Georgia Water Series
Issue 2: Doing Benefit/Cost Analysis for Water Projects: A Primer

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ISSUE 2. DOING BENEFIT/COST ANALYSIS FOR WATER PROJECTS: A PRIMER

Since being mandated in the Flood Control Act of 1936 (PL 74-738), benefit/cost analysis has been used routinely in water economics. Benefit/cost analysis gives decision makers a method for evaluating investments in water projects, for judging alternative projects and estimating the impacts of regulatory changes. The basic principle of benefit/cost analysis is that the benefits of a water project must exceed the costs. Therefore, the issue is to accurately and completely measure all of the benefits and costs attributable to a project. The principle becomes difficult due to the uncertainty inherent in dealing with projects over time.

That benefits exceed costs does not infer that water resources are necessarily being used efficiently. As Frederick notes, economic efficiency implies the maximization of the net present value of all the nations scarce resources over time while taking into account alternative uses. This is obviously not possible in practice. However, benefit/cost analysis can help decision makers in evaluating alternative projects and the sequence of investments.

When conducting project analysis, the analyst must remember that all projects will have benefits and costs to the environment, not directly accounted for in the planning. These externalities should be considered (if not explicitly analyzed) so that decision makers are aware of such costs. Further, there is also a value of improved reliability that accompanies water supply projects and third party effects. Whenever a large public spending program exists there are winners and losers.

A major shortcoming of benefit/cost analysis is the difficulty in valuing nonmarket goods. Water projects by nature will affect the fish and wildlife habitats in an area and recreational and other environmental amenities. Since these benefits and costs are not priced in the market, they are often not included in a project analysis. However note should be taken of these issues to give decision makers the ability to consider such nonmarket values while evaluating a project.

Valuing the benefit of pollution control is also difficult in benefit/cost analysis and often leads to controversy when studies are publicly released. Economists have no formula for valuing the avoided damage to humans and the environment of pollution control. What is the value of extending life or reducing illness? Still, as Frederick states, economics can be useful in determining whether the same water-quality improvements might have been achieved at a lower cost or whether the same investment could have purchased greater quality improvements.

What economists and analysts can provide decision makers is what might be called second-best or practical benefit/cost analysis. Krutilla summarized the role of economics as follows: “Economic analysis of benefits and costs of long-lived investments involve as much art as science. There is need to project the relevant course of events within the area of project influence over a very long period of time, and getting to understand human responses to changes in the social and physical environment does not come easily.”

Several items must be considered before beginning an analysis of any project, investment or spending decision (Schmidt). First, what is to be accounted for? For example, construction of a public flood control project often does not consider the effect on fish or wildlife or wetlands.

Construction of a reservoir does not always note the effects it may have on surrounding watersheds. The evaluation of a water conservation project may not include the effects on recreational use of a lake or reservoir. The decision maker must first determine the scope of the costs and benefits to be taken into account. One problem many water projects face when put before the public is the question, "why didn't you consider X or Y in making your decision?" Managers must be able to demonstrate a reasonable focus in their analysis.

Another question that must be addressed early is what is to be maximized? Returns to the system? Rate payer benefits? Water use? Environmental concerns? Whether a project is a net benefit to the system, the community, or the environment will depend on the objective that is being sought.

Third, what is the investment criteria? Whether one project is chosen over another, or no investment is made, depends on the criteria for ranking projects.

Fourth, what is the relevant time frame for the project? A period of analysis must be chosen. If a project is being financed using bonds, the appropriate time is the life of the bonds though the assets exist beyond the bond period. The analyst must also remember that different projects have different cash flows over time; some have early returns, others more distant returns.

Discount Rate

To compare investments over time, a decision maker needs to use a discount rate to reduce the flows of benefits and costs to a present value. The basic idea is that there exists a time value of money. For example, what is more valuable? $100 today or $100 ten years from now? If a person is offered $100 today or next year, what would be the response? Normally the person would take the $100 today because it is clear, without doing any sophisticated economic analysis, that the value of $100 a year from now will have fallen. What the person is doing is applying the concept of a discount rate.

