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LEAST COST APPROACHES FOR SATISFYING WATER DEMAND:

AN ALTERNATIVES ANALYSIS

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Western Water: Expanding Uses/Finite Supplies

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I. INTRODUCTION

Water development in the western U.S. has produced a number of large surface storage and diversion facilities. These surface supply projects have often resulted in significant degradation of aquatic and terrestrial environments due to water diversion and habitat inundation. In addition, the agricultural and urban water supplies which these projects produced have frequently generated pollution discharges and further environmental degradation.

Western water development has generally been governed neither by economic efficiency criteria in project planning nor by a system of economic price signals for water users. This lack of economic planning and allocation criteria has been due to various market failures and to institutional, legal, and political rigidities. Reforms in the water allocation and investment planning processes could alleviate both the economic inefficiencies and environmental costs associated with the existing water allocation and development system. The "least cost" criterion for planning water supply and pollution control facilities, along with voluntary water markets, has the potential to produce economic and environmental benefits within many western water systems.

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II. ECONOMIC EFFICIENCY CRITERIA

A. Markets

An economic allocation is said to be efficient, or "Pareto optimum", if no individual can be made better off without another individual being made worse off. In practical policy settings, an alternative formulation of the economic efficiency criterion involves "Pareto dominant" reallocations which make at least some individuals or interests better off without making others worse off, or which make some interests better off while adequately compensating other interests for their losses (Hicks-Kaldor optimality). The Pareto criterion says nothing, however, about the equity of the underlying distribution of wealth, and its attainment depends upon the existence of several conditions on the demand and supply sides of markets. Nevertheless, the competitive equilibrium paradigm is useful in understanding the importance of "least cost" approaches.

B. Demand

The consumer demand function indicates that the quantity of water demanded depends upon the price of water, the prices of substitutes, and income levels. Where water is a "derived demand" as an production input (e.g. irrigation), demand depends upon the price of water, the price of input substitutes, and the price of outputs (e.g. crops). If the price of water increases, the quantity of water demanded decreases -- empirical studies show a negative price "elasticity of demand" in both the urban and agricultural sectors. The "substitution effect" component of the effect of price increases on quantity demanded results from the decreasing relative price of water substitutes relative to the price of water, i.e., capital equipment (in the long-run) or labor (in the short- and long-run) are be used more intensively and water is used less. Water demand increments for consumption and production purposes are economically efficient up to the point at which the value of the marginal unit of water used is equal to the price of water. There are many users of water on the demand side -- households, businesses, and agriculture -- so that the potential for competitive conditions exists in terms of numbers of individuals in the market.

C. Supply

The supply curve or function represents the cost minimizing set of combinations of inputs for each level of supply. Prices of inputs used in producing water, such as labor, construction materials, energy, and finance, underlie these cost minimizing sets. Different cost functions exist for different water supply technologies, i.e. facilities for surface dam and diversion ; wastewater reclamation; and groundwater use. Cost functions for water conservation facilities and practices exist as well. The long-run marginal cost function intersects the long-run average cost function at its minimum. The long-run average cost function is the "envelope" of the family of short-run average cost functions. The profit-maximizing level of water supply is that at which the price of water equals the marginal cost of supply.

D. Competitive Equilibrium and "Second Best"

Three sets of conditions on the demand and supply sides are necessary for competitive equilibrium. (1) The marginal rates of substitution between water and its substitutes are equal to the ratio of the price of the substitute to the price of water for all consumers. (2) The value of the marginal product of water produced by each input equals the input's price, which equals the value of the marginal product of other goods produced by that input. This condition holds for all inputs. (3) The ratio of the price of water to that of other products equals the ratio of the marginal product of that other product from any input to the marginal product of water from that same input, i.e. the so-called marginal rate of transformation between two products equals the marginal rate of substitution between those two products for all producers and consumers. Several preconditions exist along with these marginal decisionmaking criteria, including the presence of large numbers of individuals and access to high quality information on both sides of the markets.

These conditions must apply not only within the water market, but also within other sectors of the economy with which water interacts in order to realize the benefits of economic welfare maximization. Due to a myriad of complicated market failures, however, some of these conditions frequently do not exist. Failures within the water market, particularly on the supply side, indicate a so-called "second best" problem. This problem is that the design of water policies to rectify violations of the optimality conditions may or may not induce increments in economic welfare. The concept of "Pareto dominance" becomes important in attempts to design water policies consistent with the optimizing preconditions which make at least some individuals or interests better off either without making others worse off, or alternatively in adequately compensating any losses.

