficiency in public subsidy programs to rural water systems, three major policy recommendations are suggested. First, rural water systems need to implement marginal cost pricing without price discrimination among rural household groups. To achieve policy goals life line rate or rebate systems should be incorporated in the water rate structure. This could be achieved through imposing regulatory conditions when providing public subsidy. Target groups in rural water systems could be determined from income tax statements.

Second, receiving of public subsidy by rural water systems should be conditional upon removing identified sources of productive inefficiency. This will require further investigation and analysis of management procedures to identify sources of potential productive inefficiency.

Finally, higher priority of public subsidy should be given to consolidation of water systems so that more of the economies of size are captured.

Limitations and Need for Further Research

Several limitations of this study may influence the derived results and conclusions.

First, change in cost structures of the sample of rural water systems due to scale economies was not considered in the analysis because of the lack of necessary cost information. The inclusion of scale economies may increase MSBCRs of public subsidy program for rural water systems.

Second, this research considered static analysis of the subsidy program. Efficiency of the program in dynamic analysis may be different. Dynamic analysis would need to incorporate excess system capacity, costs and benefits for existing versus future household customers, etc.

Third, there were missing data for observations of monthly water consumption and some variables such as household income, distance to work-place, and locational preference. These missing data may influence results of water demand estimation which may in turn give different MSBCRs among different household groups.

Fourth, this research considered only direct social costs and benefits. Inclusion of indirect social costs and benefits such as urban sprawls, spill-over effects, etc. may influence the results of welfare analysis in this research.

Further research is needed to analyze the identified limitations of this research. Other areas for further research are suggested as follows:

First, this research was concerned with only the results of government intervention in rural household water markets through public subsidy. Other types of government intervention such as regulation and taxation may influence the efficiency of public subsidy program.

Second, more information on productive efficiency and sources of inefficiency in rural water supply is needed. Public subsidy could be used as the enticement to encourage improved rural water system management and thus improvement of productive efficiency.

Third, most literature on water rate schedules emphasizes revenue requirements and allocation of water service cost among household customers. Water rate schedules should be analyzed for purpose of increasing economic efficiency (marginal cost pricing) and obtaining decision-maker's objectives through subsidy program.

Fourth, more information on net locational income is needed to assist decision makers in determining how public subsidy should be selectively provided to different socio-economic household groups for attaining social preferences.

Additional research in these areas would be useful to find more effective strategies in improving efficiency of public subsidy program for rural water systems.

A SELECTED BIBLIOGRAPHY

Adams, G., T. H. Stevens and C. E. Wills. "Modeling the Residential Demand for Electricity: The Effect of Aggregation," Research Bulletin No. 701, Massachusetts Agricultural Experiment Station, University of Massachusetts, Amherst, Massachusetts, 1985.

Agthe, D. E., R. B. Billings, J. S. Dobra and K. Raffiee. "A Simultaneous Equation Demand Model for Block Rates," Water Resource Research, Vol. 22, No. 1 (January 1986), pp. 1-4.

Arrow, K. J. Social Choice and Individual Values. John Wiley & Son, New York, NY, 1963.

Atkinson, A. B. and J. E. Stiglitz. Lectures on Public Economics. McGraw-Hill Book Company, New York, NY, 1980.

Bergland, Olvar. "Exact Measurement of Welfare Changes: Theory and Applications," Unpublished Ph.D. dissertation, University of Kentucky, Lexington, Kentucky, 1985.

Bergson, A. "A Note on Consumer's Surplus," Journal of Economic Literature, Vol. 13 (1975), pp. 38-44.

____________. "A Replacement of Certain Aspects of Welfare Economics," Quarterly Journal of Economics, Vol. 52 (1938), pp. 314-344.

Billings, R. B. "Specification of Block Rate Price Variables in Demand Models," Land Economics, Vol. 58, No. 3 (August 1982), pp. 386-394.

Billings, R. B. and D. E. Agthe. "Price Elasticities for Water: A Case of Increasing Block Rates," Land Economics, Vol. 56, No. 1 (February 1980), pp. 73-84.

Boadway, Robin W. and David E. Wildasin. Public Sector Economics. Little, Brown and Company, Boston, Toronto, 1984.

Boadway, Robin. "Integrating Equity and Efficiency in Applied Welfare Economies," Quarterly Journal of Economics., Vol. 90 (November 1976), pp. 541-556.

Bowden, Roger. "A Note on the <<Boottom Up>> Approach to measuring Compensating Variations," Metroeconomica, Vol. 36 (1984), pp. 65-76.

Brown, C. V. and P. M. Jackson. Public Sector Economics. Martin Robertson and Company Ltd., Oxford, Second Edition, 1982.

Burkhead, Jesse and Jerry Miner. Public Enterprise. Aldine. Atherton, Inc., Chicago, Illinois, 1971.

Chicoine, D. L., S. C. Deller and G. Ramamurthy. "Water Demand Estimation Under Block Rate Pricing: A Simultaneous Equation Approach," Water Resource Research, Vol. 22, No. 6 (June 1986), pp. 859-863.

Chipman, J. S. and J. C. Moore. "Compensating Variation, Consumer's Surplus and Welfare," American Economic Review,Vol. 70, No. 5 (December, 1980), pp. 933-949

Clemens, E. W. Economic and Public Utilities. Applenton-Century-Crotts, Inc. New York, NY, 1950.

Cochran, R. and A. W. Cotton. "Municipal Water Demand Study, Oklahoma City and Tulsa, Oklahoma," Water Resource Research, Vol. 21, No. 7 (July 1985), pp. 941-943.

Cohn, Elchanan. Public Expenditure Analysis. D. C. Heath and Company, Lexington, Massachusetts, 1972.

Dasgupta, Ajit K. and D. W. Pearce. Cost-Benefit Analysis. Harper & Row Publishers, Inc., Britain, 1972.

Dellenbarger, Lynn E. "Evaluating Rural Water System Pricing Strategies Using Mathematical Programming," Unpublished Ph.D. dissertation, Oklahoma State University, Stillwater, OK, 1985.

Dellenbarger, L. E., K. S. Myoung and D. F. Schreiner. "Estimates of Price Response to Rural Water Services in Oklahoma," Current Farm Economics, Vol. 57, No. 1 (March 1984), pp. 16-22.

Dellenbarger, L. E., S. K. Kang and D. F. Schreiner. "Seasonal Rural Water Demand Estimation for Oklahoma Using Multiple Tier Price Information," Stillwater, Oklahoma: Agricultural Experiment Station, Research Report P-880, August, 1986.

Deller, S.C., D.L. Chicoine and G. Ramamurthy. "Instrumental Variables Approach to Rural Water Service Demand," Southern Economic Journal, Vol. 53 (October, 1986), pp. 333-346.

Doeksen, G. A., H. L. Goodwin and R. L. Oehrtman. "Estimating Demand and Demand Elasticities for Water in Rural Areas," Paper presented at the Southern Agricultural Economics Association Meetings in Nashville, Tennessee on February 5-8, 1984.

Doll, J. P. and Frank Orazm. Production Economics: Theory with Applications. John Wiley and Sons, Inc., New York, 1984.

Dupuit, J. "On the Measurement of the Utility of Public Works," Annals des Ponts et Chaussees, Second Series, Vol. 8 (1844). Translation reprinted in Transport by D. Munby (1968).

Eckstein, O. Water Resource Development; The Economics of Project Evaluation. Harvard University Press, Cambridge, Massachusetts, 1958.

Farmers Home Administration. "A Brief History of Farmers Home Administration." USDA, February 1987.

____________. "FmHA Instructions 1942-A," U.S. Department of Agriculture, June, 1985.

____________. "Water and Waste Disposal Loans and Grants," Program AID No. 1203, U.S. Department of Agriculture, January, 1982.

Farrell, M. J. "The Measurement of Productive Efficiency," Journal of the Royal Statistical Society. Vol. CSS, Part III (1957), pp. 253-290.

Fletcher, Max E. Economics and Social Problems. Burlington, Massachusetts: Houghton Miffin Company, 1979.