If $100 is invested today at 10% interest that $100 will be worth about $260 compounded in ten years. Basically, $1 today is worth more than $1 tomorrow. This is just the impact of inflation. Yet if the interest rate were only 5% after compounding, the $100 investment would produce $162. When evaluating the benefits of a project, the lower the discount rate, the higher the present value. Thus, a low discount rate is preferred by anyone wanting to show a long term investment in its most favorable light. When looking at costs, the higher the discount rate the lower the present value. This is the preferred approach for anyone wanting to show that costs in the long-run are small. It is evident, therefore, that the use of various discount rates can be manipulated to serve a predetermined result. The use of discount rates can also lessen the impact on future generations of today's investment plans. In deciding the proper discount rate, considering inflation and the expectations for inflation, and the risk involved in the project is necessary. The choice of the discount rate can greatly influence which public project to pursue. In the literature of the economics profession much of the debate about using benefit/cost analysis has been over how to choose the appropriate discount rate.

Valuation Over Time

Different projects have different cash flows over time. Some have early returns, some later, some big, and some small. The economic problem facing the analyst is how to compare these different types of projects.

As an example, $100 can either be consumed today or invested for four years, as shown in table 1.

Table 1. Time Value of Money

Choice	Time/Consumption				
	Now	Year 1	Year 2	Year 3	Year 4
Consume Today	$100	0	0	0	0
Invest	$100	0	0	0	$146

Source: Schmidt

The choice is to consume now or to invest. If the $100 is consumed, the utility of present consumption was clearly greater than the utility of later consumption of the future returns of the investment. This would be the case though in four years, the investment produces $146 instead of $100. That infers that the utility of current consumption is greater than the utility of $146 in the fourth year, meaning that the future $146 has been discounted so that it is not worth the present $100. A trade off has been made between current and future consumption. This rate of trade off is called a person's time preference.

The rate of time preference is obtained by observing peoples choices which depend on an individual's values and opportunities. A person can consume now or invest. If the person consumes today, it can be inferred that the utility of present consumption is greater than the utility derived from waiting and consuming later through returns on investment. This would be the case though the absolute number of future units is greater.

To the above example, different timed projects can be added. For example, another choice between consumption today and investment returns in four years could be an investment that returns $133 in three years. What would need to be determined is whether this third-year project is the end of investment or whether it could be combined with some investment external to the project to produce income in the fourth year. If the third year project could be combined with another to produce $146 after another year, then the project would be the same if the $133 could be reinvested for another year at a return of 10% would produce $146. So to decide if the three- year project is preferable to the four-year investment, knowing all of the possibilities for investment would be necessary. If the choice is still to take $146 after four years, this implies that no reinvestment opportunity for the third year returning better than 10% was available (Schmidt).

Present Value: Discounting

Understanding the concept of time preference leads to calculating the present value of an investment by discounting the future backward to the present. The basic discounting formula is $1/(1+r)^t$ where r is the discount rate and t is the number of years in the investment. The task here is to find some value of *r* that makes the discounted future value of the investment equal the present consumption value. Using the example above, $\$146/(1+r)^4$, if the \$146 is discounted at 10%, then the formula would equal \$100. When \$146 is discounted at 10% the future income is reduced to the present value of \$100. So if the discount rate is 10% and a person still prefers consumption today to waiting four years for \$146 than it could be inferred that the rate of trade off, or the time preference, exceeded 10%.

Since present consumption is always worth unity (\$100), the rate of discount inferred by the choice of consumption today must be such that makes the present value of \$146 less than \$100. Or, if a person chooses to wait the four years instead of consuming today, then the time preference, or discount rate would be less than 10%.

For example, $\$146/(1+.05)^4$ would be equal to \$146/1.21 or \$121 in today's dollars. If the discount rate were 5% instead of 10%, the \$100 today would be equivalent to \$121 in four years. Put the other way, the \$121 in four years would be the same as \$100 today. At this discount rate a person would be indifferent to investing or consuming if the time preference were 5%.

Alternatively, if the discount rate rose to 12% then the formula would be: $\$146/(1+.12)^4$, or \$146/1.57 which equals \$93 today. If the time preference were 12% the \$146 in four years would be less than \$100 today and a person would choose to consume today rather than invest.

Discount rates are a reflection of the time preference, and the rate at which a person is indifferent to investing or consuming reflects the marginal rate of time preference (MRTP). Each person has a different MRTP. What can affect MRTP? It depends on wealth, uncertainty, age, impatience, health, present needs, and other factors that influence how a person spends money. For example, if wealthy, a person can afford to save for the future rather than having just enough money to meet current consumption. If older, a person's view of the future is different than if young.

