ALTERNATIVES, CRITERIA AND TIME LAGS IN WATER RESOURCE DEVELOPMENT

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Economists have long recognized that the evaluation of appropriate alternative courses of action is vital to the economic analysis of governmental programs.[1] The recent introduction of planning-programming-budgeting throughout the federal government is, in part, a practical effort to emphasize this aspect of analysis.[2] The purpose of this paper is two fold: First, to examine explicit quantitative criteria suggested for the comparison of alternative plans and; second, to assess the sensitivity of one form of economic analysis to the passage of time and the effect of this sensitivity on the evaluation of alternatives. We will examine both of these points within the context of an example.

In 1963, the Army Corps of Engineers and the Department of the Interior, jointly, issued a report on the "water and related land resources" of the last undeveloped reach of the Missouri River.[3] Eleven alternative plans for the area's natural resource base along with the benefit-cost data and a description of the intangibles associated with each alternative

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[1] Roland N. McKean, Efficiency in Government through Systems Analysis, New York, John Wiley and Sons, Inc., 1958, p. 50.

[2] U. S. Bureau of the Budget, Planning-Programming-Budgeting, Bul. 66-3, 1965.

[3] Division Engineer, Missouri River Division, Corps of Engineers, U. S. Army and Regional Coordinator, Missouri River Region, Department of the Interior, Joint Report on Water and Related Land Resources Development for Missouri River, Fort Peck Reservoir to Vicinity of Fort Benton, Missouri, 5 Vols., June, 1963.

are presented for review. In essence, the alternatives presented are different combinations of specific program elements. The elements are combined to form plans for the study reach in such a fashion as to stress the tradeoffs, with respect to economic efficiency, arising from (1) various combinations of reservoir development, and (2) resource development plans which, because they are fundamentally different in nature, are basic alternatives. The basic conflict is, should this reach of the Missouri be developed intensively for hydro power and reservoir recreation[4] or should a proposal of the National Park Service be adopted which would preserve the 180 miles of the river in its natural state for wilderness recreation. Six of the eleven alternatives presented are concerned almost exclusively with reservoir development; two more show alternatives which would be compatible with the proposal of the National Park Service and the three remaining are attempts at a compromise.[5]

Criteria for Comparison

Conceptually and from the standpoint of data collection, specification of the criteria to be used in the comparison of alternative courses of action is crucial.[6] The Joint Report suggests guidelines for such comparisons by pointing out that "Plan 4 produces the maximum excess of

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[4]As the Joint Report points out, there is little or no effective demand, either presently or anticipated, for irrigation, flood control or municipal and industrial water supply in the study region. The fish, wildlife and public land management proposals, which are included as program elements, are substantially similar for the principal alternative plans and will not be dealt with in this paper.

[5]However, in the latter cases, the partial preservation and partial reservoir development approach would be incompatible with the national wilderness waterway proposal because the NPS considers the remaining preserved reaches to be of insufficient length or quality to be of national significance.

[6]McKean, 25-49.

evaluated tangible benefits over costs." Given this specification the question arises as to whether the form of the criterion is correct for the problem involved and whether it will lead to accurate plan rankings with respect to economic efficiency.[7]

Aside from the fact that economic efficiency is only one type of analysis upon which project choice should be determined, more than one criterion form exists which purports to show the effect of a project on net national income. Benefit-cost ratios, internal rates of return and benefits minus costs have each been suggested as the proper "partial-proximate" criterion for use in determining project feasibility and ranking. The last-named permits selection of the alternative with the greatest net benefits but does not take into account the absolute level of benefits and costs involved. Whenever the benefit-cost ratios exceed 1.00, such a criterion will normally favor large projects over small. Moreover, alternative plans can potentially be ranked differently when using this method as opposed to comparisons of the ratios of benefits to costs or the internal rate of return. Table 1 illustrates these points with respect to the eleven alternatives presented by the report.[8]

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[7]We are assuming that economic efficiency will be only one criterion used in the evaluation and comparisons of the alternative plans. As the report points out, regional income distribution and preservation of numerous intangibles may be among other objectives not accounted for by benefit-cost analysis. However, our present concern is the efficiency concept since it is the only quantitative criterion suggested by the report.