Foster, C. D. "Social Welfare Functions in Cost-Benefit Analysis," Operational Research and Social Sciences, In J. Lawrence (eds), Tavistock Publications, London, 1966.

Foster, H. S. and B. R. Beatie. "On the Specification of Price in Studies of Consumer Demand Under Block Price Scheduling," Land Economics, Vol. 57, No. 4 (November 1981a), pp. 624-629.

____________. "Urban Residential Demand for Water in the United States," Land Economics, Vol. 55, No. 1 (February 1979), pp. 73-84.

____________. "Urban Residential Demand for Water in the United States: Reply," Land Economics, Vol. 57, No. 2 (May 1981b), pp. 257-265.

Fox, William F. and Richard A. Hoffler. "Using Homothetic Composed Error Frontiers to Measure Water Utility Efficiency," Southern Economic Journal, Vol, 53, No. 2 (October 1986), pp. 461-477.

Francis, Joe D. et. al. "National Statistical Assessment of Rural Water Conditions," U.S. Environmental Protection Agency, U.S. Department of Interior, Washington, DC, 1983.

Garfield, P. J. and Wallace F. Lovejoy. Public Utility Economics. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1964.

Gessaman, Paul H. and Terese M. Janovec. "Operational Characteristics of Rural Water Systems in Five North Central States," Ames, Iowa State University, Iowa, January 1982.

Gittinger, J.P. Economic Analysis of Agricultural Projects. The John Hopkins University Press, Baltimore, Maryland, 1982.

Goldman, T. A. Cost-Effectiveness Analysis. Frederick A. Praeger Inc., Publishers, London, England, 1967.

Goodwin, H. L. and Gerald Doeksen. "Consolidation: A Viable Option for Improving Operational and Financial Stability of Rural Water Systems," Journal of Community Development Society. Vol. 15, No. 2 (1984), pp. 59-71.

Goodwin, H. L., G. A. Doeksen and J. R. Nelson. "Economics of Water Delivery Systems in Rural Oklahoma," Stillwater, Oklahoma: Oklahoma State University Cooperative Extension Service Bulletin. B-745, July 1979.

Gottlieb, M. "Urban Domestic Demand for Water: A Kansas Case Study," Land Economics. Vol. 39, (May 1963, pp. 204-210.

Gould, J. P. and C. E. Ferguson. Microeconomic Theory. Richard D. Irwin, Inc., Homewood, Illinois, 5th edition, 1980.

Hausman, Jerry. "Exact Consumer's Surplus and Deadweight Loss," American Economic Review, Vol. 71, No. 4 (September 1981), pp. 662-676.

Henderson, J. M. and Richard E. Quandt. Microeconomic Theory. McGraw-Hill Book Company, New York, NY, 1980.

Henson, S. E. "Electricity Demand Estimates Under Increasing Block Rates," Southern Economic Journal, Vol. 51 (1984), pp. 147-156.

Hicks, J. R. "The Foundation of Welfare Economics," The Economic Journal, Vol. 49, No. 196 (December 1939), pp. 696-712.

______________. "The Four Consumer's Surpluses," Reviews of Economic Studies, Vol. XI, No. 1 (Winter 1943) pp. 31-41.

Houthakker, H. S. "Electricity Tariffs in Theory and Practice," Electricity in the United States, North Holland Publishing Co., Amsterdam, 1962.

______________. "Some Calculations of Electricity Consumption in Great Britain," Journal of the Royal Statistical Society, Vol. 114, Part III (1951), pp. 351-371.

Howe, Charles, W. "The Impact of Price on Residential Water Demand: Some New Insights," Water Resources Research, Vol. 18, No. 4 (August, 1982), pp. 713-716.

Howe, C. W. and F. P. Linaweaver. "The Impact of Price on Residential Water Demand and Its Relation to System Design and Price Structure," Water Resource Research, Vol, 3, No.1 (First Quarter 1967), pp. 13-32.

Hunt, E. K. and J. Schwartz. A Critique of Economic Theory. Penguin Books, Harmondsworth, 1972.

Hurwicz, L. and H. Uzawa. "On the Integrability of Demand Functions," Preferences, Utility, and Demand, In J. S. Chipman et. al. (eds), Harcourt Brace Jovanovich, New York, NY, pp. 114-148, 1971.

Irvin, G. Modern Cost Benefit Method: An Introduction to Financial, Economic and Social Appraisal of Development Projects. The MacMillian Press Ltd., London and Basingstoke, 1984.

Jones, C. V. and J. R. Morris. "Instrumental Price Estimates and Residential Water Demand," Water Resource Research, Vol. 20, 1984, pp. 197-202.

Just, Richard E., Darrell L. Hueth and Andrew Schmitz. Applied Welfare Economics and Public Policy. Prentice-Hall, Inc., Englewood Cliffs, NJ 1982.

Kahn, Alfred E. The Economics of Regulation: Principles and Institutions, Volume I: Principles. John Wiley & Sons, Inc., New York, NY, 1970.

Kaldor, Nicholas. "Welfare Propositions of Economics and International Comparisons of Utility," The Economic Journal, Vol. 49, No. 195 (September 1939), pp. 549-552.

Kelejian, H. H. "Two-Stage Least Square and Economic Systems: Linear in Parameter but Nonlinear in the Endogenous Variables," Journal of American Statistical Association, Vol. 66, No. 334 (June 1971), pp. 373-374.

Kurtillia, J. "Welfare Aspects of Benefit-Cost Analysis," Journal of Political Economy, (June 1961).

Lawrence, R. L. "Country Water," Southern and Texas Water Works Journal, Vol. 61, No. 11 (February, 1980) page 8.

Leftwich, Richard H. and Ross D. Eckert. The Price System and Resource Allocation. The Dryden Press, New York, NY, 1985.

Lipsey, R. G. and K. Lancaster. "The General Theory of Second Best," Review of Economic Studies, Vol. 24 (July, 1956), pp. 11-32.

Marshall, Alfred. Principles of Economics. The MacMillian Press Ltd., London and Basingstoke, 1930, page 124.

Mishan, E. J. Cost-Benefit Analysis. Praeger Publishers, New York, NY, 1976.

Myoung, Kwang-Sik. "Application of Mathematical Programming for Optimal Investment, Water Supply and Pricing Decisions for Rural Water Systems in Oklahoma," Unpublished Ph.D. dissertation, Oklahoma State University, Stillwater, OK, 1982.

Myoung, Kwang-Sik and Dean F. Schreiner. "An Investment Programming Model for Rural Community Water Systems," Technical Bulletin T-161, Agricultural Experiment Station, Division of Agriculture, Oklahoma State University, Stillwater, Oklahoma, 1984.

Musgrave, R. A. The Theory of Public Finance. McGraw-Hill, New York, NY, 1959.

Nordin, J. A. "A Proposed Modification of Taylor's Demand Analysis: Comment," Bell Journal of Economics, Vol. 7 (1976), pp. 719-721.

Oklahoma Rural Water Association. "Directory of Oklahoma Rural Water Systems, Officials and Agencies," Oklahoma City, OK, 1984-1985.

Oklahoma Water Resources Board. "Oklahoma Comprehensive Water Plan," Oklahoma City, OK, September 1975.

__________. "Rural Water Systems in Oklahoma," Oklahoma City, OK, 1980.

Opaluch, J. J. "Urban Residential Demand for Water in the United States: Further Discussion," Land Economics, Vol. 58, No. 2, (May 1982), pp. 225-227.

Pareto, Vilfredo. Cours de'Economie Politique. Vol. 2 (Lausanne, 1896).

Pasour, E. C. Jr. "A Further Note on the Measurement of Efficiency and Economies of Farm Size," Journal of Agricultural Economics, Vol. 32, No. 2 (1981), pp. 132-146.

Peacock, A. and C. Rowley. "Pareto Optimality and the Political Economy of Liberalism." Journal of Political Economy. May/June, 1972.

Pearce, D. W. and C. A. Nash. The Social Appraisal of Projects: A Text in Cost-Benefit Analysis. John Wiley & Sons, New York, NY, 1981.

