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Water Resources Project Evaluation Criteria: Conventional Wisdom or Heresy; Opportunity Costs and Double Counting; Net Returns or Change in Net Returns?

by Roger B. Long

University of Idaho

Moscow, Idaho

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Abstract

Water resource project evaluation is a subject that has received much attention over time. Currently, some advocate evaluating projects by their change in net benefits (which is determined by subtracting net benefits without the project from net benefits with the project). Such a formulation implies that what happens when a project is developed is a function of what might have happened if the project had not been developed. This paper contends that such a formulation is illogical since the two events are mutually exclusive or unrelated. The correct economic evaluation criteria is to select the alternative with the greatest net benefit (net benefit alternative i must be greater than the net benefit from all other alternatives, $NBA_i > NBA_a, \ldots, NBA_z$).

What is the correct evaluation criteria?

Water resource project evaluation criteria are under constant scrutiny. The Water Resources Council through its "Principles and Standards" has recently endorsed a "with" minus "without" criteria by which to judge proposed projects. Some economists have embraced this idea, probably because it says we should analyze two alternatives and not just one (the proposed project). This is a step in the right direction, however, it fails to emphasize all the possible alternatives that might exist. Also, it draws our attention away from the "net benefits" criteria constrained by available capital. It also implies that pre-project evaluation is somehow different than expost project evaluation, when in fact project evaluation criteria should be no different either before or after the project is built. In looking into the future we deal solely with conjecture (a necessity), but by looking back we hopefully have some facts to effect an evaluation.

Within recent years the water resources field has developed a new evaluation criteria, or evaluation theory if you will, that indicates the "with project" net benefits should exceed the "without project" net benefits. On the surface this criteria appears appropriate; however, if more than two alternatives are possible it seems to ignore those additional alternatives that also may exist. Such a rule then becomes suspect. Since in the case of most economic projects there are a myriad of alternatives in addition to the proposed, it would seem that these other possibilities are being ignored. This is the first apparent weak feature of the with-without procedure.

Young, in his address to the Western Agricultural Economics Association meetings in July, 1978, concluded, generally, that all past water development projects in the West were failures based on several studies and especially the with-without criterion. Young went further than the Principles and Standards [U.S. Water Resources Council] and defined the change in net income as ΔZ, where:

$\Delta Z = Z_1 - Z_0$, and where

$$Z_i = \sum_{i=1}^{m} Y_i P_{yi} - \sum_{j=1}^{n} X_j P_{xj}, \text{ or}$$

net benefit = total revenue - total cost

(or net revenue) (TR_i) (TC_i)

Z_1 = net benefits with project

Z_0 = net benefits without project

Y_i = crop outputs

P_{yi} = output prices

X_j = inputs to production

P_{xj} = input prices

So far as the above definition goes it appears to be appropriate; however, it has some dangerous implications if misused. First, it implies that all the income changes are brought about by the project (i.e., the ceteris paribus condition). This is simply not true, in either a static sense and especially in a dynamic economic sense. For example if Z_1 represents irrigated agriculture and Z_0 dryland agriculture, the levels of inputs used (labor, fertilizer, water, machinery, cropping patterns, etc.) would be entirely different and by no means the same. Secondly, in the dynamic growth of the area one would expect the two alternatives to develop very differently. Certainly the technology and cultural cropping patterns that would emerge from an irrigated area would be entirely different from the dryland area. Hence, to imply that ΔZ is due entirely to the project is erroneous. It is the result of the project and all the other changes that also take place.

The point that I am leading to is that in stating that $\Delta Z = Z_1 - Z_0$ implies the net income change from the project is a function of not only the "with project" net income, but also the "without project" net income. Let's look at this implication further:

$$\text{if } \Delta Z = Z_1 - Z_0$$

$$\text{then } \Delta Z = [TR_1 - TC_1] - [TR_0 - TC_0],$$

$$\text{and } \Delta Z = TR_1 - TC_1 - TR_0 + TC_0$$

If this is true, the revenues given up become costs and the costs given up become benefits or revenue. Now I ask, how can revenues become costs and costs become revenues? Is there something wrong in our reasoning process? You bet there is! ΔZ is simply illogical because it cannot exist; Z_1 and Z_0 are determined by two discrete, mutually exclusive, independent events! In simple English the with and the without alternatives cannot occur at the same time on the same piece of land. In terms of regional growth over time, we are dealing with two separate aggregage production functions. And what about all the other alternatives that might exist? Shouldn't we deduct their net benefits too? In addition, if there are more than two alternatives (besides with and without), aren't we being arbitrary? Which two should we subtract?