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III. Market Failures

A. Decreasing Costs

The technology of supply can be such that a very large size of operation relative to the total market is required in order to lower per unit production costs. This mayl violate the optimality conditions because (1) competition on the supply side is constrained due to the existence of only one (monopoly)or a few (oligopoly) large suppliers, and (2) the setting of price equal to marginal cost requires a deficit by the supplier. Decreasing cost conditions probably existed for some of the large water supply projects constructed by the federal government as well as by some state and local water agencies in the western U.S.. Such "economies of scale" associated with decreasing costs have been a prime reason for the institutionalization of water supply monopolies as part of the economic development of the West.

B. Public Goods

Public goods or collective goods are enjoyed in common in the sense that individual use or consumption does not lead to a dimunition in any other individual's consumption of the same good. Consumptive trade-offs among individuals are not made for public goods, and the marginal cost is zero. Features of water supply projects which have public goods aspects are flood control and, where congestion is not a concern, recreation. The public goods aspect has often formed the rationale for public subsidies for water supply projects, such as the "non-reimburseable" component of federal reclamation projects.

C. Externalities

Externalities result when water use by consuming or producing interests has negative (or positive) impacts on other individuals or interests. Negative externalities from water use result from diversion of water and from pollution discharges in that wildlife habitats, recreational values, drinking water quality, and various property values are adversely affected. These types of externalities involve costs which are not incorporated into the supply curve so that market prices do not reflect the resulting damages. Legislation designed to control various types and sources of water pollution aim to internalize these external costs to a degree by, for example, setting standards for the discharge of pollutants. The subsidization of pollution controls, however, detracts from this internalization process.

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IV. Existing Systems of Water Allocation

A. Pricing

1. Local

Water pricing at the local level is implemented by independent special districts, municipally owned waterworks, mutual water companies, and private companies. Many hold water rights generally as riparian landholders or as appropriaters under state water law. In California, for example, some 2,500 local water districts handle nearly three-fourths of the state's annual water usage. Generally speaking, these water suppliers price water to meet their revenue and cash-flow requirements as the primary goal, i.e. historic average cost pricing prevails. Meters, a precondition for use-based pricing, exist in some urban districts and in very few agricultural districts. Of the metered users, declining block rate structures reflecting an era of decreasing costs of supply dominate, although rate structure revisions toward flat rate structures are occurring. In agriculture, per acre fee assessments with no relation to actual use are common (e.g. one-third of California irrigation water use is distributed in this way). Even in the urban sector, taxes and assessments are an important source of revenue in addition to water charges (e.g. nearly one-half in California urban districts).

2. State and Federal

State and even federal water projects use pricing procedures which vary somewhat among western states. The state (SWP) and federal (CVP) projects in California provide a good illustration, however, of the methods often applied. New contract prices are less than the full marginal cost of new project supply due to (1) use of taxpayer revenues to subsidize project development and operation, (2) application of historical average costs to the calculation of repayments in project water prices, and (3) the absence of price elasticity as a demand determinant in the planning of future supply projects.

3. Impact on Least Cost Supply Development

The use of taxpayer revenues, fee assessments, and historical average cost pricing procedures sends water price signals to users which are far below the marginal costs of new supply projects. In some cases, particularly in agriculture, no water price signal is sent at all. Given the institutional orientation of many water supply agencies, particularly federal and to some extent state, toward surface dam and diversion projects, these pricing procedures provide incentives which are counter to least cost development among all alternatives. Water contractors and users have the option of reducing their demand for new surface water supplies by increasing efficiency of use, by reusing and reclaiming water, and by groundwater management. The costs of these alternatives, however, are derived from today's markets for labor, finance, and materials, which must then be compared to the costs of project surface water derived from the past economic conditions upon which historical costs are based. In addition, subsidies for such alternatives, if extant, are usually much smaller than those applied to federal and some state supply projects. The result is that these pricing procedures discourage development of lower cost alternatives on the demand side of the market to surface water supply projects.

B. Water Investment Planning

1. Rational Economic Planning

Long construction times on many types of water projects make a planning process essential. Rational economic planning requires: (1) systematic projection of future water demands under stated assumptions about economic and population growth, with the effects on water demand of changes in relative prices and price elasticity of demand explicitly taken into account; and (2) analysis of alternative water supplies, including surface storage and diversion, wastewater reclamation, groundwater management, and other potential sources. In water systems in which water markets and marginal cost pricing of new supplies do not exist, rational planning also requires that investments in water use efficiency and conservation facilities be included as well, since such demand-reducing measures cannot be expected to occur as a result of market price incentives.

