ABSTRACT

Inconsistencies are inherent in the cost-sharing rules applied to water-resource development by different Federal agencies for different project purposes. These inconsistencies have been criticized by both Federal and local interests in vague terms of "equity" and "efficiency," but no one has provided a model--needed by policy makers--that explains the relationships between alternative cost-sharing rules and efficiency. The model presented herein is designed to (1) measure the loss of economic efficiency that can result from different cost-sharing rules and (2) provide optimal cost-sharing rules that induce efficient water-resource development. The optimal rules call for an "association" of benefits and costs and "equal" cost-sharing for all ways of providing a single project purpose.

Optimal Cost-Sharing Rules for
Efficient Water-Resource Development *

Harold E. Marshall **

Cost-sharing rules, dictating the proportion of water-resource project costs to be borne by Federal and non-Federal groups, differ among project purposes (such as flood control or recreation) as well as among techniques for providing a project purpose. A problem recognized in project planning is the inconsistency of these present cost-sharing rules. First, rules may differ within an agency (both for a single purpose and for different purposes). The Army Corps of Engineers, for example, can provide local flood protection with reservoirs, levee systems, or diversion channels, and each of these techniques may entail different cost shares to the non-Federal or local group. Also, the rules for cost-sharing flood protection differ from those governing water quality, recreation, and navigation. Secondly, rules differ among agencies with respect to a given project purpose. The Bureau of Reclamation pays full costs, the Army Corps of Engineers pays all or a portion of full costs, and the Soil Conservation Service pays only a portion of full costs for providing flood control.

---

* Prepared as a contributed paper to the Western Agricultural Economics Association Annual Meeting, Corvallis, Oregon, July, 1969.

** Natural Resource Economist, Water Resources Branch, Natural Resource Economics Division, ERS, USDA.

For comments on this paper, I am grateful to Jack Knetsch, Barry Field, and Garry Crane from the George Washington University, and George Pavelis, William Heneberry, and Clifford Dickason from ERS.

Problems of overbuilding [3, p. 239] and failing to minimize construction costs [4, p. 50] have been identified. But most economists rest their cases for change in cost-sharing rules on intuitive notions of efficiency and equity, and little has been done to explain the connection between cost-sharing rules and economic efficiency in a way that is straightforward and useful to policy makers.

The objectives of this paper are (1) to measure via a hypothetical model the efficiency loss of building a project purpose to the scale and with the technique(s) deemed appropriate by the non-Federal faction under different cost-sharing rules, and (2) to define the cost-sharing rules that will induce the non-Federal faction to select the most economically efficient scale and technique(s) for a project purpose. The efficient purpose development is one that maximizes net "efficiency" benefits--the increase in value of goods and services to the national economy. National objectives other than efficiency, such as income redistribution, might require different cost-sharing rules from those proposed here [2, p. 507]. However, this model emphasizes the potential efficiency costs, in terms of net benefits foregone, of employing alternative cost-sharing rules.

In practice, local decisions on scale and on techniques of production are often made independently in water-resource development, and the decisions are therefore handled separately in this paper.

MODEL

Assumptions:

A Federal and non-Federal faction participate in the planning and financing of a water-resource project. It is assumed that non-Federal (local) factions cannot afford to finance a purpose to the optimal scale for society without Federal assistance. Each faction has a downward sloping demand schedule (marginal efficiency benefits or marginal willingness-to-pay schedule) for a purpose output. Because both local identifiable beneficiaries and widespread, non-identifiable beneficiaries (the rest of the nation) profit from a purpose, marginal benefits accruing "locally" are added vertically (as for a public good) to marginal "widespread" benefits to derive the total demand function.

The production function for each purpose output is characterized by diminishing marginal returns to extra units of a given input.

The Federal agency plans projects to maximize net benefits for society, and the non-Federal group attempts to maximize net benefits accruing to itself. A statement of the two factions' interaction is necessary for understanding the relationship of cost-sharing to efficiency. Local groups, through hearings and discussions with agency representatives, have an opportunity to bargain with the Federal agency on a project. Because cost-sharing rules are established in legislation, little bargaining occurs over how much the local group will pay for a given scale or technique(s) of production. However the local faction can bargain (with its veto threat of not pledging its cost share) for a project with that scale and combination of techniques which maximize that faction's own net benefits. A conflict of interest arises between the two factions if the efficient project from the local viewpoint is not also efficient from society's viewpoint. The cost-sharing effects on efficiency depend on the factions' relative bargaining strengths.

