Public Investment Decisions in Water Resource Development

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I. INTRODUCTION

This paper concerns with the rationalization of how decisions ought to be made in public water resource development. But it concerns less with the practice of how the decisions are actually made. Economic evaluation for public resource development requires the selection of a desirable goal, a system of economic profitability measurement, and a suitable budget allocation guide.

These three steps of procedures incorporated in the economic evaluation were analyzed in terms of their applicability and limitations. That is, the objective of this paper was to critically examine (1) the economic criteria, which can be served as a sound goal in economic evaluation for public resource development, (2) the benefit-cost analysis, which is commonly used both for justifying and for evaluating relative profitability of investment alternatives, and (3) the method of efficient budget allocation among water resource projects.

A normative goal for public resource development would be to maximize economic welfare in terms of improving economic efficiency condition. However, the enhancement of national income would become an operational goal. The system of economic evaluation can be based on the benefit-cost analysis if definitions and measurement skills were improved. Finally, equi-marginal principle was discussed to serve a decision guide for efficient budget allocation among the projects where funds are varying.

II. ECONOMIC CRITERIA

Decisions by the government regarding resource development are largely made by political process rather than economic evaluation. Although these investment decisions are governed by our political processes, economics and enginerring have played some important roles at all decision levels. Economic efficiency may be a key factor in determining an optimum resource allocation in public resource development.

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Efficiency, in essence, is the relationship between the amount of capital input and the quantity of resulting output. The larger the output per unit of input, the greater the efficiency of a process. The economic efficiency will require for any given resource endowment and state of technology, the maximum level of the preferred composition of output. That is, the economic efficiency is defined as a situation in which productive resources are so allocated among alternative uses that any change in the pattern can not improve any individual's position and still leave all other individuals as well off as before (Krutilla, et al. 1958, pp. 16-17).

A. Welfare Maximization

A sound economic evaluation may be dependent upon the question of economic efficiency versus economic welfare criteria. One hypothesis being suggested is that the economic evaluation for resource development must encompass welfare as well as efficiency criteria.

A commonly accepted criterion of increasing economic welfare is the Pareto criterion "that a change makes at least one individual better off without making the others worse off" (Kelso, 1964, p. 62). This criterion is usually interpreted to mean that welfare is increased by a change rendering it possible to make one person better off and leave no individuals worse off by compensating the losers. An increase in national income resulting from a resource development project is sufficiently close with the Pareto criterion 'with compensation' (Kelso, 1964, pp. 62-63).

Increase in national income can become an indicator of increase in economic welfare if certain restrictive assumptions are made and if the resulting distribution of income is not altered toward inequality. According to Ciracy-Wantrup (1956, pp. 307-310), an increase of national income may be regarded as a practical approximation to the Pareto "with" criterion, provided that the policy under consideration does not appreciably increase inequality of income distribution, and provided further that there are other policies in operation which work independently and continually in the direction of greater equality of income distribution.

The efficiency consideration is involved in each resource development project and its income distribution consequences. The subjective value judgement will determine whether the criterion is "most efficient" if it is "most equalitarian". But, for the efficiency criterion one can determine a cardinal measure of preferredness, subject to restrictive assumptions, whereas for the income redistributive consequence he can do no more than describe it. Therefore, the operational goal for resource development evaluation might be to maximize economic welfare through the enhancement of national income. The Pareto criterion

"with compensation" may not be attainable, if not impossible, but close to it when this goal is attempted.

B. The Enhancement of National Income

It would seem, then, that projects leading to more or most enhancement of national income, together with its income redistributive consequences, are operational goals for resource project evaluations. Since the enhancement of national income is an outcome of achievement of economic efficiency, the maximum enhancement of economic efficiency is determinable cardinally among alternative projects in the sense of the most income gain among those examined (Kelso, 1964, p 64). As a result, the ordering of alternative project can be obtained by the criterion "enhancement of national income". This will serve as an aid to rational decision makers at all levels of government in authorizing and allocating the federal budget in water resource development.