If a person or a water utility has an MRTP of 8% and can lend someone money (or invest it in a future project) at 10% return, what would happen? Since the time preference of money is 8%, any return above 8% would produce an investment rather than consumption. If a return on an investment is less than 8% a person would rather consume today than invest the money. That decision would continue to be made until the marginal rate of time preference was equal to what is called the marginal rate of transformation---that rate at which a person is indifferent to investing or consuming.

A desirable investment is one whose rate of return exceeds this equilibrium rate. Depending on the age of a utility, its health, its financial position, present needs, and other factors, the concept of the discount rate can be used to decide that point where investing in the future would be the best choice.

Investment Criteria and Discounting

Before performing any type of investment analysis it is necessary to decide the investment criteria: what rules should be followed to tell the decision maker whether or not to proceed with any water project? A number of investment criteria can be identified:

1. Maximize average returns or average investment
2. Return on book value
3. Minimize the payback period
4. Breakeven analysis
5. Maximize present value
6. Maximize the Internal Rate of Return
7. Benefit/Cost Ratios

The first two investment criteria are often used in the business world. Measuring returns on investment is calculated by taking the annual net payoff and dividing it by the initial investment. This and the return on book value are short term investment measures that are not applicable when examining multi period financial analysis. Just minimizing the payback period is also not useful for water projects since it ignores net cash flows beyond the point at which the investment has generated the payback. Using a breakeven analysis has similar problems.

The three criteria that are best suited to determining whether a water project should be undertaken are the concepts of net present value, the internal rate of return and the benefit/cost ratio. All three are ways to evaluate multi period investments. When asking, if a water investment is economically feasible, the criteria to use are as follows:

1. If the Net Present Value of the stream of benefits and costs of a project is above zero, the project is economically feasible.

2. If the Internal Rate of Return of the project is above the cost of capital used to finance the project, the project is economically feasible.

3. If the ratio of benefits to costs is above one (or the benefits minus costs are above zero) the project is economically feasible.

When evaluating projects, benefits and costs clearly accrue over many years. Thus, it is necessary to discount the present value of a project over time. The discounted present value of a project is the summed discounted value of the cash flow produced by the project. The formula for the discounted present value is simply the sum of each years discounted cash flow and is:

$$\sum_{t=0}^{t=n} \frac{B_t}{(1 + r)^t}$$

where B is the net cash flow (revenues minus costs) of a project each year. For a water project, this could be zero, negative or positive. For example, during the construction phase of a project, costs would be higher than revenues since the project is not producing revenues. The notation n is the number of years in a project and t_0 is the present or initial year's negative net budget and is not discounted since the interest on borrowing is not due until the end of the year. Net Present Value (NPV) is the sum of the present value of the stream of benefits and the discounted stream of future costs minus the capital cost of the project. The capital costs are negative net cash flow despite the year of occurrence.

The criteria for investment is to invest only if the NPV is positive. Sometimes analysts separate discounted negative from discounted positive returns, sum separately, and subtract one from the other to get the NPV. Choosing projects with positive NPV is called the excess benefit method (Schmid). If there are many projects to accomplish, the NPV can be ranked until a project is reached where the NPV is zero. Then it is necessary to determine if the budget can meet the needs of all the projects that have positive NPV's. Schmid notes an opposite but symmetrical concept to NPV called the net terminal value (NTV), defined as:

$$NTV = \sum_{t=0}^{t=n} B_t (1 + r)^t$$

Here, the criterion is to invest in any project whose NTV is greater than zero. Then, the terminal value of benefits (TVB) is the sum of compounded positive B_t's that exceeds the TVK or terminal value of costs.

Different Size Projects

Net present value is an amount and not a rate. Consequently, only projects with the same amount of capital can be compared directly. If projects with different size investments are being compared, relating the returns to the capital needs of each project is necessary. What is needed is the return per dollar of investment. This is done using the formula, B-OC/K, where B is the discounted stream of benefits that accrue to the project over its lifetime, OC is the discounted yearly operating cost of the project and K is the initial capital investment. As an example, see table 2. Here the choice of two different projects, one with an initial investment of $100 and the other with an initial investment of $200 is shown . The first project with an investment of $100 would return a benefit of $110 after one year. The second project returns $218 after the first year. For both cases there are no operating costs to worry about at this point. At first glance it seems that project two is a better use of money since it returns $18 after one year compared with a gain of only $10 from the first project. Nevertheless, since the two projects are of different sizes, this answer would be incorrect.

