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WELFARE IMPLICATIONS OF GOVERNMEMT INTERVENTION IN RURAL POTABLE WATER MARKETS:A CASE WITH THE UNITED STATES

KANG SU-KI*
DEAN F. SCHREINER**

I. Introduction

1. 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 competitve 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 market stems mainly from the characteristics of a natural monopoly, decreasing unit cost, and failure to provide equity for needed rural household. 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.

2. Problems, Objectives and Analytical Methods

The Consolidated Farm and Rural Development Act[1] authorizes Farmers Home Administration (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 per-

*Research Associate, Korea Rural Economics Institute, Seoul, Korea.
**Professor, Department of Agricultural Economics, Oklahoma State Univ.
[1] PL 92-419, 30 August, 1972, United Statutes at Large 86, pp. 657-677.

cent 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 rual water systems (STRWS [2]) is implicitly stated in FmHA grant and loan instructions (FmHA 1985) 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 benefitting from subsidy are motivated to settle in rural areas for purposes of exploiting locational preference. Thus, policy makers need information on the distribution 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, and (2) measure the distribution of public subsidy among major socio–economic groups within rural water systems.

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

II. Analytical Framework

1. Cost–Benefit Analysis in Evaluation of Public Subsidy Program

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 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 incorporationg 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

[2] One which supplies water to a rural community with a population of 10,000 persons or less in the United States.

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. Marshallian 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.

2. General Framework

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; Vartia 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 opportuity cost of the subsidy and assumed equal to long–term U.S. Treasury bond rates. Subsidy benefit distribution is 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 $W_i=\overline{Y}/Y_i$, where $\overline{Y}$ 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 $Q_i=(\overline{C}/C_i)^r$ 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.

3. 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 soceity 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 displeaure to some taxpayers who do not agree with STRWS, say, low income urban households. Measurement of this displeasure is technicassy infeasible, thus not considered in this study.

Observable costs are classified into two major categories, public or government costs and private or recipient cost. 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.

4. Analytical Model

Social Costs and Benefits under No Distributional Weights

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

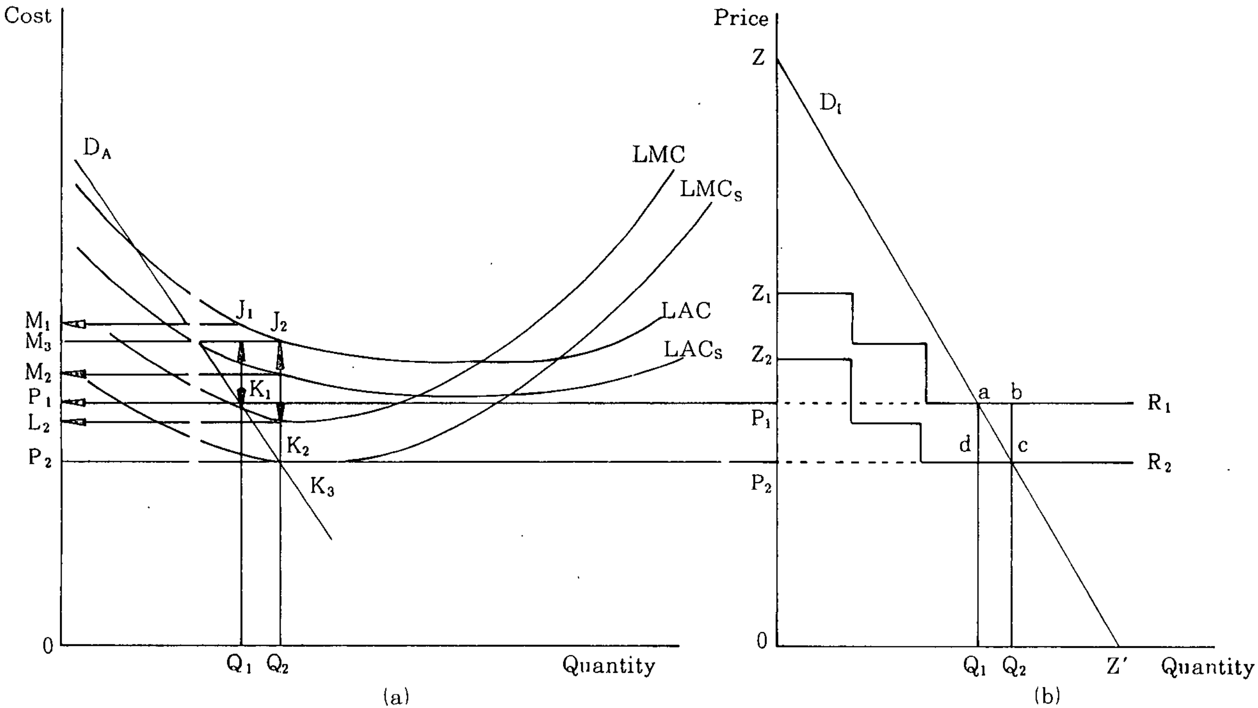
Consider a representative rural water system characterized as a decreasing cost firm in Figure 1 (a). The system has long–run marginal cost *(LMC)*, long–run average cost *(LAC)*, and faces aggregate water demand (D_A). It is assumed that the monopolistic rural water system does marginal cost pricing 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 1 (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 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 $C=f[K(g), M(g), W(g)]$ where C is annual total cost, $K(g)$ is annualized fixed capital investment, $M(g)$ is annual operation and maintenance cost of water distribution facilities, and $W(g)$ is annual water purchase or annual cost of water source at the water supply of g. Then marginal cost is represented as $LMC=f'[K(g), M(g), W(g)]$. When lump sum subsidy is provided to rural water system then the new cost function is given as $C_s=f_s[K(g)-S(g), M(g), W(g)]$ where $S(g)$ 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 subsidies, large systems receive large lump sum subsidies. The new marginal cost under subsidy is represented as $LMC_s=f_s'[K(g)-S(g), M(g), W(g)]$.