By maximizing its enhancement, the national income is maximized in so far as that particular kind and amount of resource development at that particular time and place can accomplish this desired goal. In reality, it is based on a "proximate" criterion to enhancement of national income which is, itself, a proximate criterion of enhancement of economic welfare. According to Mckean (1958), in practical problem solving, therefore, we have to look at some "proximate" criterion which serves to reflect what is happening to satisfaction, profits, or well-being. Actual criteria are the practical substitutes for the maximization of whatever we would ultimately like to maximize (Mckean, 1958, p 29).

III. BENEFIT-COST ANALYSIS

For projects to be justified, the legal requirement (Flood Control Act, 1936) is that benefits must exceed costs, to whomsoever they may accrue. The ratio at which benefits exceed costs has an important influence on the choice of projects. This is so-called benefit-cost analysis which serves both for justification and for relative evaluation of projects. The former requires loose standards which will support poor project of a ratio, 1.0, the latter requires consistency of standards so that the relative economic merit will be indicated (Eckstein, 1958, p 48).

Benefit-cost analysis requires quantification both in physical and economic terms. The necessity of quantifying in terms of dollar is frequently pointed out as a weakness of benefit-cost analysis. An attempt to overcome these difficulties and to determine the relevance of quantification including definitions is an important stimulus of scientific progress. It may be argued, therefore, that the necessity of quantifying makes benefit-cost analysis worthwhile (Ciracy-Wantrup, 1955, p 678).

A. Definitions

Quantifying and measuring all benefits and costs "to whomsoever they may accrue" are not only beyond the present ability of economic science, but presents conceptual difficulties and complexities which can never be overcome except by making very specific assumptions (Eckstein, 1958, p. 48). First of all, both benefits and costs require a clear cut definition. According to the Report of the Subcommittee on Benefits and Costs, the benefits of a project to an individual has been defined to correspond to that amount of money which he would be willing to pay if he were given the market choice of purchase. A symmetry definition was recommended by the subcommittee with regard to the costs. Secondly, a method of comparing and aggregating the benefits that accrue to different people must be defined (Eckstein, 1958, p 48). Again, the simplest assumption, of adding the benefits of all people weighted equally may be consistent with the classical welfare economics of interpersonal comparisons.

B. Measurement

Beyond the conceptual difficulties, there are some problems of measurement that are so acute that even with perfect prediction of all relevant data about the projects themselves, other information, particularly about cost, is necessary which is not available in quantitative form. If we want to measure all costs of a project "to whomsoever they may accrue", we must include the social cost of taxation (Eckstein, 1959, p 49). Because the money costs of the project reflect the value of the resources which are used.

Eckstein extends that these costs may be beyond measurement. As long as they can not be quantified, the total costs of a project can not be measured and the test of economic justification can not be performed with assurance, except where the margin of benefits over costs is very large. As a result, the absolute measurement of benefits and costs may be impossible because of the arbitrariness of definitions, the complexity of some of the costs and benefits, and the requirements of prediction (Eckstein, 1958, p 50). Instead, the relative measurement of benefits and costs is usually done with much more confidence.

In practice, measuring outputs and inputs generated by the projects is based on market prices. It is generally accepted that market prices of output so far as the private economy is concerned are an acceptable measures of the value of those outputs to the whole economy. Market prices of inputs are similarly acceptable as measures of the values of alternative products which those inputs could produce or, in other words, as adequate measures of the opportunity costs of the outputs (Mckean, 1958, p 103). An implicit assumption behind this is that the allocation of resources and the structure of the prices in the

economy are approximately close to the perfectly competitive economy.

Many projects outputs are not sold through the market, and hence do not carry market prices. Some inputs, as indicated before, may not be acquired in any market. The opportunity prices to be assigned to inputs are not directly market determined. For all these cases, prices will require imputation (Kelso, 1964, p 70). Examples of these are such as power and navigation projects in which benefits are taken to be equal to alternative cost, the cost of providing comparable output by the cheapest alternative means, In these events, the benefits are again limited by willingness to pay (Eckstein, 1958, p 52).

For evaluating relative profitability, the benefit-cost analysis, like any investment criterion, is suited only certain kinds of investment decisions. In general, three constraints were appeared in the literature (Eckstein, 1958, p. 55): (1) The economic nature of the costs must be reasonably uniform, that is, there must be no extreme variations of capital intensity; (2) the benefits must be uniform at least at the conceptual level and must have roughly equal degrees of uncertainty; and (3) the life spans of the projects among which choices are to be made must be identical.