The purpose of this part of the paper is to point out that each of our possible economic alternatives in terms of project development (from absolutely no development to the ultimate in future development) represents single discrete choices at any point in time which we can either accept or reject. It is physically impossible to do both. As economists it is our job to identify the possible alternatives and then select the alternative that provides the greatest net benefit or return or income. In other words maximizing Z_i makes sense, but what can we do with ΔZ?

Choosing between project alternatives is a difficult job because economists lack data about all possible alternatives. Often we are forced to choose between two alternatives, the with or the without. If this is the case, the with is "justified" if its returns (not net income or net benefits) more than cover the costs (including the cost of capital because it is borrowed capital). Please note that I am deliberately ignoring environmental impacts and social costs, and focusing only on economic evaluation. Regardless of what these factors are we are still forced to select between two independent or discrete events.

Leftwich and Sharp offer some insight into the evaluation of irrigation projects in the following citation.

> "Suppose the government develops an irrigation project for $1 billion and finances it from selling securities. In the future the government will have to service the debt by raising taxes $1 billion plus interest. But, what about the flow of benefits or income in the future? There is no net burden shifted if income from the irrigation project is in excess of the costs of servicing the debt. As a matter of fact, there is a net gain to future tax payers in this event."

One might readily react to this quotation by asking--what about the without alternative? What about all those foregone opportunities or alternatives that we so often find deducted as costs? Who is correct here Leftwich and Sharp or the Principles and Standards?

Furthermore, why is the economic evaluation of water resources projects different than any other economic alternative? Do we need a separate body of theory? I don't think so, especially if it involves ΔZ. We do need some special efforts to correctly identify environment changes, social costs, and opportunity costs. From an economic point of view the evaluation of a water project is no different from that of a highway project or building an airport. As economists, our job is to identify all alternatives, determine the costs and benefits of each, and select the optimum project. Environmental impacts cloud our evaluations because we cannot put dollar figures on them. Social costs cloud our picture because they are difficult to identify and shift over time. The point is that when we make a resource development decision, we are forced to select between known alternatives (or what we feel to be estimated known alternatives). We must pick one alternative with its peculiar arrangement of pluses and minuses. Once this is done (the project is built) the other alternatives become irrelevant--the project becomes a fixed cost. Our choice now is whether to use the project (to supply irrigation water) or not use the project. If there were a number of reclamation projects standing around idle, I would tend to agree with Young. Most projects that I know of are still in use. This is not to say that all are creating net benefits or are not a complete disaster.

<u>What is a net benefit?</u>

The Principles and Standards implies that the change in net benefits ($\Delta Z = Z_1 - Z_0$) is the isolated impact of a water development project. This tends to imply that the net benefit from the project is the difference between the "with" alternative and the "without" alternative. While this is only an implication, it is clearly contradictory to the conventional tautology that net benefits are defined thusly:

net returns = total returns - total costs

or

net benefits = total returns - total costs

or

net incomes = total returns - total costs

Whichever terminology one wishes to use (net return, net benefit, or net income) the implication is the same. The idea that the net benefit (or change in net benefit) is the difference between independent alternatives has no place in economic theory or management theory. While economists would be very careful to point out that they are talking about a change in net benefits and not in a net benefit, the implication is clear (although without any foundation) that the change in net benefits from a project is identical to the net benefit of the project. This could be true if all other factors were, in fact, held constant--but this would not be the case in terms of long term regional economic growth. Part of our problem here is that we cannot quantify and separate the contributions of each factor of production (water, land, labor, capital, and technology) and the fact that when these factors are combined in a production function they probably work together in a synergistic way. The fact that economists have measurement problems separating out marginal factor products and marginal value products in practice is only confounded by trying to identify the contribution of a project by subtracting alternatives.

Opportunity costs--a useful but misused concept.