Table 2. Example of Discounting Different Size Projects

	Capital K	Benefits (year 1)	$\frac{B}{(1+r)^n}$ PV 3%	$\frac{B-OC}{K}$ *at* 3%
1st project	$100	$110	107	1.07
2nd project	$200	$218	211	1.06
OC = Operating cost (equal 0 here)				
At 3% Project 1	PV = 110/1.03 = $107	NPV = $7		
Project 2	PV = 218/1.03 = $211	NPV = $11		

Source: Schmid

First, the example deals with not just investment, but time. As noted earlier, a dollar today is not worth the same amount in a years time. So it is necessary to discount the earnings to account for the passage of time. Using a discount rate of 3% the present value of $110 today would be $107 and the Net Present Value of project one would be $107 minus the cost of the project ($100, which is not discounted since project costs are paid at the time of inception) or $7. Using the same formula, the present value of project two is $218/1.03 or $211 and the NPV is $11. So it appears that project two returns more than project one. However, it requires twice as much capital, so ranking project two over project one is incorrect. What is needed is to relate the returns to capital by using the formula (B-OC)/K. In the above example, with operating cost still assumed to be zero, project one is returning $107/100 or $1.07. For every dollar of capital investment, the project generates $1.07. For project two the formula is $211/200 or $1.06---a return less than project one. Since project one provides a higher return for the capital invested it would be a superior use of funds.

Internal Rate of Return

Another measure of the effectiveness of public investment is the internal rate of return. This is the rate of discount that reduces the cash flow of a project to a zero net present value. The IRR is the statement of expected yields over the life of the project---or the average annual yield of the investment. The investment criterion is to invest only if the IRR is greater than the opportunity cost of capital. In formula form the IRR is the *r* (rate of discount) for which:

$$\sum_{t=0}^{t=n} \frac{B_t}{(1+r)^t} = 0$$

Unfortunately no easy method exists for determining the correct *r* except trial and error. For example, using the data from project two above, when the discount rate was 3%, the present value of the project was $218/1.03 or $211 for an NPV of $11. So the NPV when the discount rate is 3% is above zero. To reduce the NPV to zero a higher discount rate is needed. The next step is to try a higher rate, for example 7%. Now the present value is $218/1.07 or $204 leaving an NPV of $4

($204 minus the $200 cost of the project). The discount rate is still too low but is moving in the right direction. At 11%, the present value of $218/1.11 or $196, leaves an NPV of -$4.00. This is too high . At 9%, the present value of the benefits is $218/1.09 or $200, leaving a net present value of zero. The internal rate of return of this project is therefore 9%---the average yield of the project. The investment criteria using the IRR is to invest in a project if the IRR is greater than the opportunity cost of capital. If bonds are available at 6%, and the IRR is 9% then the project is returning more than the cost of the investment. If on the other hand, a utility had to borrow money at 12% then a project that returned an average of only 9% per year would not be an efficient use of funds.

Table 3 illustrates a five-year project with the annual net benefits shown in column two. The annual payoff stream is the revenue generated by the capital investment of an initial $1000 minus the operating costs. The example shows the use of a discount factor of 5% . For each year of the project, the analyst first must determine the present value. In year one, with a discount rate of 5% the formula shows the present value to be $400/1.05 or $380. As a note, to get the present value it is possible to divide by 1.05 or multiply by .95---the answer is the same. In year two the formula is now $200/(1.05)^2$ or 200/1.10=$182. The remaining years are done in similar fashion. After determining the present value for each year, the five years are added. At a discount rate of 5% the project returns a present value of $1058 and not the $1200 of adding up the annual payoff stream since taking into account the effect of time on money is necessary. The net present value of the project is the present value of the net benefits, $1058 minus the capital cost for $1000, or $58. Thus, the NPV is above zero and the internal rate of return must be above 5%.