Poister, Theodore H. Public Program Analysis. University Park Press, Baltimore, Maryland, 1978.

Ramamurthy, Ganapathi and David L. Chicoine. "Capital Costs of Rural Water Systems: An Empirical Approach," Water Resources Bulletin. Vol. 20, No. 20 (April 1984). pp. 255-260.

Ray, A. Cost-Benefit Analysis: Issues and Methodologies. The John's Hopkins University Press, Baltimore and London, 1984.

Ricardo, David. The Principle of Political Economy and Taxation. McMillian Press. London, 1829.

Russel, N. P. and T. Young. "Frontier Production Functions and the Measurement of Technical Efficiency," Journal of Agricultural Economics. Vol. 34 (1983), pp. 139-150.

Sassone, Peter G. and William A. Schaffer. Cost-Benefit Analysis. Academic Press, Inc., New York, NY, 1978.

Samuelson, P. A. "Constancy of the Marginal Utility of Income." Studies in Mathematical Economics and Econometrics in Memory of Henry Schmitz, University of Chicago Press, Chicago, Illinois, 1942.

Sauerlender, Owen H. et. al. "Criteria for Regionalization of Water and Waste Management Systems," Research Publication Number 84. Institute for Research on Land and Water Resources. The Pennsylvania State University, University Park, Pennsylvania, 1984.

Scitovsky, T. "A Note on Welfare Propositions in Economics." Review of Economic Studies, Vol. 9, No. 1 (November 1941), pp. 77-88.

Scott, A. "The Test Rate of Discount and Charges in the Base-Level Income in the United Kingdom," The Economic Journal, Vol. 87, No. 346 (June, 1977), pp. 219-241.

Self, P. Econocrats and the Policy Process. Westview Press, Boulder, Colorado, 1977.

Sen, A. "The Impossibility of a Paretian Liberal," Journal of Political Economy, Vol. 78 (January, 1970), pp. 152-157.

Shoup, Carl S. "The Economic Theory of Subsidy Payments," Joint Economic Committee, U.S. Congress, the Economics of Federal Subsidy Programs, Part 1 (May 8, 1972), page 73.

Slogget, G. R. and D. B. Badger. "Economics and Growth of Rural Water Systems in Oklahoma," Stillwater, Oklahoma: Oklahoma State University Cooperative Extension Service Bulletin. B-716, August, 1974.

Solley, W. B., E. B. Chase and W. B. Mann. "Estimated Use of Water in the United States in 1980," Geological Survey Circular 1001, United States Department of Interior, Washington, DC, 1983.

Squire, L. and Herman G. van der Tak. Economic Analysis of Projects. The Johns Hopkins University Press, Baltimore and London, 1984.

Stevens, T. H. and Eleni Kesisoglu. "The Effect of Price on the Demand for Water in Massachusetts: A Case Study," Research Bulletin No. 698, Massachusetts Agricultural Experiment Station, University of Massachusetts, Amherst, Massachusetts, 1984.

Stevie, Richard G. and Robert M. Clark. "Costs for Small Systems to Meet National Interim Drinking Water Regulations." Journal of American Water Works Association, Vol. 74, No. 1 (January 1982), pp. 13-17.

Sugden, Robert and Alan Williams. The Principle of Practical Cost-Benefit Analysis. Oxford University Press, Britain, 1978.

Taylor, L. D. "The Demand for Electricity: A Survey," Bell Journal of Econometrics, Vol. 6 (Spring 1975), pp. 74-110.

Terza, J. V. and W. P. Welch. "Estimating Demand Under Block Rates: Electricity and Water," Land Economics, Vol. 58, No. 2 (May, 1982), pp. 181-188.

Tobin, J. "On Limiting the Domain of Inequality," Journal of Law and Economics, Vol. 13 (October 1970), pp. 447-483.

Tweeten, Luther. Foundations of Farm Policy. University of Nebraska Press, Lincoln and London, 1979.

U. S. Department of Commerce. "Statistical Abstract of the United States 1985," Washington, DC, December 1984.

Vartia, Y. D. "Efficient Methods of Measuring Welfare Changes and Compensated Income in Terms of Ordinary Demand Functions," Econometrica, Vol. 51, No. 1 (January 1983), pp. 79-98.

Wildavsky, A. "The Political Economy of Efficiency," Public Administration Review, XXVI, 4, (December 1966).

Willig, Robert D. "Consumer's Surplus Without Apology," American Economic Review, Vol. 66, No. 4 (September 1976), pp. 589-597.

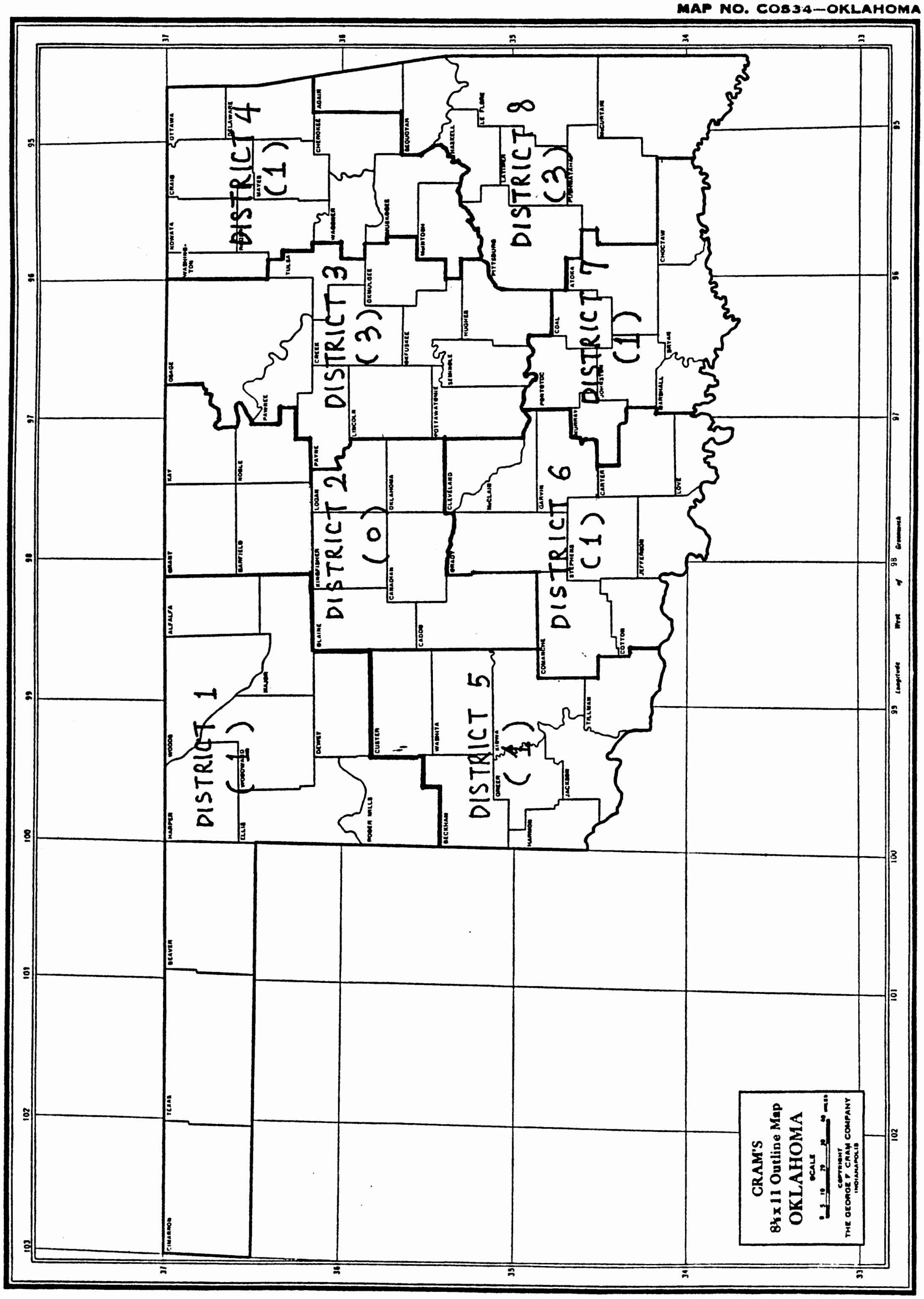
Wong, S. T. "A Model of Municipal Water Demand: A Case Study of Northeastern Illinois," Land Economics, Vol. 48, (February 1972), pp. 34-44.