Part of the reason there is a desire to subtract one alternative from another independent alternative is a misinterpretation of how to apply the opportunity cost concept. Agricultural economists and especially resource economists like to use the opportunity cost concept. When appropriately utilized it adds greater validity to analyses. However, when incorrectly used the results can be erroneous. Samuelson points out that "The best alternative use is of course the proper one to use in reckoning opportunity costs." Obviously he is referring to the use of opportunity costs to price factors of production in a competitive situation. An industry must meet the price that a factor can earn elsewhere. Opportunity costs refer to setting prices for production factors. Some economists have a tendency to use opportunity costs in enterprise budgets in such a way that it results in double counting of factor costs. For example, enterprise budgets may sometimes include not only depreciation costs of owning and operating machinery but also the "opportunity cost" of having the capital invested in that machinery. In actual practice when an entrepreneur invests his money (cash) in machinery he no longer posesses the capital. Depreciation on his machinery is an appropriate charge for his cost of owning and operating his machinery. When he bought the machinery he gave up his cash, consequently he can no longer put his money in the bank to collect interest. Again, he has two alternatives, he may choose one or the other, but he cannot do both at the same time. The same type of argument holds for family labor and charging an opportunity cost where it is concerned. True, when a person selects between two employment opportunities the cost of taking one job is giving up the other. Once the person takes one job and the other goes to someone else that alternative is no longer relevant and it makes no sense to deduct that so-called "opportunity cost."

Young critized the USBR for not including opportunity costs for farm labor in justifying bureau projects. While there may exist some equal employment opportunities elsewhere, that opportunity cost is no longer relevant once an irrigator or anyone else is committed to his operation.

Some of this same type of thinking is also applied when evaluating environmental alternatives. Before we build a dam we may have a salmon fish run or snail darter. Prior to building the dam we may choose between these two alternatives, assuming they are the only alternatives possible. From a purely economic point of view we would choose the alternative that provides the greatest net income or benefit. Up to the time we choose between alternatives we may view them as alternative or opportunity costs. Once the decision is made either to produce fish or irrigate, the other becomes a foregone alternative--but not an "opportunity cost" to be deducted from the operational project.

Similar logic applies to the spectrum of water resource projects. Once we build a project, the other alternatives become irrelevant (especially since only one alternative can be developed at a time using the given resources). Foregone alternatives could replace the project at any time their net incomes exceed those from the project. Such an event is apparently rare but always possible.

Consider the idea of opportunity costs for capital (perhaps our most flexible factor of production). It has many alternative uses and a well-established opportunity cost or price. If we use capital to buy farmland and equipment, is it proper to charge an opportunity cost because this factor has other uses? No. One can only use a fixed sum of capital once. We cannot both invest in machinery and collect bank interest from the same dollars. To itemize both as a cost of production would simply be double counting. Naturally an investor is interested in the return on his capital. He may calculate or allocate income to his fixed factors (typically his labor, machinery capital, and land capital) and if his returns are higher elsewhere he may liquidate his capital assets and reinvest elsewhere. This, however, is not a "cost" as such to farming or any other enterprise.

In summary, the concept of opportunity costs is a very useful economic tool when used properly! Its proper use is to evaluate the price of a factor of production in terms of its alternative uses. It is not proper to use opportunity costs in a budgetary sense when they represent foregone alternatives. Consider the Internal Revenue Service, how much tax would it collect if it allowed individuals to deduct opportunity costs for capital and labor? In the same manner, consider the water development project, how many more would be built if we deduct foregone "opportunity costs?" And for that matter, how many private enterprisers would make new investments if they were made to charge for foregone "opportunity costs."

In conclusion, economists need to sharpen their thinking between true opportunity costs and foregone opportunities. Methodologies or theories that stress hypothetical ideals (change in net income) need to be viewed with caution, especially when they imply relationships that are not the truth because they cannot exist. It is human nature to want the best of all worlds or the best part of all possible alternatives (and none of the costs if possible). Unfortunately, this is not usually possible. Usually we must choose the best alternative and accept its minuses along with its pluses. It only muddies the decision making water to try and include foregone costs as real costs of our selected alternative.

Back to the basics.

So far I have criticized the change in net benefits or "with" minus "without" methodology and the improper use of opportunity costs. What then is the proper way to evaluate economic alternatives? In the case of water resource projects, and from a purely economic point of view, we need to return to evaluating alternatives by net benefits or net income. Certainly this should include the environmental pluses and minuses that may not be quantifiable. If it took income to build water resources projects (in terms of tax dollars) then we should evaluate economic success in terms of the income it produces either in terms of net benefits or net income. In Idaho we attempted to evaluate the Boise Project (a USBR irrigation project) in terms of the net income (value added income) associated with irrigation. We cannot claim this income was earned wholly by the water project because there are to many other factors that interacted with the water to produce the income measured. Rather, the income is associated with the development of the project. The project, by providing irrigation water, allowed certain development to take place. While water may be a necessary condition for economic development, it certainly is not sufficient. As for the foregone "without" development of the area, its reconstruction is nearly impossible considering the multitude of factors involved, and is of academic interest and irrelevant to the success or failure of the actual project. By saying this, I do not mean to imply that economists should not evaluate all possible alternatives (including the without) when planning future projects.