Suppose the rural water system is provided a lump sum subsidy in the amount of $S(g)$. 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 LMC_s and LAC_s as shown in Figure 1 (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 LMC_s. The marginal price for an individual household within the system is p_2 in Figure 1 (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 1 (b).

FIGURE 1 **Public Subsidies and Change in Social Welfare.**



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 1 (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 1 (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 $Zaq_1O-Z_1aq_1O=ZaZ_1$.

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 $Zcq_2O-Z_1bq_2O=ZaZ_1-abc_3$.

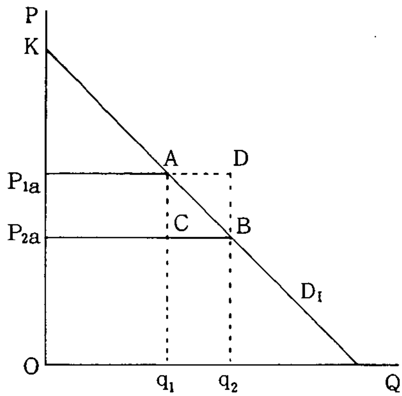
Now the marginal social benefit–cost ratio (MSBCR) is the ratio between the added social benefits and the added social costs with public subsidy. The added social benefits are $Zcq_2O-Zaq_1O=acq_2q_1$. The added social costs are $Z_1bq_2O-Z_1aq_1O=abq_2q_1$. Then MSBCR is given by acq_2q_1/abq_2q_1 which will always be less than one.

Two problems arise in empirical measurements with this approach. First, only R_2, q_2, D_1 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

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

FIGURE 2 **Price Change and Social Welfare**



illustrated in Figure 2. D_l is the same household demand curve as in Figure 1 (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 1 (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 1 (b). The water bill for the individual household under R_2 is the area represented by Z_2cq_2O in Figure 1 (b). Then the average price p_{2a} at q_2 in Figure 2 is given by the water bill Z_2cq_2O divided by the quantity demanded, q_2, in Figure 1 (b). Similarly, p_{la} at q_l in figure 2 is the average price when the system, without STRWS, sets the marginal price at p_l for the water supply of Q in Figure 1 (a). This in turn gives the individual household within the system marginal price of q_l with rate schedule R_l in figure 1 (b). Ther water bill for the individual household under R_l is the area represented by $Z_{laq_i}O$ in Figure 1 (b). Then the average price p_{la} at q_l in Figure 2 is given by the water bill Z_laq_lO divided by the quantity demanded, q_l in Figure 1 (b).

Social benefits and costs without STRWS are simply private benfits and costs. With STRWS the social benefits are private benefits, KBq_2O and social costs are private costs $p_{2a}Bq_2O$ plus public costs $p_{la}DBp_{2a}$ in Figure 2. MSBCR is the change in social benefits, $KBq_2O\text{-}KAq_lO=ABq_2q_l$, over the change in social costs, $p_{la}Dq_2O\text{-}p_{la}AQ_JO=ADq_2q_l$.