Young, R. A. "Price Elasticity of Demand for Municipal Water: Case Study of Tucson, Arizona," Water Resource Research, Vol. 9, No. 4 (June 1973), pp. 1068-1072.

APPENDIX A

MAP OF FmHA DISTRICTS IN OKLAHOMA WITH NUMBER OF

RURAL WATER SYSTEMS SURVEYED


MAP NO. C0834—OKLAHOMA
CRAM'S
8½x11 Outline Map
OKLAHOMA
DISTRICT 1
(1)
DISTRICT 2
(0)
DISTRICT 3
(3)
DISTRICT 4
(1)
DISTRICT 5
DISTRICT 6
(1)
DISTRICT 7
(1)
DISTRICT 8

APPENDIX B

SURVEY QUESTIONNAIRE OF FmHA DISTRICT OFFICE

Dear Sir/Madam:

The Department of Agricultural Economics at Oklahoma State University has conducted continuing research on the benefits and costs of rural water systems in Oklahoma. In 1984 we administered a survey questionnaire for a sample of rural water systems that were members of the Oklahoma Rural Water Association and a sample of households within those rural water systems. We are currently trying to follow-up with the same sample of systems to obtain data on current operations and rural water issues.

The sample of systems we are surveying includes the following from your district:

Rural Water System A
Rural Water System B
Rural Water System C

For those systems having FmHA activity (grants or loans) we are asking the District Offices of FmHA to provide us copies of the systems' Statement of Budget, Income and Equity for the years 1981 through 1986. We are also requesting data on any FmHA grants and loans received by these systems since their inception and up to the current date including information on size of grant and loan, date received, and terms, (interest rate, repayment period, purpose of grant or loan). You may use the enclosed table to present this information for each system in our sample.

We are also enclosing a copy of the questionnaire being sent to the systems for your information. If you have any questions, please do not hesitate to contact me at (405) 624-6157 or Mr. Suki Kang who is administering the questionnaire at (405) 624-7075. Thank you for your assistance.

Sincerely,

Name of System:

Does this system have FmHA activity (grants or loans)? ___ Yes ___ No

Grants	Year Granted	*Purpose of Grant	Amount	Remarks
1				
2				
3				
4				

Loans	Year Obtained	*Purpose of Loan	Amount	Terms	
				Repayment Period	Interest Rate
1					
2					
3					
4					

Name of System:

Does this system have FmHA activity (grants or loans)? ___ Yes ___ No

Grants	Year Granted	*Purpose of Grant	Amount	Remarks
1				
2				
3				
4				

Loans	Year Obtained	*Purpose of Loan	Amount	Terms	
				Repayment Period	Interest Rate
1					
2					
3					
4					

*Purpose of grant or loan: (1) Initial construction of facilities, (2) Capacity expansion, (3) Purchase of water system, (4) Renovation of existing system, (5) Other (Please specify).

APPENDIX C

SURVEY QUESTIONNAIRE FOR RURAL WATER SYSTEMS

Dear Sir/Madam:

The Department of Agricultural Economics at Oklahoma State University is conducting research on improved strategies for operation and management of rural water systems in Oklahoma. In 1984 the Oklahoma Rural Water Association and the Farmers Home Administration (FmHA) assisted us in identifying a sample of rural water systems for purposes of obtaining management information. Your manager was kind enough to provide us questionnaire information on your system at that time. We are in the process of updating this information and kindly request your continuing support. Results of the survey questionnaire should prove helpful to agencies assisting water systems such as yours in improving efficiency of operation and management.

Enclosed is a survey questionnaire we would like you to fill out and send back to us in the self-addressed stamped envelope. This information will be treated in a confidential manner and used only for purposes of completing our research analysis. Mr. Suki Kang will be calling you within 10 days to answer any questions you may have in filling out the survey. If you have any questions at this time please call me at (405) 624-6157 or Mr. Suki Kang at (405) 624-7075.

Thank you for your cooperation.

Sincerely,

Rural Water System Managers Survey Questionnaire
Department of Agricultural Economics
Oklahoma State University
Stillwater, OK 74078

1. Name of your rural water system?

   Name ______________________________
   Address ____________________________
   County _____________________________
   Tele. No. ___________________________

2. When was your rural water system incorporated?

   Year: ______________

3. How many users (number of connections) did you have in 1981-1985?

Year	1981	1982	1983	1984	1985	1986 (if available)
Connections						

4. What were your connection (initiation) fees for a new customer for the following years?

Year	1981	1982	1983	1984	1985	1986 (if available)
Fees ($)						

5. How many miles of water line did your system have in 1981-1985?

Year	1981	1982	1983	1984	1985	1986 (if available)
Miles						

6. What is your current water rate schedule? (You may wish to attach your rate schedule to this questionnaire.)

7. When was the last time this rate schedule was changed? _________ year.

8. What were the annual total gallons of water supplied (billed to your customers) from your system in 1981-1985?

Year	1981	1982	1983	1984	1985	1986 (if available)
Gallons						

9. What additional percentage of water could be supplied with your existing system over what was supplied in 1986?

Less than 10%	( )	10% - 20%	( )
21% - 30%	( )	31% - 40%	( )
41% - 50%	( )	more than 50%	( )

10. Do you plan to increase water supply capacity of your system within the next 5 years? If yes, what percentage?

Less than 10%	( )	10% - 20%	( )
21% - 30%	( )	31% - 40%	( )
41% - 50%	( )	more than 50%	( )

11. What were the amounts of water provided by your own source of water (wells, holding ponds, etc.) and purchased from other systems in 1981-1985?

Year	1981	1982	1983	1984	1985	1986 (if available)
(Gal.) Own Source Purchased						

12. Did your system receive grants from any government agency other than Farmers Home Administration since inception (or last 20 years)? Yes ___ No ___
If yes, please list them below.

Grants

*Name of Agency or source	Year granted	**Purpose of Grant	Amount ($)	Remarks
a.				
b.				
c.				

13. Did your system receive loans from any government agency other than Farmers Home Administration since inception (or last 20 years)? Yes ___ No ___
If yes, please list them below.

Loans

*Name of Agency	Year Obtained	**Purpose of Loan	Amount ($)	Terms	
				Repayment Period (years)	Interest Rate (%)
a.					
b.					
c.					

*Name of Agency or source: (1) Economic Development Administration, (2) Housing and Urban Development, (3) Ozarks Regional Commission, (4) Water and Power Resources Service, (5) Environmental Protection Agency, (6) Oklahoma Water Resources Board, (7) Federal Revenue Sharing Funds (8) Other Agencies (Please specify).

**Purpose: (1) Initial construction of facilities (2) Capacity expansion, (3) Purchase of water system(s), (4) Renovation of existing system, (5) Other (Please specify).

14. If your system received a grant or low interest loan how has this influenced your charges to customers? Please make multiple checks if appropriate (X).

    a. Ability to lower connection (initiation) fees ( )
    b. Ability to lower the fixed monthly service charge ( )
    c. Ability to lower overall water rate schedule ( )
    d. Ability to lower water rate schedules for larger quantities of water consumed ( )

15. If there are no government grants or low interest loans available for future capacity additions or facility improvements of your system, how would this influence management decisions for your system? Please make multiple checks if appropriate (x).

    a. Limit number of new connections ( )
    b. Encourage number of new connections ( )
    c. Increase connection fees for new customers ( )
    d. Increase fixed monthly service charge ( )
    e. Increase overall water rate schedule ( )
    f. Increase water rate schedule for larger quantities of water consumed ( )
    g. Limit amount of water supplied per customer per month ( )
    h. Other (Please specify)

       (1) ____________________
       (2) ____________________
       (3) ____________________

16. If government grants or low interest loans were available to your system for <u>low income customers</u> would you be willing to give such customers:

    a. An annual rebate based on level of family income? ( )
    b. Lower connection (initiation) fees according to family income level? ( )
    c. Reduce water rate schedule according to family income level? ( )
    d. Provide the following amounts of water per month free of charge:

       first 1000 gallons ( )
       first 2000 gallons ( )
       first 3000 gallons ( )
       first 4000 gallons ( )

17. If government grants or low interest loans were available to your system for <u>agricultural purposes</u>, would your system be willing to give reduced rates for farm business and farm family use?