Results of research on the Boise Project which was initiated in 1910 were estimated as shown in Table 1 [Nelson and Long]. Benefit-cost ratios reflect annual net income benefits as opposed to annual project costs (depreciation, capital costs, operations and maintenance costs).

Net value added compared to project costs.

In an attempt to measure the degree of economic success of the Boise Project of Idaho from 1910 to 1970 we estimated net value added from irrigation and compared it to annual project costs. Essentially this means that total revenues from irrigated crops were determined and that annual production costs and depreciation of machinery and capital investments were deducted (including water project costs). Table 1 summarizes annual benefit cost ratios over time. In the early years of the project, 1910 through 1930, it was economically successful in the sense that benefits always exceeded costs although just barely in 1924 and 1926. During the depression, calculated benefit-cost ratios were below one in some years and even negative during one year (1932). During the second world war the economic success became more and more pronounced and since that time the project might be termed highly successful.

Was the project an economic success? The answer to this question (in terms of income) depends somewhat on what point in time you pick

Table 1: Annual benefits and costs, Boise project, Idaho, 1910-1970.

Year	Benefits	Costs	Benefits-Costs Ratio
1910	171,045	32,751	5.22
1911	363,180	159,213	2.28
1912	508,385	179,894	2.83
1913	541,264	229,504	2.36
1914	683,191	218,379	3.13
1915	1,289,457	539,038	2.39
1916	3,399,465	566,005	6.01
1917	5,315,507	645,001	8.24
1918	7,251,380	1,236,941	5.86
1919	8,917,690	1,219,463	7.31
1920	5,045,923	1,390,121	3.63
1921	5,476,195	1,337,300	4.09
1922	4,206,130	1,116,828	3.77
1923	5,196,417	1,111,553	4.67
1924	1,543,795	1,127,745	1.37
1925	3,600,774	1,119,471	3.22
1926	1,694,945	1,056,758	1.60
1927	4,274,885	1,028,897	4.15
1928	3,738,029	1,056,225	3.54
1929	4,970,057	1,151,238	4.32
1930	2,631,901	879,436	2.99
1931	293,850	967,468	0.30*
1932	- 537,418	1,193,860	-0.45*
1933	1,896,453	998,565	1.90
1934	2,038,221	1,007,119	2.02
1935	2,150,767	1,028,066	2.09
1936	3,804,501	997,140	3.82
1937	2,611,918	947,503	2.76
1938	1,658,806	1,035,400	1.60
1939	1,367,827	913,550	1.50
1940	1,255,568	867,162	1.45
1941	3,606,830	858,219	4.20
1942	8,365,991	949,012	8.82
1943	12,164,198	1,026,105	11.85
1944	12,725,016	978,197	13.01
1945	14,534,075	965,180	15.06
1946	14,906,569	799,953	18.63
1947	16,886,901	842,168	20.05
1948	16,978,374	1,247,054	13.61
1949	13,969,988	1,214,836	11.50
1950	11,826,927	2,306,619	5.13
1951	16,687,801	2,523,681	6.61
1952	17,318,960	2,694,119	6.43
1953	11,321,646	2,919,204	3.88
1954	14,288,554	2,665,094	5.36
1955	14,970,124	2,652,177	5.64
1956	17,126,415	3,155,870	5.43
1957	15,262,649	3,417,898	4.47
1958	16,534,082	3,452,867	4.79
1959	21,597,467	3,924,098	5.50
1960	20,608,724	3,890,226	5.30
1961	24,102,411	3,834,153	6.29
1962	22,185,909	3,875,093	5.73
1963	23,197,070	3,938,103	5.89
1964	19,865,012	3,937,077	5.05
1965	21,596,519	3,968.564	5.44
1966	23,487,498	4,298,164	5.46
1967	21,617,045	4,478,026	4.83
1968	21,760,680	4,809,321	4.52
1969	24,672,063	5,423,717	4.55
1970	22,579,934	5,804,259	3.89

*Benefits-cost ratio is less than 1.

to look back over the results. For example:

From	Degree of Success
1910-1929	Marginally successful to successful
1929-1940	Not successful or barely successful
1940-1970	Highly successful

Looking back over 61 years, the project failed to cover project costs in only two years (1930 and 1931). This was the result of a general depression--not project failure. For the other 59 years the project was an economic success. It might be desirable to compare this result with other possible alternatives, but it would be incorrect to subtract net benefits from another hypothetical set of independent events.

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