Table 3. Illustration of Discounted Net Present Value and Internal Rate of Return Calculations (Capital Cost = $1000)

Payoff period year	Annual payoff stream P_0	Discount factor @ 5%	Present value V_0	Discount factor @ 8%	Present value V_0
1	400	0.95	380	0.93	372
2	200	0.91	182	0.86	172
3	200	0.86	172	0.79	158
4	300	0.82	246	0.73	219
5	100	0.78	78	0.68	68
	1200		1058		989

5%	8%	7.5%	V_0 @ 7.5%
400/1.05	1.08	1.075	372
200/1.10	1.16	1.16	173
200/1.16	1.26	1.24	161
300/1.22	1.36	1.34	224
100/1.28	1.47	1.44	70
			1000

Applying a discount rate of 8%, the present value of the stream of benefits is $989, making the net present value of the project $1000-989 or -$11. Thus, the IRR is below 8%, but not by much. Trying 7.5% the NPV is zero, making the internal rate of return for this project 7.5%. Finally, the IRR is similar to NPV/K in that all capital and only capital is the limiting factor. This is the case since the IRR is computed in terms of net cash flow streams and ignores how the net flow was obtained (Schmid).

Two of the criteria for making an investment decision are when NPV is greater than zero and when the IRR is greater than the cost of capital. Schmid points out that these two criteria can give different answers. For example, from Schmid:

Table 4. Contrary Investment Criteria

Project	Capital	Net Benefits		NPV (4%)	IRR
		Year 1	Year 2		
A	100	0	115	106.3	7
B	100	110	0	105.7	10

Using the Net Present Value concept, project A is a better investment than project B. However if ranked by the internal rate of return, the opposite is true. In the above example, if the discount rate were 5% rather than 4% a reversal of ranking by NPV would take place. In fact, at all higher discount rates project B is better using both NPV and IRR. So Schmid says the question is not which method is better but whose opportunity cost is to count. The answer is based on the choice of discount rate which means the answer depends on how the future is to be considered. Using sensitivity analysis can deal with many of these issues. Sensitivity analysis uses a limited number of alternative forecasts to analyze different assumption and uncertainty.

The following exercise calculates the Net Present Value of a water project, uses discount rates, calculates a benefit/cost ratio and an internal rate of return. The example that will be presented is for a single-output project. For many water investments however, multiple outputs from the same investment in the same resource base are typical. Then the issue is to allocate the joint costs of multiple output projects to each output or service. An example of such a project is a multiple purpose reservoir. The raw material of the reservoir can be used to produce several outputs such as power, navigation, irrigation, recreation, and drinking water. The difficulty is in how to charge each output the correct price. This determination however is most often done by politics or negotiation. No general formulas are available for this cost allocation and it is normally done on an ad hoc basis for each project. The decision on the allocation of costs is independent of the decision to proceed with a project or reject the investment. The decision is still based on the investment criteria outlined: benefit/cost ratios, NPV and internal rates of return. However, Congress has required the allocation of costs to the project purposes in order to provide some ability to recover costs from project outputs. These are categorized as reimbursable and non-reimbursable costs. Reimbursable costs should be recovered from direct beneficiaries while non-reimbursable costs have a “public good” nature.

Doing Benefit/Cost Analysis

In a fictitious city of Spalding, the water manager and the board are considering a project to expand the size of its reservoir. The manager has contacted the city's engineers and told them the size of the necessary expansion. The capital investment for the project has been estimated at $3,981,927. The project is to be financed with the sales of bonds for six years at an average yield of 5.5%. Table 5 shows the initial data supplied by the city's engineers and bond advisor regarding the estimated revenues, costs and interest expenses for the project.

Note that since the project is being financed with bonds, a new cost has been added to the yearly estimates---interest on the bonds. The net benefits shown in the last column represent the revenue minus the operating costs minus the cost of borrowing at the 5.5% interest rate. The question to the water manager and the board is, given the above data, should the City of Spalding invest in this project?

Table 5. City of Spalding Reservoir Expansion Project

Year	Estimated revenue from project	Yearly operating costs	Interest cost on bonds	Net benefits
	- - - - - - - - - -	- - - - - - - - - - $	- - - - - - - - - -	- - - - - - - - - -
1995	2,589,483	1,667,285	192,412	729,786
1996	2,667,167	1,717,303	164,912	784,952
1997	2,747,183	1,768,822	135,197	843,174
1998	2,829,598	1,821,887	103,772	903,939
1999	2,914,486	1,876,544	70,812	967,130
2000	3,001,921	1,932,839	36,307	1,032,775
				4,445,756

The discount rate to be used is 5.5%, which is the cost of borrowing the funds. The first step is to arrive at the discounted net present value of the steam of benefits from the project. Using a discount rate of 5.5%, and the discounting formula of $1/\,(1 + r)^{t}$ the first year's stream of benefits is discounted as: $729,786/1.055 or $691,740, where r=.055 and t=1. For year two, the discount factor is 1.113 which is 1.055*1.055 (t=2). Multiplying 1.055*1.055*1.055 or 1.113*1.055 finds the third year's discount factor. For each year of the project this calculation is carried out as shown in table 6.