    Yes ___ No ___

18. What are some of the major current management and operation decisions for your system? Please rank in order of importance beginning with 1 as highest importance, 2 as next highest, etc.

    a. Determining the appropriate rate schedule ( )
    b. Properly maintaining physical facilities of water distribution system ( )
    c. Planning capacity needs of the system to meet future growth of water demand ( )
    d. Maintaining or improving water quality ( )
    e. Maintaining positive cash flows ( )
    f. Other (please specify)

        (1) ______________________________
        (2) ______________________________
        (3) ______________________________

19. What are your ultimate management objectives? Please rank objective 1 as the highest objective, 2 as next highest, etc.

    a. Maintain annual break-even cash flow ( )
    b. Maintain (or increase) reserve fund for future additions to the system ( )
    c. Increase capacity (number of users) of the system for purposes of decreasing costs per user ( )
    d. Increase capacity (number of users) of the system for purposes of serving more rural people ( )
    e. Accomodate service requests to existing customers (users) of the system ( )
    f. Provide stable water supply (pressure) to all customers ( )
    g. Other (Please specify)

        (1) ______________________________
        (2) ______________________________
        (3) ______________________________

20. Are there training programs in areas of rural water system operation and management that you feel would be beneficial to you or your system? Please check any of the following areas you feel are important or list your own needs:

    a. Financial management ( )
    b. Personnel management ( )
    c. Determining water rate schedules ( )
    d. Maintaining good customer relations ( )
    e. Use of microcomputers in operations such as correspondence using word processor, customer billings, management of resources, or inventory of equipment and supplies ( )
    f. Other (please specify)

        (1) ______________________________
        (2) ______________________________
        (3) ______________________________

21. What is your fiscal year?

January to December ( )

______ to ________ ( )

22. Your Name: ______________________________________

Phone Number:____________________________

Thank you very much for your cooperation.
5-6-87

APPENDIX D

SUMMARY OF THE SAMPLE RURAL WATER SYSTEMS MANAGERS SURVEY RESPONSE

TABLE XIII

CONNECTION (INITIATION) FEES FOR A NEW CUSTOMER

System Code	Amount ($)	Remarks
A	50 (25)	deposit for home owner (for rent)
B	750	
C	25	
D	550	
E	500	
F	150 (500)	(membership fee)
G	50 (10)	deposit for home owner (for rent)
H	250	
I	200	
J	25	deposit
K	183	

TABLE XIV

THE LAST TIME CURRENT RATE SCHEDULE WAS CHANGED

System Code	Year
A	1984
B	1986
C	1986
D	1985
E	1982
F	1983
G	1983
H	1983
I	1984
J	1986
K	1983

TABLE XV

WHAT ADDITIONAL PERCENTAGE OF WATER COULD BE SUPPLIED WITH YOUR EXISTING SYSTEM OVER WHAT WAS SUPPLIED IN 1986?

Classification	Number of Systems
None	1
Less than 10%	2
10% - 20%	1
21% - 30%	1
31% - 40%	2
41% - 50%	3
More than 50%	1

TABLE XVI

DO YOU PLAN TO INCREASE WATER SUPPLY CAPACITY OF YOUR SYSTEM WITHIN THE NEXT FIVE YEARS?

Classification	Number of Systems
None	1
Less than 10%	2
10% - 20%	1
21% - 30%	-
31% - 40%	-
41% - 50%	-
More than 50%	1
No response	6

TABLE XVII

SOURCE OF WATER (OWN VS. PURCHASED), 1983

Classification	Number of Systems
Own	6
Purchased	3
No Response	2

TABLE XVIII

IF YOUR SYSTEM RECEIVED A GRANT OR LOW INTEREST LOAN, HOW HAS THIS INFLUENCED YOUR CHARGES TO CUSTOMERS?

Influence	Number of Systems
Ability to lower connection (initiation) fees	-
Ability to lower the fixed monthly service charge	-
Ability to lower overall water rate schedule	-
Ability to lower water rate schedules for larger quantities of water consumed	-
No influence	2
No response	9

TABLE XIX

IF THERE ARE NO GOVERNMENT GRANTS OR LOW INTEREST LOANS AVAILABLE FOR FUTURE CAPACITY ADDITIONS OR FACILITY IMPROVEMENTS OF YOUR SYSTEM, HOW WOULD THIS INFLUENCE MANAGEMENT DECISIONS FOR YOUR SYSTEM (MULTIPLE CHECK)?

Influence	Number of Systems
Limit number of new connections	4
Encourage number of new connections	-
Increase connection fees for new customers	4
Increase fixed monthly service charge	2
Increase overall water rate schedule	4
Increase water rate schedule for larger quantities of water consumed	1
Limit amount of water supplied per customer per month	-
Limit replacement of old lines	1
Close system	1
No response	4

TABLE XX

IF GOVERNMENT GRANTS OR LOW INTEREST LOANS WERE AVAILABLE TO YOUR SYSTEM FOR LOW INCOME CUSTOMERS, WOULD YOU BE WILLING TO GIVE SUCH CUSTOMERS (MULTIPLE CHECK):

Willingness	Number of Systems
An annual rebate based on level of family income	2
Lower connection (initiation) fees according to family income level	2
Reduce water rate schedule according to family income level	2
Provide the following amounts of water per month free of charge:	
first 1,000 gallons	
first 2,000 gallons	
first 3,000 gallons	
first 4,000 gallons	
No willingness	3
No Response	5

TABLE XXI

IF GOVERNMENT GRANTS OR LOW INTEREST LOANS WERE AVAILABLE TO YOUR SYSTEM FOR AGRICULTURAL PURPOSES, WOULD YOUR SYSTEM BE WILLING TO GIVE REDUCED RATES FOR FARM BUSINESS AND FARM FAMILY USE?

Yes	No	No Response
0	5	6

TABLE XXII

WHAT ARE SOME OF THE MAJOR CURRENT MANAGEMENT AND OPERATION DECISIONS FOR YOUR SYSTEM (TOP PRIORITY)?

Major Decisions	Number of Systems
Determining the appropriate rate schedule	1
Properly maintaining physical facilities of water distribution system	2
Planning capacity needs of the system to meet future growth of water demand	0
Maintaining or improving water quality	2
Maintaining positive cash flows	1
No response	5

TABLE XXIII

ULTIMATE MANAGEMENT OBJECTIVES (TOP PRIORITY)

Objectives	Number of Systems
Maintain annual break-even cash flow	3
Maintain (or increase) reserve fund for future additions to the system	1
Increase capacity (number of users) of the system for purposes of decreasing costs per user	0
Increase capacity (number of users) of the system for purposes of serving more rural water people	0
Accomodate service requests to existing customers (users) of the system	0
Provide stable water supply (pressure) to all customers	2
Update and maintain existing facilities	1
No response	4

TABLE XXIV

NEEDED TRAINING PROGRAMS (MULTIPLE CHECK)

Training Programs	Number of Systems
Financial management	3
Personnel management	2
Determining water rate schedules	4
Maintaining good customer relations	5
Use of microcomputers in operations such as correspondence using word processor, customer billings, management of resources, or inventory of equipment and supplies	2
Management in accounting and laws	1
No program necessary	1
No response	3

APPENDIX E

SAMPLE DATA BY OBSERVATION ON WATER DEMAND

TABLE XXV

MONTHLY WATER CONSUMPTION (GALLONS)