[8]Plan 4 (the "best" of the alternative reservoir plans) had both the highest B/C ratio and rate of return and the greatest excess of tangible benefits over costs. The solution was not parallel for the three compromise plans (8, 10, 11). In that case, Plan 11 had the greatest excess of tangible benefits over costs but had a B/C ratio of 1.49 (nearly equal to Plan 8 with the lowest excess benefits of the three). Plan 10 had the highest ratio (1.69) and rate of return (5.6) but placed second in excess benefits. The two proposals compatible with the wilderness waterway (6, 7) ranked tenth and eleventh, respectively, under

Table 1. Comparisons of Criterion Forms and Project Rankings[a]

Plan	K ($1,000)	O/K	Net Discounted B-C ($1,000)	B/C	r (Percent)	Rank Based On B-C	Rank Based On B/C	Rank Based On r
1	$455,452	.0059	$422,027	1.78	5.9	5	5	6
2	480,457	.0059	458,841	1.80	6.0	4	4	5
3	414,679	.0062	472,071	1.95	6.5	3	2	2
4	392,887	.0064	477,102	2.00	6.8	1	1	1
5	463,635	.0062	472,940	1.85	6.2	2	3	4
6	154,414	.0099	150,453	1.74	6.0	10	7	5
7	29,567	.0306	31,491	1.53	6.3	11	9	3
8	286,515	.0066	159,034	1.46	4.7	9	11	10
9	417,167	.0061	380,985	1.76	5.8	6	6	7
10	258,905	.0076	221,713	1.69	5.6	8	8	8
11	392,490	.0061	230,486	1.49	4.8	7	10	9

[a]Assumed 100 year project life and 2 7/8 percent discount rate.

NOTE: K represents fixed investment;
O represents operation, maintenance and replacement costs;
r represents the internal rate of return.

Thus comparison of net benefits is useful only for projects similar in scale and character.

Because the proposed plans are mutually exclusive alternatives, the objective of ranking via benefit-cost criterion should be maximization of national income not determination of project scale. Assuming that implementation of one of the plans would not exhaust the total budget and that other programs exist elsewhere in the nation with equally favorable benefit-cost ratios (relatively realistic assumptions), the proper ranking criterion when comparing alternatives which differ in nature is either

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the benefits minus costs criterion but seventh and ninth and fifth and third, respectively, under the ratio and rate of return criteria. Overall, the three forms of ranking placed the alternatives in substantially different orders especially when comparing the projects which differed in nature (4, 6, 7).

the ratio or the rate of return and not benefits minus costs.[9]

Time Lags

Nearly seven years have elapsed since the Joint Report was issued. To date, no action has been taken on its recommendations. However, during the intervening years an executive directive has changed the proxy values assigned to the recreation benefits of a project. In addition, the costs and discount rates used for project evaluation have increased.

The sensitivity of the economic feasibility to changes in the data will be illustrated by recalculating the benefit-cost evaluations of the principal alternative plans (4, 6, 7) after making adjustments to some of the original data. We have used the discount rate expected to be specified by the U. S. Treasury for the evaluation of water resource projects in the current fiscal year. In the last seven years this rate has risen from 2 7/8% to 5.0%. An intermediate rate of 3.253% was also used for purposes of comparison. Both fixed investment and operation, maintenance and replacement costs (OMR) were increased to reflect the fact that the cost index has experienced a substantial relative rise in recent years.[10]

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[9] Choice of either the B/C ratio or the rate of return depends upon the value judgement which you wish to make with respect to the appropriate budget constraint and the ability to reinvest annual net benefits. Moreover, it must be recognized that use of the ratio criterion favors projects with low O/K ratios. Therefore, if projects which differ in nature are being compared, attention must be paid to the value of the O/K ratio.
Otto Eckstein, Water Resource Development, Cambridge, Harvard University Press, 1958, pp. 53-65.