IV. BUDGET ALLOCATION AMONG THE PROJECTS

Should the public funds be allocated in private sector or should it instead be spent for a public project on water resource development? If the public project, should it have built one high dam, two intermediate-sized dams or three smaller ones? This allocation question involves the amounts and forms of public investments. This requires the two different sets of criteria—one for evaluating relative profitability of the projects and the other for allocating budget among the projects. The former is aiming at helping the decision maker to choose wisely alternative project and/or to rank the alternatives according to their profitability. The relevant criterion was benefit-cost analysis under some restrictive assumptions. The latter deals with the decision of efficient resource allocation, specifically where the funds are available for more than two projects. Equi-marginal principle would be appropriate.

A. Constraints

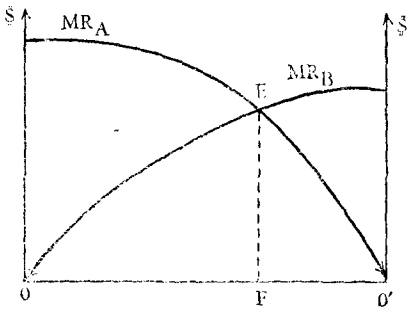
For allocating scarce resources to most efficient ends, it is neither wise nor practicable to get too far away from the limitation of reality (Kelso, 1964, pp 73-74). The limitations of reality, whatever they may be in each planning situation, are the constraints. That is, they are the constraints on the decision maker's freedom of choice. Constraints, then, may be many types—physical, legal, administrative, financial and budgetary, institutional, uncertainties, and others.

Financial and budgetary restraints, like many others, must at least be specified: (1) Limitation on the total amount of public funds available; (2) the degree to which investment must yield (alternative investment opportunities for use of the limited funds); and (3) to what degree the net benefits will be determined by discount rates and by time horizons. In short, they are limitation on budget size, specification of opportunity cost (desired profitability level), and specification of time preference and interest rates.

B. Equi-marginal Principle

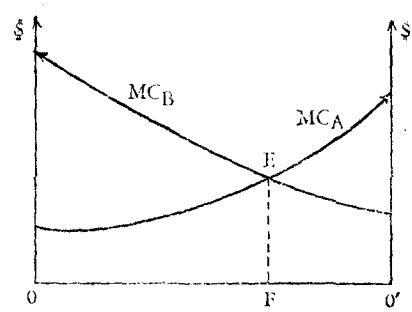
In essence, the budget allocation problem is to determine the scale of a project plan which may consist of various seperable segments of a project or a number of projects. The objective function would be to maximize net benefits (discounted) from a given amount of public funds, or, conversely, to minimize resource outlays (public funds) for a given amount of net benefits. The decision guide, then, would be equating marginal benefits (marginal costs) of all seperable segments of a project or number of projects. That is, so long as the budget size is varying, all sperable segments of a project (or number of projects) can be added to the project plan as long as extra benefits exceed extra costs (Eckstein, 1958, pp 65-66).

With a limited expenditure, the decision maker allocates funds among the several projects (two projects or segments in our example) in such a way as to contribute to maximum net benefits. The best, or the optimum, allocation is one that causes the marginal benefits in each project to be equal. Note that the total net benefits of any amount of expenditure is always the area under the marginal benefit curve (see left diagram). When marginal benefit in the two projects are equal at point E (EMR point), total net benefits—the entire area under the marginal curves—are maximum. The



Expenditure for A ⟶
⟵ Expenditure for B

Maximization of benefits with given expenditure



Benefits of A ⟶
⟵ Benefits of B

Minimization of expenditure for a given amount of benefits

assumptions made are that project B has a lower marginal benefit for any given expenditure, and marginal benefits diminish because of the successively less important projects.

Alternatively, how should the decision maker minimize cost in order to obtain a given level of net benefits from the two projects? To minimize the total variable cost (right diagram), the decision maker ought to decide the scale of the project plan so that the two marginal costs are equal. The total cost will be minimized when the project A is limited to a point where OF of total net benefits can be derived from, and when the project B is limited to the point where O'F could be derived from. If project A is getting bigger and project B smaller, cost would be higher, because the MC_A curve lies above the MC_B curve to the right of point E. Similarly, cost would be higher if project B is getting bigger and project A smaller. Since the total variable cost is the area under the marginal cost curves, the point E gives a minimum cost solution. The implicit assumptions made are that project A has a lower marginal cost curve, and both curves are rising at point E which may be necessary condition for the solution.