Observation	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	6,000	6,000	8,000	6,000	8,000	11,000	15,000	19,000	26,000	25,000	8,000	8,000
2	7,000	5,000	6,000	4,000	6,000	8,000	8,000	7,000	7,000	7,000	6,000	7,000
3	8,000	8,000	7,000	8,000	8,000	8,000	5,000	8,000	8,000	6,000	6,000	5,000
4	4,000	2,000	3,000	3,000	3,000	6,000	4,000	4,000	5,000	16,000	8,000	7,000
5	5,000	5,000	5,000	5,000	5,000	9,000	10,000	14,000	11,000	4,000	6,000	5,000
6	8,000	7,000	14,000	6,000	9,000	8,000	11,000	11,000	11,000	5,000	9,000	8,000
7	4,000	7,000	9,000	8,000	14,000	28,000	51,000	60,000	38,000	9,000	8,000	7,000
8	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
9	3,000	5,000	5,000	7,000	6,000	6,000	13,000	12,000	7,000	5,000	5,000	6,000
10	8,000	4,000	8,000	8,000	14,000	13,000	42,000	46,000	38,000	17,000	13,000	10,000
11	7,000	6,000	6,000	9,000	12,000	9,000	14,000	15,000	9,000	5,000	7,000	7,000
12	33,000	26,000	30,000	34,000	42,000	-	-	-	-	-	-	-
13	5,000	3,000	5,000	5,000	4,000	9,000	17,000	17,000	18,000	4,000	4,000	4,000
14	7,000	4,000	7,000	5,000	5,000	6,000	4,000	6,000	6,000	5,000	6,000	5,000
15	6,000	6,000	3,000	9,000	5,000	5,000	6,000	7,000	9,000	6,000	11,000	9,000
16	3,000	2,000	3,000	3,000	3,000	3,000	3,000	3,000	5,000	3,000	4,000	4,000
17	-	-	-	5,000	4,000	6,000	4,000	5,000	-	-	-	-
18	-	-	-	23,000	24,000	15,000	12,000	14,000	-	-	-	-
19	-	-	-	3,000	3,000	4,000	3,000	3,000	-	-	-	-
20	-	-	-	2,000	2,000	4,000	7,000	5,000	-	-	-	-
21	-	-	-	6,000	7,000	8,000	7,000	6,000	-	-	-	-
22	3,672	2,989	-	4,409	10,706	7,934	28,734	34,226	-	-	-	-
24	5,000	4,200	4,700	-	-	-	-	5,600	17,000	13,800	10,360	6,000
25	3,250	3,300	3,000	-	-	-	-	5,050	18,250	4,400	3,400	3,800
26	24,500	24,500	22,000	-	-	-	-	8,000	23,500	19,200	10,900	-
27	1,650	1,700	1,700	-	-	-	-	2,900	3,500	2,100	1,900	1,900
28	-	-	-	-	-	-	33,490	2,140	2,500	2,460	2,350	2,530
29	-	-	-	-	-	-	4,020	3,740	4,000	3,270	3,500	3,150
30	6,000	4,000	3,500	5,000	6,000	6,000	6,000	4,000	6,000	5,000	4,000	5,000
31	-	2,000	3,000	1,000	1,000	1,000	2,000	1,000	1,000	1,000	1,000	2,000

TABLE XXV (Continued)

Observation	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
32	5,000	5,000	4,000	3,000	-	5,359	1,000	6,000	15,000	11,000	3,000	4,000
33	-	-	-	8,810	6,310	6,840	12,710	20,330	15,950	8,620	14,180	3,930
34	3,000	4,000	2,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
35	7,000	8,000	6,000	7,000	8,000	15,000	11,000	21,000	17,000	10,000	6,000	6,000
36	3,150	2,000	735	1,875	1,980	1,230	9,100	6,730	14,820	2,190	3,070	730
37	2,800	3,000	3,000	3,000	3,000	3,000	4,000	6,000	3,000	6,850	1,150	4,000
38	1,123	1,768	2,253	2,408	2,277	1,995	2,851	5,047	3,556	3,514	3,097	3,293
39	6,000	4,000	2,100	4,916	4,000	4,000	2,400	3,000	2,000	1,500	1,500	1,000
40	7,260	2,580	2,470	4,520	4,110	5,350	8,320	13,410	10,840	12,570	3,160	3,190
41	5,660	4,271	4,607	5,061	6,391	6,494	6,795	5,867	5,372	4,240	5,641	4,265
42	6,000	4,000	22,000	14,000	14,000	25,000	30,000	22,000	11,000	25,000	12,000	7,000
43	2,000	3,000	2,000	3,000	3,000	4,000	4,000	3,000	3,000	4,000	2,000	3,000
44	4,000	6,000	5,000	4,000	4,000	4,000	4,000	14,000	5,000	5,000	4,000	16,000
45	2,000	2,000	2,000	2,000	2,000	5,000	5,000	5,000	5,000	5,000	7,000	7,000
46	11,564	4,106	1,424	-	-	603	943	18,784	4,205	558	2,813	3,280
47	5,505	2,283	5,588	8,280	5,895	5,334	5,499	9,504	8,635	7,359	6,723	5,210
48	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	9,000	7,000	7,000
49	2,000	4,000	1,000	2,000	2,000	3,000	2,000	3,000	1,000	2,000	2,000	2,000
50	1,894	1,942	1,868	1,894	1,923	2,020	1,820	1,892	18,691	1,926	1,863	2,138
51	-	-	-	-	-	-	-	21,000	14,000	12,000	11,000	4,000
52	-	-	-	-	-	-	-	3,000	2,000	3,000	2,000	3,000
53	-	-	-	-	-	-	-	4,000	3,000	3,000	3,000	3,000
54	-	-	-	-	-	-	-	3,000	4,000	3,000	2,000	2,000
55	-	-	-	-	-	-	-	19,000	20,000	17,000	1,000	7,000
56	-	-	-	-	-	-	-	12,000	5,000	4,000	2,000	3,000
57	-	-	-	-	-	-	-	6,000	7,000	7,000	1,000	1,000
58	-	-	-	-	-	-	-	8,000	5,000	5,000	4,000	3,000
59	-	1,000	45,000	4,970	3,950	5,160	10,960	10,960	7,560	-	-	-
60	-	3,100	4,000	3,960	3,580	4,280	3,530	4,990	3,940	-	-	-
61	-	5,100	8,000	6,820	7,050	9,670	11,190	13,240	6,490	-	-	-
62	-	6,100	12,990	10,260	10,419	15,030	16,650	33,250	18,310	-	-	-
63	-	4,100	7,040	3,900	3,810	5,600	7,100	8,280	9,350	-	-	-

TABLE XXV (Continued)

Observation	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
64		3,100	1,000	6,900	3,800	14,600	7,400	14,400	10,600	-	-	
65	-	3,400	8,400	9,890	6,710	9,800	7,800	12,400	11,200	-	-	-
66	-	3,100	4,560	3,960	2,090	4,610	4,070	6,190	5,210	-	-	-
67	-	9,400	12,200	10,300	10,600	13,100	6,800	23,000	15,200	-	-	-
68	6,020	6,770	8,810	6,960	7,000	8,940	8,170	8,400	7,890	6,930	7,230	8,750
69	2,070	2,050	1,840	1,950	2,220	2,360	3,260	3,230	3,470	2,990	2,480	4,000
70	-	4,840	5,410	4,440	5,840	5,740	5,830	5,120	5,090	5,850	6,310	5,300
71	-	2,160	1,470	2,070	1,660	1,960	2,710	2,060	3,570	3,110	2,690	1,920
72	6,620	4,820	5,230	5,740	4,820	4,840	3,320	3,400	5,610	3,650	3,860	3,570
73	-	1,800	1,540	2,420	1,690	2,030	1,940	3,690	8,170	6,620	4,150	2,730
74	-	4,070	5,510	4,870	3,040	500	9,760	1,170	12,540	5,180	1,550	2,330
75	-	5,380	5,130	7,210	3,860	8,000	9,320	8,000	7,530	10,720	5,880	11,480
76	-	4,620	5,690	4,840	5,190	4,980	5,460	4,500	4,130	4,650	4,600	5,410
77	-	4,260	2,700	2,080	5,450	4,560	3,650	6,580	5,160	6,010	5,090	4,090
78	-	7,150	4,820	6,460	7,060	6,390	6,690	6,700	4,010	6,350	3,510	9,930
79	5,600	6,420	8,180	7,000	5,600	7,000	6,300	8,300	11,400	9,200	6,600	5,900
80	-	4,800	5,580	5,480	5,740	5,640	4,710	4,890	4,520	7,990	4,060	4,710
81	-	11,000	12,000	13,000	13,000	10,000	10,400	10,000	10,000	9,600	9,000	5,550
82	-	2,550	2,580	1,680	2,840	3,030	3,160	2,850	2,700	2,870	3,150	2,880
83	6,300	6,200	2,800	5,100	7,100	13,000	8,200	11,400	1,200	10,600	10,000	8,200
84	-	2,360	2,170	1,660	3,080	2,610	3,480	2,820	2,920	4,350	3,310	2,430
85	-	-	-	-	-	-	-	-	10,700	4,300	2,400	3,300