The present value of the stream of net benefits from the city's water project is $4,370,314. This produces a net present value of $4,370,314-$3,981,927 (the capital cost of the project) or $388,387. The first test of whether this project is economically feasible is passed: the discounted net present value of the project above zero. Here for an investment of about $3.9 million, the return is more than $4.3 million.

Table 6. Discounting the Stream of Benefits

Year	Discount factor at 5.5%	Net Present Value of the Stream of Benefits*
1995	1.055	$691,740
1996	1.113	705,257
1997	1.174	754,855
1998	1.239	729,571
1999	1.307	739,961
2000	1.379	748,930
		4,370,314

*Calculated as Net Benefits/Discount Factor.

The second test for a feasible project is; does it produce a benefit cost ratio above one? Here the formula is, $4,370,314/$3,981,927 or 1.1. For each $1.00 of costs, this project returns $1.10---a feasible investment.

The third test of the feasibility of the project is its internal rate of return. In the above example, a 5.5% discount rate was used since that was the cost of borrowing funds. If the net present value of the calculations were below zero, then the IRR would be below 5.5%. However, since the NPV was above zero, the IRR is clearly above 5.5%. For a cost of 5.5% this project returns an average yearly return above 5.5%. This is again the definition of a feasible project and an acceptable use of public money.

Since the discount rate to calculate the IRR is above 5.5%, the analyst can try any rate above that reduces the NPV to zero. As an example, the yearly net benefits from table 5 using 10% show the stream of benefits to be $3,749,451 (table 7). Thus the net present value is $3,749,451 - $3,981,927= -$232,476. That produces a benefit/cost ratio of $3,749,451/$3,981,927= 0.94; a ratio below one. If the discount rate were 10%, this would not be an economically feasible project. So in calculating the internal rate of return, 10% is too high.

Table 7. Calculating the Internal Rate of Return

Discount Factor at 10%	Discounted PV
$729,786/1.10	$663,441
784,952/1.21	648,720
843,174/1.33	633,965
90,939/1.46	619,136
967,130/1.61	600,701
1,032,775/1.77	583,488
	$3,749,451

Using 8% as the discount rate the IRR is calculated and shown in table 8. The discounted stream of benefits is $3,981,927, which produces an NPV of zero, and a benefit/cost ratio of exactly one. The internal rate of return is 8% since the definition of the IRR is the discount rate that makes the net present value of a project zero. Thus, for a cost of 5.5% per year, the City of Spalding receives an average return of 8% per year. Overall the project is economically feasible and is an economically acceptable use of the investment funds.

Table 8. Getting the IRR

Discount Factor at 8%	Discounted PV at 8%
1.08	$675,727
1.17	670,899
1.26	669,185
1.36	664,661
1.47	657,911
1.59	649,544
	3,981,927

Choice of Ratio

If an analyst is comparing projects of different sizes and scales there is a need to transform the project evaluation into a common unit. The previous method, using the formula (B-OC)/K, transformed the units into dollars of capital invested. This infers that capital is the limiting factor to which returns are to be maximized. Usually, a utility is faced with capital rationing. Consequently the return to capital should be maximized. Since the ranking of different projects is by how well they produce a return on capital, the implicit assumption is that the use and return on capital are the most important factors to consider. However several other factors may be as important and will affect how projects are ranked. Of particular interest is the issue of operating costs. For some projects the limiting factor may not be the availability of capital but the year to year operating costs incurred after the construction of a project. For example, with low interest rates and a good credit rating, a water utility may have easy and inexpensive access to capital. So while an important and limiting factor, it is not the only factor. Once a project is complete, the strain that new operating costs put on the system is often just as important. Using the formula (B-OC)/K, operating costs are not regarded as a limiting factor. However if operating costs are put in the denominator along with capital then operating costs are also a limiting factor.