[10] In our calculations both types of costs were adjusted upward by 10%. Published indicies and conversations with federal agencies indicate that probably this figure is nearer to 20%.
Engineering News-Record, published weekly by McGraw-Hill, Inc., New York.

Without making a value judgement on the proper proxy values to be used in evaluating recreational benefits or on the means used for deriving visitor-day projections,[11] the guidelines laid out in Supplement No. 1 to Senate Document 97[12] are used to adjust recreation benefits. The effect is to increase the unit-value placed upon a visitor-day at the wilderness waterway from $1.50 to $5.00.

Alternative cost methods were used in the report to calculate benefits from hydro power. The two factors of importance in this calculation are the plant load factor assumed for peaking power and the values assigned to energy output and plant capacity. The Joint Report used a 15% load factor and power values based on 1957 price levels. Both technological advances and market demands will cause these values to change. As an illustration of the sensitivity of the analysis to such changes, we have used 15%, 25% and 40% plant factors in our recalculations.[13] Table 2 illustrates the results of our recalculations.

Conclusions

We have attempted to illustrate the sensitivity of economic efficiency

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[11] Independent estimates of the average number of annual visitor-days over the time horizon of the analysis were made by the National Park Service and the Corps of Engineers. Substantial differences existed between the two projections. However, the final figures used in the original analysis were merely averages of the two estimates.

[12] Ad Hoc Water Resources Council, Evaluation Standards for Primary Outdoor Recreation Benefits, Washington, Government Printing Office, 1964.

[13] These plant factors are equivalent to 1,300; 2,200; and 3,500 hours of plant operation annually. Fixed investment estimates were adjusted on a straight-line basis to take account of changes in the plant load factor. Power benefits of $19 / Kw and 2.1 mills / Kw hr. were used in the Joint Report. We have accepted these values for our recalculations even though recent developments in nuclear and lignite thermal plants indicate that cost economies have been realized since 1957.

Table 2. Adjusted Benefit-Cost Evaluation of Principal Alternatives[a]

Plan	O/K	Net Discounted B-C ($1,000)	B/C	r (Percent)
15% Plant Load Factor and 3.253% Discount Rate				
4	.0064	$328,295	1.63	5.9
6[b]	.0099	137,937	1.62	6.1
7[b]	.0305	55,340	1.89	9.1
25% Plant Load Factor and 3.253% Discount Rate				
4	.0074	$147,436	1.32	4.7
6	.0113	86,315	1.43	5.3
40% Plant Load Factor and 3.253% Discount Rate				
4	.0082	$ 45,716	1.11	3.8
6	.0123	57,278	1.31	4.8
15% Plant Load Factor and 5% Discount Rate				
4	.0061	$ 56,540	1.11	5.6
6[b]	.0095	29,840	1.14	5.9
7[b]	.0302	26,221	1.50	9.0
25% Plant Load Factor and 5% Discount Rate				
4	.0071	$-41,198	0.91	4.5
6	.0109	3,859	1.02	5.1
40% Plant Load Factor and 5% Discount Rate				
4	.0079	$-96,166	0.76	3.6
6	.0118	-11,937	0.93	4.6

[a]Assumed 100 year project life, 10% increase in original costs, $5.00 per visitor-day benefit for wilderness river and straight line reduction to fixed investment for recalculations changing original plant load factor.

[b]Evaluation will be identical at alternative plant load factors with a given discount rate because no hydro power component is attached to this plan.

analysis to the specification of the criterion form and to time lags. The results indicate that careful thought must be given to the specification of the criterion used to compare alternatives which differ in nature and that the analysis must be updated when time lags are important. Perhaps of greater interest, however, is the fact that this applies even to those projects with an initially high benefit-cost ratio and that performance of some type of sensitivity analysis is an essential component of any economic feasibility study.