Analysis:

The cost-sharing rule that induces the local faction to select the most efficient scale of production can be explained with the demand and cost functions in Figure 1.[1] The optimal scale of output is that Q at which marginal social benefits (MSB) is just equal to marginal social costs (MSC) [5, pt. V (C) (3)]. Thus, the Federal faction will plan for the scale of output Qo. The local faction will choose that Q at which marginal benefits to the local faction (MLB) is just equal to marginal cost for that faction (MLC), which is determined by the cost-sharing rule.[2] Let us assume that MLB is equal to 75% of MSB at every level of output. If (at the margin) the local faction shares costs in the same proportion (75%) as it shares benefits, the Q at which MLB=MLC is Qo, the optimal scale for society. If the local faction shares 50% of MSC, the faction chooses Q_2 output. If the local faction succeeds in having the project purpose built to this scale, the loss to society in net "efficiency" benefits is measured by the triangle abc in Figure 1. If the local faction shares 90% of MSC, it will choose Q_1 output. If the project purpose is built to scale Q_1, potential net "efficiency" benefits of aed are lost. Thus, the normative policy prescription for cost-sharing to induce the local faction to plan for the efficient scale of a

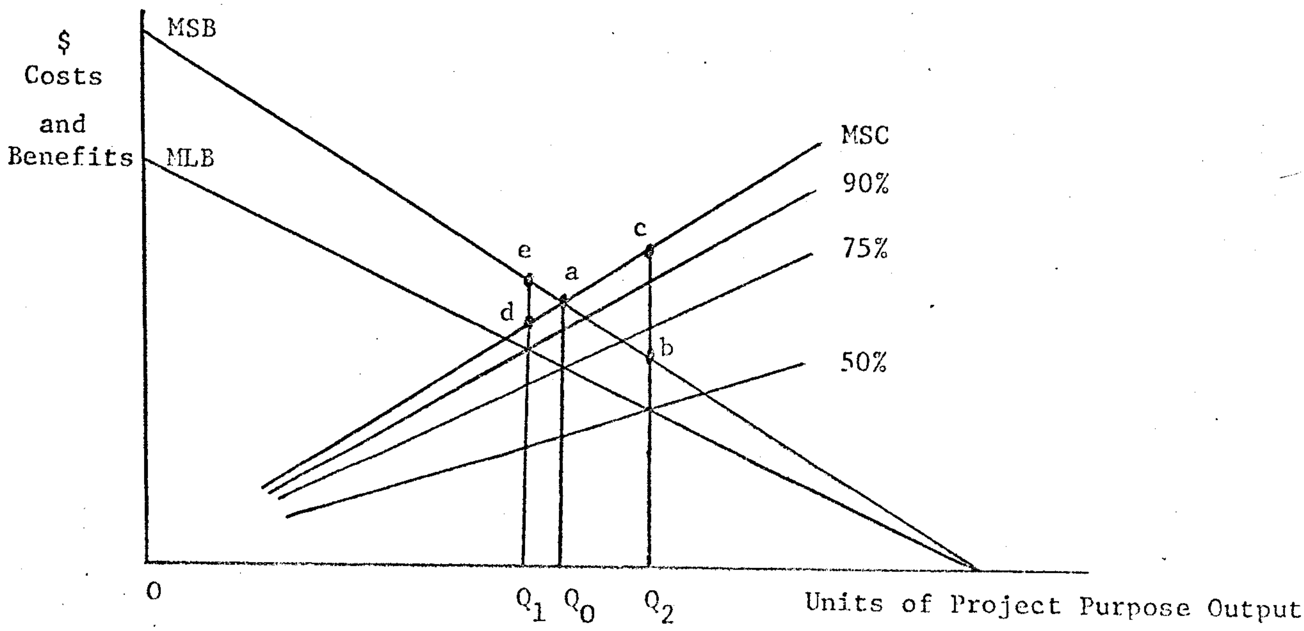

Figure 1

purpose is to impose on that faction a cost share of equal proportion to its benefit share at the margin.

The triangles abc and aed are similar, and the social benefits loss (assuming linear functions) is the same for overbuilding as it is for underbuilding scale by an equal number of units. Also, as the demand and cost functions become steeper, the areas aed and abc increase.

An example of a cost-sharing rule that might lead to overdevelopment of scale is that applied to water quality control by a Federal agency. Local benefits undoubtedly accrue to persons living in the project area. However, because benefits are considered widespread, no local cost-sharing is imposed. Thus, local groups will be induced (ceteris paribus) to bargain for that scale of water quality control at which MLB becomes zero. At this scale (as illustrated in Figure 1) MSB may be less than MSC.