If a new project produces any new operating costs, the use of B/(K+OC) produces a lower absolute number than (B-OC)/K except on negative net return projects. Putting operating costs in the denominator will lower the rate of return of the benefits of a project. This may however be a more realistic picture of what a utility faces in making project decisions.

As an example, consider a two-year project with an initial capital investment of $100. In this example, the gross benefits due to the project are estimated to be $168 and the operating cots are $53 over the two-year period, producing a net benefit of $115. Since the project involves costs and returns over time, discounting the project to its present value is necessary. Using a discount rate of 3%, the present value of the gross benefits is shown as $\$168/(1.03)^2$ or $168/(1.06)=$158. The present value of the operating costs is $\$53/(1.03)^2$ or $53/1.06=$50. If operating costs are not a limiting factor and the formula (B-OC)/K is used then the rate of return is $158-50/100=$1.08. For each dollar of capital invested the project returns $1.08 in net benefits. On the other hand, if operating costs are a limiting factor then B/(K+OC) is $158/50+100=$1.05. The rate of return on both capital and operating cost is smaller than if capital were the only consideration.

If a utility has high operating costs compared with capital then any project will appear to return fewer dollars when operating costs are included in the denominator. The calculation of a project's internal rate of return is similar since it only regards the return on capital and not operating costs as the important factor. Kuhn suggests that if operating costs are not regarded as limiting, agencies or utilities would be encouraged to classify many costs as operating costs when there is vagueness in such clarification. For a project with high operating costs there would be lower net returns available in future years for capital expenditures. Thus a political judgement is needed to monitor how costs are classified and to monitor the trade off between capital limits now and in the future (as quoted in Schmid).

The best policy in doing benefit/cost analysis is for the analyst to show the decision makers both return calculations and let the policy maker decide which is to be regarded as the limiting factor. What is clear is that different answers can be achieved using different methods. Care must be taken when presenting the results of a benefit/cost study to be precise and open regarding the assumptions being made.

Discount Rate Concepts

As should be clear, the choice of what discount rate to employ is an important decision affecting the outcome of any benefit/cost analysis. Different groups, and individuals, have different marginal time preference rates and therefore different discount rate choices. Which discount rate to use is therefore a matter of public choice.

If prices in the analysis are in real (inflation adjusted) terms then the discount rate should also be in real terms. The discount rate chosen must include an inflation premium, or at least a pure time preference calculation.

Three main concepts guide the choice of discount rates---the social time preference, the cost of funds, and the opportunity cost of capital. The social time-preference or the social discount rate is a rate of discount that is completely free of all risk and uncertainty considerations. The social discount rate could be appropriate in an economy of stable prices and economic conditions. Here the value of goods and services would not experience unexpected changes. A social discount rate is used to account for time and nothing else. This is the lowest discount rate, normally around 2% to 4%. When using the social discount rate the best approximation is the interest rate of long-term government bonds of small denominations sold directly to savers. This can usually be found in the rate of interest being paid for US Savings Bonds. Over the years, in evaluating large federal water projects, this discount rate has often been used. If an agency wants to improve the chances that its project has a positive benefit/cost ratio then this discount rate is employed. Obviously this represents a policy decision favoring spending on a project.

A second discount rate idea is the cost of funds, or the market rate of interest. This uses the market rate of borrowing to finance a project as the discount rate. The market rate of interest reflects the price instability, risk, and uncertainty that the market assigns to a project over time. This also should include the inflation risk that the market assigns over time. Thus the interest rate on short-term bonds is lower than for long-term bonds. If a utility borrows funds for only two years, the inflation risk is much less, and inflation estimates are more reliable, than borrowing over thirty years. The higher interest rates paid for thirty year bonds reflects inflation uncertainty and the general uncertainty and risk over a long period. Tax policies and regulations on capital affect market rates so there are many different market rates. Often used to reflect this discount rate is the government long-term bond rate for government projects. This discount rate is normally higher than the social rate of discount so projects have a lower benefit/cost ratio than if using the first discount rate. Observed market rates contain an inflation premium. If the observed market rate of interest is used to discount projects, both costs and benefits over time should be inflated using a three to five year average of the Consumer Price Index.