From our approach the point of equi-marginal benefits (costs) provides not only the optimum solution subject to constraints, but also indicates the best decision on profitability (budget requirement) which the decision maker can compare this level with the opportunity cost of the public funds. If more funds are available, this point becomes the desired level of profitability which is determined by the political process.

The desired level of profitability (the point of equi-marginal benefits or costs) can be expressed by B/C ration, absolute B−C amount, and rate of return. One should, however, note that the budget allocation decision solved by equi-marginal principle has nothing to do with the benefit-cost analysis. Again, the B/C, B−C, and internal rate of return provides only the relative economic ranking of the projects if these criteria were adapted in calculating investment profitability. Another word, marginal benefit (cost) curves come from total benefit (cost) schedule of the projects. As a result, Eckstein's "B/C or B−C?" arguement should not be misinterpreted (Eckstein, 1958, pp. 65-67).

V. SUMMARY AND CONCLUSION

A rational decision on a public water resource development requires a desirable goal. This goal might be to achieve economic efficiency in which productive resources are so allocated among competing uses that any change in arrangement can not improve any individual's position and leave all other individuals as well off as before. Economic welfare and enhancement of national income are major indicators in measuring the economic efficiency of the public

resource development. As a result, the operational goals for resource development might be to maximize economic welfare as well as the enhancement of the national income.

Economic feasibility (justification) and relative profitability of alternative projects should be estimated. These will serve as an aid to rational decision makers in authorizing and allocating the federal budget in water resource development. These are usually done by benefit-cost analysis under some restrictive assumptions. The benefit-cost analysis, like any investment criterion, provides only the economic justification and relative profitability of the projects. In turn, the question of efficient resource allocation, the determination of amount and form of public investments, is remained.

Should the government build one high dam, two medium-sized dam or three smaller ones if the public funds are available for more than two project? Once the objective and constraints are specified, the next step is to equate marginal benefit (cost) of all seperable segments of a project or number of projects. This is so-called equi-marginal principle we examined. The principle is that any decision maker can obtain the maximum return (net benefit) from a given expenditure that can be spent for two or more projects if he allocates the funds in such a way that marginal benefits in each case are equal. In this case, marginal benefits must diminish as more and more funds are used to any one of the projects. Conversely, he can obtain the minimum budget requirement for a given return (net benefit) that can be derived from two or more projects of he sets a limit on project size to which marginal costs in each project are equal. Here, marginal costs must rise as pursuing more benefits from any one of the projects.

Once again, the B/C ratio, itself is a good indicator for justifying and evaluating the economic profitability of the projects, but has nothing to do with the determination of the scale of a project (plan) if funds are varying. This is solved by the equi-marginal principle.

VI. LITERATURE CITED

Ciracy-Wantrup, S. V. "Benefit-Cost Analysis And Public Resource Develop-
1955 ment", *Jour. Farm Econ.* Vol. 37, No. 4.

Ciracy-Wantrup, S. V. "Concepts Used As Economic Criteria For A System
1956 Of Water Rights", *Land Econ.* Vol. 32, No. 4.

Eckstein, Otto. *Water Resource Development:* The Economics Of Project Evalu-
1958 ation, Harvard University Press, Cambridge, Mass.

Kelso, M. M. "Economic Analysis In The Allocation Of The Federal Budget
1964 To Resource Development", Economics and Public Policy in *Water Resource Development;* edited by S. C. Smith and E. N.

Castle, Iowa State Univ., Ames, Iowa PP. 56-81.

Krutilla, John V., and Eckstein, Otto. *Multiple Purpose River Development:* 1958 Studies in Applied Economic Analysis, Resource for The Future, Inc., Washington, D. C., Published by The John Hopkins Press, Baltimore.

Mckean, Ronald N. *Efficiency In Government Through Systems Analysis With* 1958 *Emphasis On Water Resource Development,* A RAND Corporation Research Study, Wiley and Sons, New York.