TABLE XXVI

MONTHLY WATER BILL ($)

Observation	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	16.80	16.80	19.20	16.80	19.20	22.60	26.60	30.60	37.60	36.60	19.20	19.20
2	18.00	15.60	16.80	14.00	16.80	19.20	19.20	18.00	18.00	18.00	16.80	18.00
3	19.20	19.20	18.00	19.20	19.20	19.20	15.60	19.20	19.20	16.80	16.80	15.60
4	14.00	10.00	12.40	12.40	12.40	16.80	14.00	14.00	15.60	27.60	19.20	18.00
5	15.60	15.60	15.60	15.60	15.60	20.40	21.60	25.60	22.60	14.00	16.80	15.60
6	19.20	18.00	25.60	16.80	20.40	19.20	22.60	22.60	22.60	15.60	20.40	19.20
7	14.00	18.00	20.40	19.20	25.60	39.60	62.60	71.60	49.60	20.40	19.20	18.00
8	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
9	12.40	15.60	15.60	18.00	16.80	16.80	24.60	23.60	18.00	15.60	15.60	16.80
10	19.20	14.00	19.20	19.20	25.70	24.60	53.60	57.60	49.60	28.60	24.60	21.60
11	18.00	16.80	16.80	20.40	23.60	20.40	25.6	26.60	20.40	15.60	18.00	18.00
12	44.60	37.60	41.60	45.60	53.60	-	-	-	-	-	-	37.60
13	15.60	12.40	15.60	15.60	14.00	20.40	28.60	28.60	29.60	14.00	14.00	14.00
14	18.00	14.00	18.00	15.60	15.60	16.80	14.00	16.80	16.80	15.60	16.80	15.00
15	16.80	16.80	12.40	20.40	15.60	15.60	16.80	18.00	20.40	16.80	22.60	20.40
16	12.40	10.00	12.40	12.40	12.40	12.40	12.40	12.40	15.60	12.40	14.00	14.00
17	-	-	-	25.00	22.10	27.90	22.10	25.00	-	-	-	-
18	-	-	-	79.81	53.85	56.74	48.08	53.85	-	-	-	-
19	-	-	-	22.12	22.12	25.00	22.12	22.12	-	-	-	-
20	-	-	-	16.35	16.35	25.00	33.66	27.89	-	-	-	-
21	-	-	-	30.77	30.66	36.54	33.66	30.77	-	-	-	-
22	9.60	9.60	-	9.60	12.50	11.54	21.54	24.04	-	-	-	-
23	13.47	12.50	9.60	13.47	10.10	10.10	10.58	15.39	-	-	-	-
24	10.61	8.86	9.20	-	-	-	-	10.11	30.10	16.86	11.36	11.86
25	8.25	8.37	7.98	-	-	-	-	10.48	32.50	9.62	8.37	8.86
26	45.50	45.50	41.20	-	-	-	-	13.98	42.70	34.60	17.80	-
27	6.24	6.36	6.36	-	-	-	-	7.61	8.50	6.99	6.60	6.60
28	-	-	-	-	-	-	14.49	13.14	13.50	13.46	13.35	13.53
29	-	-	-	-	-	-	14.02	13.74	14.00	13.27	13.50	13.15
30	20.00	15.50	13.25	17.75	20.00	20.00	20.00	15.50	20.00	17.75	15.50	17.75

TABLE XXVI (Continued)

Observation	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
31	-	11.00	13.25	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00
32	17.75	17.75	13.50	13.25	-	17.75	29.00	24.50	40.25	31.25	13.25	15.50
33	-	-	-	21.75	20.00	22.25	35.75	51.50	42.50	26.75	38.00	15.50
34	13.25	15.50	11.00	13.25	13.25	13.25	13.25	13.25	13.25	13.25	13.25	13.25
35	22.25	24.50	20.00	22.25	24.50	40.25	31.25	53.75	44.74	29.00	20.00	20.00
36	13.25	11.00	11.00	11.00	11.00	11.00	26.75	22.25	40.25	11.00	13.25	11.00
37	13.25	13.25	13.25	13.25	13.25	13.25	15.50	20.00	13.25	22.25	11.00	15.50
38	11.00	11.00	11.00	11.00	11.00	11.00	13.25	17.75	15.50	13.25	13.25	13.25
39	20.05	15.50	11.00	17.75	15.50	15.50	11.00	13.25	11.00	11.00	11.00	11.00
40	22.25	13.25	11.00	17.25	15.50	17.75	24.50	35.75	31.25	33.50	13.25	13.25
41	20.00	15.50	15.50	17.75	20.00	20.00	22.25	20.00	17.75	15.50	20.00	15.50
42	20.00	15.50	56.00	38.00	38.00	62.75	74.00	56.00	31.25	62.75	33.50	22.25
43	11.00	13.25	11.00	13.25	13.25	15.50	15.50	13.25	13.25	15.50	11.00	13.25
44	15.50	20.00	17.75	15.50	15.50	15.50	15.50	38.00	17.75	17.75	15.50	42.50
45	11.00	11.00	11.00	11.00	11.00	17.75	17.75	17.75	17.75	17.75	22.25	22.25
46	33.50	15.50	11.00	-	-	11.00	11.00	49.25	15.50	11.00	13.25	13.25
47	20.00	17.75	20.00	24.50	20.00	17.75	17.75	29.00	26.75	22.25	22.25	17.75
48	22.25	22.25	22.25	22.25	22.25	22.25	22.25	22.25	22.25	22.25	22.25	22.25
49	11.00	15.50	11.00	11.00	11.00	13.25	11.00	13.25	11.00	11.00	11.00	11.00
50	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	49.25	11.00	11.00	11.00
51	-	-	-	-	-	-	-	24.90	17.90	15.90	14.90	7.90
52	-	-	-	-	-	-	-	6.90	6.90	6.90	6.90	6.90
53	-	-	-	-	-	-	-	7.90	6.90	6.90	6.90	6.90
54	-	-	-	-	-	-	-	6.90	7.90	6.90	6.90	6.90
55	-	-	-	-	-	-	-	22.90	23.90	20.90	6.90	10.90
56	-	-	-	-	-	-	-	15.90	8.90	7.90	6.90	6.90
57	-	-	-	-	-	-	-	9.90	10.90	10.90	6.90	6.90
58	-	-	-	-	-	-	-	11.90	8.90	8.90	7.90	6.90
59	-	7.00	10.25	10.25	8.75	11.65	17.60	17.60	14.15	-	-	-
60	-	8.75	10.25	8.75	8.75	10.25	8.75	10.25	8.75	-	-	-
61	-	11.65	15.25	12.95	14.15	16.25	17.95	19.15	12.95	-	-	-

TABLE XXVI (Continued)