However, unresolved is the problem of no observable information on p_{la} and q_l, the average price and quantity without STRWS. Thus, computation of p_{la} and q_l is necessary. Price p_{la} 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_l is obtained by substituting p_{la} into individual household water demand functions. The size of q_l 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_I and q_2 in Figure 2, that is,

$$(1) \qquad MSB = \int_{q_I}^{q_2} D_I(p)\ dq$$

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

$$(2) \qquad MSC = p_{Ia}(q_2 - q_I)$$

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

$$(3) \qquad MSB/MSC = \int_{q_I}^{q_2} D_I(p)\ dq / p_{Ia}(q_2 - q_I)$$

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;

$$(4) \qquad \frac{MSB_i}{MSC_i} = \frac{\int_{q_{iI}}^{q_{i2}} D_i(p)dq}{(q_{i2} - q_{iI})p_{iI}}$$

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-economec group i.

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

q_{iI}=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_{iI}=price of water per thousand gallons at the monthly water consumption q_{iI} 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 comparisions 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; 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 subsidides 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, 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:

$$(5) \qquad \frac{W_i{}^*MSB_i}{MSC_i}=\frac{W_i{}^* \int_{q_{i1}}^{q_{i2}} D_i(p)dq}{(q_{i2}-q_{i1})\, p_{i1}}$$

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 weight is based on the assumption that the marginal utility of consumpion 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 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 $\theta_i=U_i/\bar{U}=(C_i/\bar{C})^{-r}=(\bar{C}/C_i)^r$ where θ_i is a consumption distribution weight for the average househlod 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 househlod, 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 $MSB_{wi} = Q_i^* MSB_i = (\bar{C} / C_i)^r \cdot MSB_i$ 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:

$$(6) \qquad \frac{\theta_i^* MSB_i}{MSC_i} = \frac{\theta_i^* \int_{q_{i1}}^{q_{i2}} D_i(p)dq}{(q_{i2} - q_{i1})\, p_{i1}}$$

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 inefficient.

Subsidy Distribution by Scoio-Economic Group

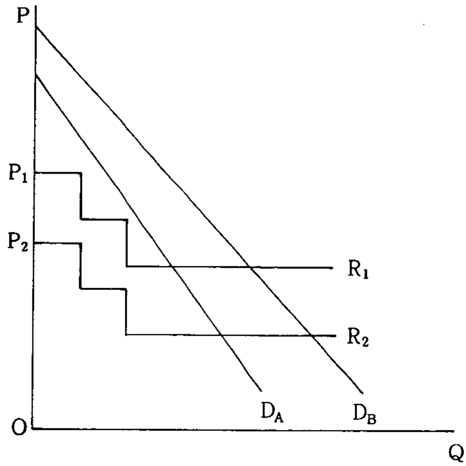
This approach is based on the assumption that a decision maker wishes to classify recipients of public policy by socio-economic characteristics and measure subsidy distribution between the interested groups.

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 rual 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 illustated in Figure 3. 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

FIGURE 3 **Distribution of Benefits Under Subsidy for Alternative Socio–Economic Groups (Decreasing Block Rate)**



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_i, D_A, R_2 and price axis, and R_1, D_B, R_2 and price axis, respectively.

5. Calculation of Subsidy Costs

The subsidy costs ars 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:

(7) $\beta = i(1+i)^n/(1+i)^n - 1$

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

(8) $AGC_{uj} = \beta\ (LSG_j/Q_j)$

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:

(9) $$AGC_{nj} = \beta\,(LSG_j/N_j)$$

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:

(10) $$ALC_{wj} = LIL_j(\beta - \alpha)/Q_j$$

where β and α are capital recovery factors at i social discount rate and r is 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:

(11) $$ALC_{nj} = LIL_j(\beta - \alpha)/N_j$$

where N_j denotes number of households rural water system j and other notations are the same as in equation (9).

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.

III. 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 techniqe. 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 househlods within those systems.

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 elasticites 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 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.

IV. Analytical Results

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 supplies (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 $42,190 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 $61.00 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 household 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.

V. 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–conventional 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 desinged 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 through 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 groups and not to water systems for general reduction in water cost.

Forth, 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.

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