The third main discount rate is the opportunity cost of capital. This is what the rate funds would yield if invested in projects or tradeable assets at the highest available yields (this is normally the highest discount rate). Using this discount rate infers that water projects are equal to any other investment that a public agency can make. What is being compared is using public funds to invest in water projects or putting those funds into another opportunity to produce returns. Those who oppose water projects normally want to employ this rate. The lowest available estimate of the opportunity cost of capital is the after tax profits or stockholder equity. Premiums for inflation and risk have been included in this rate. However, in the private sector the opportunity cost of capital is higher than returns on stockholder equity, before or after taxes. Since capital is rationed most firms have alternative investment opportunities at rates several points above the market rate of interest. This interest rate level would be the most economically efficient discount rate and would insure only the most productive projects would be undertaken by either the public or private sector. Using this discount rate concept would lower the number of water projects found to be feasible.

Since the 1950s the pressure on analysts doing benefit/cost analysis is to adjust the discount rate upward. At the very least, the analyst needs to adopt a discount rate at least equal to the long-term cost of government borrowing and near the yield of corporate bond yields. If a utility is borrowing money to finance a project then the average cost of the bonds is a good approximation of the correct discount rate.

The three discount rate methods can each affect the outcome of a benefit cost analysis (table 9). Consider a three-year project with net benefits of $100, $130, and $150 for each year. To these, discount rates of 3% or the social discount rate, 6% or the market cost of funds, and 8% for the opportunity cost of money can be applied. An analyst using the social discount rate would say the project had a net discounted present value of $358, higher than the other two. The lower the discount rate the better any project appears.

Table 9. Example of Different Discount Rates

Net benefits	3% rate	PV	6% rate	PV	8% rate	PV
$100	1.03	$97	1.06	$94	1.08	$93
130	1.06	123	1.12	116	1.17	111
150	1.09	138	1.19	126	1.26	119
Total		358		336		323

The use of a discount rate therefore can be a major, if not the major, determinant in the evaluation of a project. Therefore, the choice of discount rate is a policy decision. Once made, the analyst can accomplish the benefit/cost calculations. The analyst must be clear which rate is used and report the results accordingly.

So what is the common practice? In Britain for example, all government projects are required to use a discount rate of 10% in conducting their analysis. In the US, no consistent discount rate is applied. A US Office of Management and Budget (1972) Circular A-94 required a 10% discount rate on all federal projects, but its use varies by agency. The Water Resource Development Act of 1974 (P.L. 93-251, Sec. 80a) mandated the use of a floating rate equal to the average interest yield realized each year on 15-year government bonds. Congress however did not want to see sharp rises in rates being applied to federal projects so it mandated that the increase each year not go up more than .25%. In a period of rapidly rising interest rates, the discount rate used by federal projects in the 1970s and 1980s never caught up to actual bond yield rates. For example, in 1981 the prime interest rate was 20%, the US 15-year government bond reached 14% and the discount rate used by water agencies was about 7.6%. In 1987 the discount rate was 8.6% and in February 1993 it was 6.77%.

Regulatory agencies throughout the federal government also use different rates. For example, the US Environmental Protection Agency rejected the use of discount rates in judging spending on asbestos removal costs. Essentially the EPA said that the discount rate was zero. The rationale was that the EPA did not want to discount the value of future lives saved.

So what can an honest analyst do? The analyst should use an interactive, iterative process, to show policy makers how the discount rate and investment criteria might offset the budget size and ranking of projects. This should include using sensitivity analysis to show decision makers how answers can change, given the assumptions used in choosing a discount rate.

Other Lessons

Budget constraints are common and have the greatest impact on the ability of a utility or agency to do a project. Budget size is rarely determined by ranking projects that have a positive rate of return but instead by the limits of the agencies ability to raise money.

While some agencies have cutoffs that rank minimally qualified projects, if there is political support for a project, it will seldom fail to meet the minimum test. On the other hand, if there is significant political opposition, no benefit/cost analysis is likely to diminish that opposition.

The choice of a project is seldom a function of project ranking by any formal economic criteria. The choice tends to a matter of accepting or rejecting one or a small group of projects at a time. However, identifying the threshold or marginal project where the NPV equals zero is necessary to know if the amount of capital available is equal to that needed to finance all projects that have some positive net returns (excess benefits) (Schmid).

Finally, choices made in the early stages of decision-making are crucial. Often assumptions and choices made early are forgotten and subsequently drive the decision making process without further analysis.

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