The other decision on which the Federal and non-Federal factions must agree is the technique(s) used in production. The cost-sharing rule that induces the local faction to select the least-cost combination of techniques for providing a purpose can be illustrated with the isoquant-isocost graph in Figure 2. Let us assume that $Q=Q(X_1,X_2)$ where X_1 and X_2 represent techniques of production. (For example, dams, diversion channels, and levees

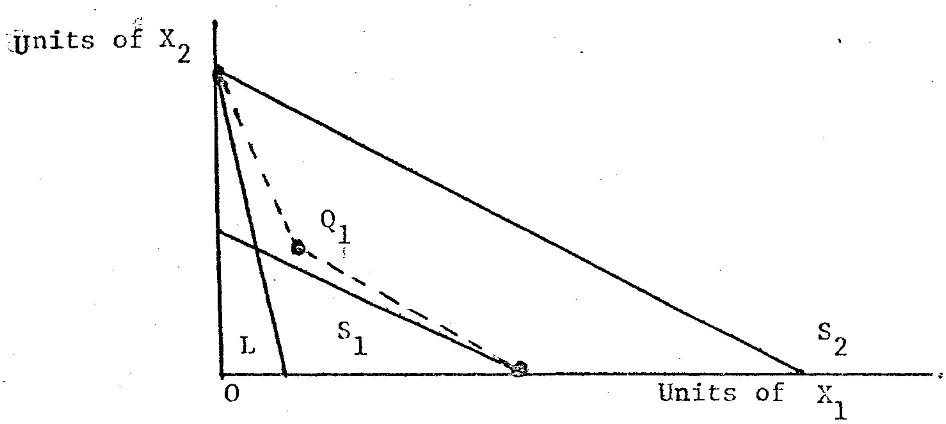

Figure 2

are "intermediate" techniques (factors) used in the production of flood protection.) Q_1 is a specified level of output that can be produced with the combinations of X_2 and X_1 indicated by the three dots on the dashed-line isoquant. The isocosts, S_1 and S_2, represent two budget levels for society, and both have the slope P_1/P_2, where P_1 and P_2 equal the cost per unit to society of X_1 and X_2 respectively. To obtain the least-cost combination of techniques (to society) for providing Q_1, X_1 must be used exclusively. This is illustrated in Figure 2 by the corner solution at which S_1 touches the isoquant on the horizontal X_1 axis. The Federal agency will therefore plan for the purpose to be produced with X_1. However, the local group will negotiate for a plan with the least-cost combination of factors for itself. The slope of the local isocost (L) is equal to the ratio $a_1P_1/a_2/P_2$, where a_1 and a_2 represent respectively the local cost shares of factors X_1 and X_2. The local faction will want the factor X_2 to be used exclusively, as is indicated by the corner solution at which L touches the isoquant on the vertical X_2 axis. Thus, if $a_1 \neq a_2$, and therefore the slope of L is not equal to the slope of S_1 and S_2, the budget constraint to the local faction may touch Q_1 at a combination of factors different from the least-cost combination to society. In Figure 2, for example, if X_2 rather than X_1 is used to produce the purpose, the loss to society is measured by the extra resources (S_2-S_1) spent for production.

An example of such a situation is found in the Army Corps of Engineers flood control program. If two techniques--a large reservoir and a levee system--were alternatives for providing comparable flood protection to a local group, that local group would bargain for that technique (ceteris paribus) that costs them least. Thus, if the local cost share for a large reservoir and levees were 0% and 25% respectively (a possibility under existing cost-sharing rules), the local faction would be induced to bargain for reservoir protection. If the reservoir costs $100,000 more to build than the levee, an efficiency loss of $100,000 results from building the reservoir. (This is assumed to be a single-purpose flood control project.)

POLICY IMPLICATIONS

The implications of the model for scale and technique combinations of maximum efficiency can be summarized in terms of the inconsistencies of cost-sharing listed earlier. First, within one Federal agency, the cost of each technique used to provide flood control should be shared in the same proportion by the non-Federal faction. Secondly, different cost-sharing rules for different purposes are to be anticipated and are acceptable if the non-Federal faction shares costs in proportion to benefits at the margin. Finally, to discourage non-Federal factions from seeking the Federal agency that will provide a purpose for the lowest non-Federal cost share relative to non-Federal benefits, the cost share imposed on the non-Federal faction should be in the same proportion to total costs for a project purpose administered by any of the Federal agencies.

REFERENCES

[1] Adams, Dale W., and Norman Rask, "Economics of Cost-Share Leases in Less-developed Countries," American Journal of Agricultural Economics, 50:935-942, November, 1968.

[2] Freeman III, Myrick A., "Income Distribution and Planning for Public Investment," American Economic Review, 57:495-508, June, 1967.

[3] Regan, Mark, "Economically Desirable Institutional Arrangements and Cost-Sharing Requirements," Economics of Watershed Planning, ed. by G. S. Tolley and F. E. Riggs, Ames, Iowa State University Press, pp. 230-245, 1961.

[4] Renshaw, Edward F., Toward Responsible Government: An Economic Appraisal of Federal Investment in Water Resource Programs, Chicago, Idyia Press, 1957.

[5] U.S., Congress, Senate, Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources, Sen. Doc. 97, 87th Cong., 2d. Sess., 1962.

FOOTNOTES

[1] An analysis similar to the explanation of Figure 1 has been used to determine the optimal cost-share lease for efficient agricultural production [1].

[2] MLB and MLC are a part of MSB and MSC respectively.