Observation	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
62	-	12.95	18.65	17.15	17.15	20.15	20.65	29.15	21.65	-	-	-
63	-	10.25	14.15	8.75	8.75	11.65	14.15	15.25	16.25	-	-	-
64	-	8.75	7.00	12.95	8.75	19.95	14.15	19.65	17.15	-	-	-
65	-	8.25	15.25	16.25	12.95	16.25	14.15	17.95	18.65	-	-	-
66	-	8.75	10.25	8.75	7.00	10.25	10.25	12.95	11.65	-	-	-
67	-	16.25	18.65	17.15	17.15	19.15	12.95	24.15	20.15	-	-	-
68	16.10	16.94	19.46	17.18	17.30	25.91	24.29	24.76	23.95	21.96	22.56	25.43
69	9.80	9.80	9.44	9.62	10.16	12.36	14.34	14.34	14.93	13.86	12.34	16.00
70	-	16.95	18.00	16.25	18.70	18.53	18.70	17.48	17.30	22.18	23.23	21.13
71	-	11.73	10.81	11.50	10.58	11.27	13.11	11.50	14.68	16.51	15.22	13.33
72	19.80	16.95	17.65	18.53	16.95	16.95	14.33	14.50	21.76	17.56	17.98	17.35
73	-	11.40	10.35	12.42	10.58	11.50	22.80	14.85	21.68	23.86	18.61	15.49
74	-	15.55	18.18	16.95	13.80	9.20	23.50	9.43	26.30	20.71	12.25	14.41
75	-	17.83	17.48	20.55	15.20	21.55	23.10	21.55	21.93	29.02	22.18	30.34
76	-	17.80	18.35	16.95	17.48	17.13	18.00	16.43	15.73	19.66	19.66	21.34
77	-	16.60	13.10	11.50	18.00	16.43	14.85	19.68	17.48	22.60	20.50	18.40
78	-	20.43	16.95	19.55	20.30	19.43	19.30	19.93	15.55	23.23	17.77	28.69
79	15.35	19.55	21.68	20.30	18.35	20.30	19.43	21.93	25.20	27.92	23.86	22.39
80	-	16.95	18.18	18.00	18.53	18.35	16.78	16.95	16.43	26.05	18.40	19.87
81	-	24.80	25.80	26.80	26.80	23.80	24.20	23.80	23.80	28.36	27.70	21.55
82	-	12.65	12.65	10.58	12.42	13.80	13.98	13.34	13.11	15.76	16.51	15.76
83	19.43	19.30	13.34	17.48	20.43	26.80	21.80	25.20	9.66	29.46	28.80	26.50
84	-	12.19	11.73	10.58	13.80	12.88	14.50	13.34	13.57	19.03	16.93	14.68
85	-	-	-	-	-	-	-	-	29.20	16.40	10.70	13.40

TABLE XXVII

FAMILY SIZE, INCOME, ALTERNATIVE SOURCE OF WATER, WORK DISTANCE, AND LOCATIONAL DUMMY

Observation	Family Size (FAMS)	Annual Income ($1,000) (INCOM)	Alternative Source of Water (%) (NRS)	Distance to Work Place (MILE)	Locational Preference (Yes=1, No=0) (LPD)
1	5	37.5	0	0	0
2	3	22.5	0	7	1
3	3	22.5	0	12	0
4	2	47.5	99	-	1
5	2	27.5	0	10	0
6	3	37.5	0	2	0
7	4	57.5	0	0	0
8	1	47.5	100	0	0
9	2	42.5	0	5	0
10	2	57.5	0	13	1
11	3	57.5	0	30	1
12	3	57.5	0	5	0
13	2	57.5	0	5	1
14	3	37.5	98	7	1
15	3	57.5	60	4	1
16	2	37.5	0	0	1
17	2	12.5	100	-	0
18	4	37.5	0	12	1
19	1	7.5	100	-	1
20	2	22.5	0	5	0
21	3	52.5	100	-	1
22	1	7.5	0	-	1

TABLE XXVII (Continued)

Observation	Family Size (FAMS)	Annual Income ($1,000) (INCOM)	Alternative Source of Water (%) (NRS)	Distance to Work Place (MILE)	Locational Preference (Yes=1, No=0) (LPD)
23	3	17.5	0	0	1
24	3	5	0	0	0
25	3	12.5	0	0	1
26	5	17.5	40	0	0
27	5	12.5	50	23	1
28	2	5	0	0	1
29	3	22.5	0	-	0
30	2	22.5	100	-	-
31	4	7.5	90	0	1
32	4	22.5	95	50	1
33	3	22.5	0	14	1
34	2	22.5	100	-	0
35	4	12.5	50	-	1
36	2	5	98	-	-
37	1	32.5	0	0	-
38	3	22.5	100	0	0
39	1	5	0	0	1
40	3	5	100	-	1
41	2	17.5	10	-	1
42	8	12.5	80	0	1
43	2	32.5	50	-	-
44	4	12.5	0	5	1
45	1	12.5	5	-	1
46	2	11	25	-	1
47	4	37.5	0	-	-

TABLE XXVII (Continued)

Observation	Family Size (FAMS)	Annual Income ($1,000) (INCOM)	Alternative Source of Water (%) (NRS)	Distance to Work Place (MILE)	Locational Preference (Yes=1, No=0) (LPD)
48	3	27.5	100	8	0
49	1	12.5	99	-	1
50	2	27.5	90	7	1
51	1	5	0	-	1
52	2	27.5	0	-	1
53	1	5	0	-	1
54	3	22.5	0	-	1
55	8	12.5	0	0	0
56	2	7.5	0	0	1
57	1	7.5	0	1	-
58	2	22.5	0	-	1
59	3	22.5	0	30	1
60	2	12.5	0	0	1
61	3	22.5	10	31	0
62	4	17.5	0	20	0
63	3	22.5	0	20	0
64	2	7.5	0	0	0
65	4	42.5	0	-	-
66	2	7.5	0	0	0
67	4	27.5	0	0	-
68	3	32.5	100	20	-
69	3	7.5	0	0	-
70	3	12.5	0	2	-
71	2	22.5	0	25	0
72	2	22.5	0	5	1

TABLE XXVII (Continued)

Observation	Family Size (FAMS)	Annual Income ($1,000) (INCOM)	Alternative Source of Water (%) (NRS)	Distance to Work Place (MILE)	Locational Preference (Yes=1, No=0) (LPD)
73	5	7.5	0	-	1
74	5	12.5	0	-	1
75	1	5	0	-	0
76	2	17.5	75	-	1
77	3	7.5	0	2	1
78	3	17.5	100	2	1
79	4	22.5	0	5	0
80	4	17.5	100	20	0
81	5	17.5	0	9	1
82	2	7.5	5	0	1
83	3	47.5	0	3	1
84	2	12.5	100	3	1
85	2	5	100	-	1

VITA

Suki Kang

Candidate for the Degree of

Doctor of Philosophy

Thesis: WELFARE IMPLICATIONS OF PUBLIC SUBSIDY TO RURAL WATER SYSTEMS IN OKLAHOMA

Major Field: Agricultural Economics

Biographical:

Personal Data: Born at Imsil, Korea, February 24, 1949, Son of Duyeol and Yebun Kang.

Education: Graduated from Jeonju High School, Jeonju, Korea, in February, 1968; received the Bachelor of Science degree in Agricultural Economics from Seoul National University in February, 1972, Seoul, Korea; received the Master of Science degree in Agricultural Economics from Oklahoma State University, Stillwater, Oklahoma in December, 1984; completed requirements for the Doctor of Philosophy degree from Oklahoma State University with a major in Agricultural Economics in December, 1987.

Professional Experience: Korean Army, March 1972 to June 1974; Researcher, National Agricultural Cooperative Federation, Seoul, Korea, 1975 - 1978; Fellow, Food and Agriculture Organization of the United Nations, Thailand, 1979-1981; Research Associate, Korea Rural Economics Institute, Seoul, Korea, 1981-1983; Research Assistant, Department of Agricultural Economics, Oklahoma State University, October, 1984 to August, 1987.