2. Actual Project Planning

Water project planning rarely approximates a rational economic process due primarily to the water supply institutions that have arisen as a result of market failures. In general, economic planning becomes more relevant to the supply agencies as the amount of subsidy decreases and the degree of use- and cost-based pricing increases. This means that local districts and agencies tend to behave relatively more rationally in this regard. Even though such local districts may not apply economic pricing, the tax base that forms the collateral for project investment financing coincides to some degree with the project beneficiaries, thereby creating a kind of economic incentive in supply planning at the district level.

State and federal agencies tend to plan water projects with little or no economic criteria. In California, the SWP planning and operation procedures are different from those of the federal CVP, yet neither has developed a rational economic way of determining supply, demand, and water prices. The CVP plans supply projects and sets prices of resulting water contracts low enough to clear the market, i.e., supply determines demand. The SWP generates demand artificially by committing the state to contractual entitlements for future water deliveries and, in some cases, to the financial backing of the underlying bonded debt, and then plans supply projects. In both cases, an economic price plays no role in the planned balancing of water demand and supply, and the least cost criteria applied to all supply-augmenting as well as demand-reducing options is not used to determine which investments should be pursued.

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V. Reforming Water Project Planning

A. Context

Given the many market failures related to water resource use, the use of social cost-benefit analysis has been proposed for many years as a means to ensure economic efficiency in water project investments. This cost-benefit framework has not been meaningfully implemented as an integral part of public water investment decisionmaking for various institutional and technical reasons. Given the many measurement problems involving the damages of externalities and the public goods aspects of water resource developments, this framework's impact has been more conceptual than applied. As a result, water resource use and planning must rely on quantitative evaluation of private benefits and cost within the context of regulatory constraints.

B. Demand/Marketing

Water pricing reforms for local, state, and federal projects focus on (1) marginal variable cost pricing for existing supplies wherein the capital expenditures have already been committed; (2) rate structures reflecting the rising marginal costs of new supplies; and (3) seasonal pricing to manage developed supplies according to weather/hydrologic conditions. These reforms apply not only to water supply systems but also to sewage and water pollution control systems.

Water marketing provides the opportunity to increase the efficiency of water use within the confines of the existing developed supply system, and to provide economic signals as to the value of water compared to the costs of new supplies. The particular inefficiency associated with the appropriative water rights system can be alleviated by allowances for voluntary selling or leasing of water rights. Markets for water pollution discharge permits, which are used to a degree in some European settings, also have efficiency potentials. Both tradeable water rights and discharge permits require regulatory constraints.

C. Least Cost Planning

Least cost supply planning is required for economic efficiency purposes. Surface supply storage and diversion, groundwater management, wastewater reclamation, and other water supply measures are the options available to most water supply agencies in a least cost analysis. In addition, where economic pricing and water marketing conditions do not exist, the least cost analysis would include various demand-reducing measures such as urban water conservation devices, landscaping, irrigation management, and tailwater reuse which if implemented would yield the equivalent of new supplies. Each of these supply-augmenting and demand-reducing options has a distinct long-run marginal cost curve associated with its development in any specific area. The long-run least cost curve which combines all of these options to determine the sequence of investments is an envelope of the individual long-run marginal cost curves for these options.

Least cost water pollution control planning is similar to that of water supply planning. The options are treatment, disposal, discharge, materials recycle, water reclamation/reuse, and conservation and source reduction. In lieu of operating effluent pricing and tradeable discharge permit systems, the least cost pollution control plan includes demand-reducing measures such as source reduction, water conservation, and material recycling as well as such supply projects as treatment plants and discharge facilities.

D. Examples/Case Studies

1. Least Cost Supply Planning -- IID/MWD Water Trade

The economic merits of a water trade between the IID and the MWD, a trade now under active consideration, have been recognized for years. The economic benefits to both sides can be evaluated, and the range of negotiation established. Water conservation in the Imperial Valley as part of a least cost supply plan for the MWD demonstrates how, in lieu of true water markets, water supply agencies such as the MWD must include demand-reducing measures along with supply-augmenting facilities in determining the least cost plan.

2. Least Cost Pollution Control Planning -- Westlands Water District

The problem of agricultural water pollution externalities was highlighted by the visible damage to waterfowl at Kesterson Reservoir in California's Central Valley. Agricultural water pollution in specific, and the non-point sources in general, represent the major remaining water pollution problem in the U.S. It can be expected that water pollution regulations, such as those presently facing many California irrigation districts, will be developed for many irrigation districts in the West as the evidence on external damages mounts. The Westlands Water District (WWD), which contains the problem lands which polluted Kesterson, has a number of options in both the off-farm, pollution disposal side, as well as on the on-farm, drainage -reduction side. Least cost analysis is appropriate for the WWD in making pollution control investment choices. Markets for water supply can play a constructive role here in enhancing the economic efficiency of off-farm water reclamation and of on-farm water conservation and drainage reduction.

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