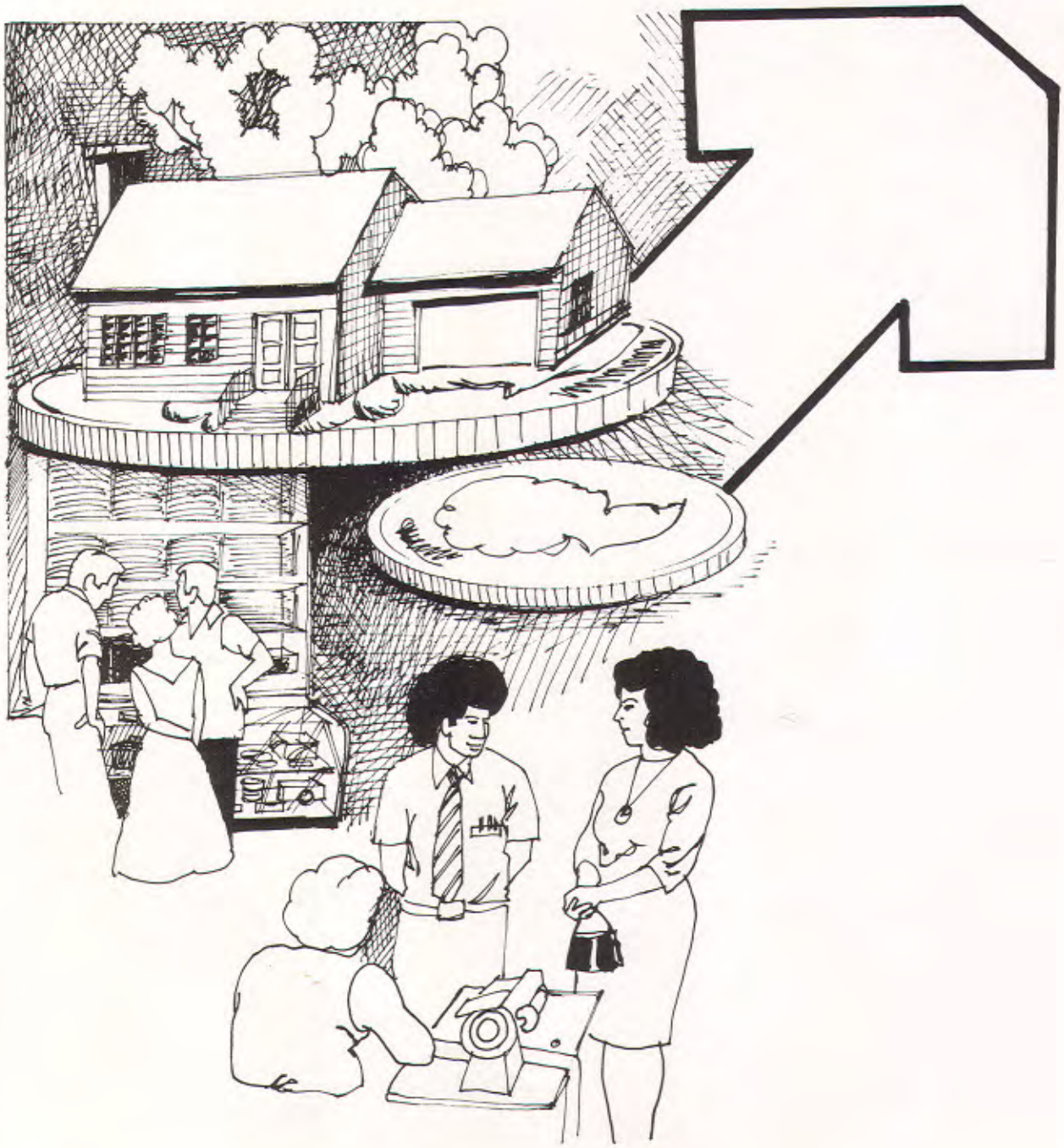
Part II



Chapter 5

Cost-Benefit Analysis: Is the Project Worthwhile?

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WHAT IS COST-BENEFIT ANALYSIS?

If a business firm sells a product for which the costs exceed the revenues, this is a signal to the firm's decision makers that the market does not place a high enough value on the product to justify its production costs. Operating at a loss cannot continue for long; the firm either goes out of business or produces a product it can sell at a profit. Businesses also face investment decisions: whether it would be profitable to build a new plant or purchase new equipment.

Local government faces similar decisions. Its resources are always limited—that is, there is only so much revenue from taxes, bond issues, and other revenue sources. The list of alternative programs and projects on which local government could spend its limited revenues always exceeds the available revenues. If optimum use is to be made of these limited revenues, local government must spend them in ways that are socially profitable, generating the most benefits for the community relative to the costs incurred.

Cost-benefit analysis is a technique for evaluating the social profitability of alternative uses of local government's scarce resources. Are projects A, B, and C all worthwhile? Or just A and C? And which of these projects is the most worthwhile if available funds are limited to $500,000? As indicated below, the business firm evaluates the profitability of investments by subtracting costs ($900) from revenues ($1,000) to determine profit ($100). In a cost-benefit analysis, social costs ($1,500) are subtracted from social benefits ($2,000), yielding net social benefits ($500). In the public sector net social benefits parallel the concept of profits in the private sector and are defined as social benefits minus social costs.

Cost-benefit analysis involves the following steps to determine whether a project is worthwhile:

1. *Identify* the costs and the benefits that will result from a course of action (project or program).
2. *Measure in dollars* these costs and benefits so that both costs and benefits are stated in common denominator units that can be compared with potential alternative uses of local government revenues.
3. Incorporate the *time dimension* in the evaluation, because costs and benefits must be examined for the entire life of the project or program, not just for the current fiscal year.

Profitability for the business firm and local government

Business Firm		Local Government	
Revenues	$1,000	Social Benefits	$2,000
Costs	900	Social Costs	1,500
Profit	$ 100	Net Social Benefits	$ 500

4. *Decide* whether the result of the first three steps yields a large enough social profit (net social benefits) to justify the expenditure of limited funds.

These four steps of cost-benefit analysis are illustrated here for a hypothetical road improvement project. The city council of the city of Midway is deliberating on whether to spend $2.5 million for widening, improving traffic signals, and making other improvements to North Road. The growth of outlying residential areas has resulted in increased commuter trips to jobs in the city of Midway and has increased traffic on North Road. Members of the city council request information on the projected benefits to the community from these improvements. City staff personnel are directed to conduct a cost-benefit analysis to determine whether the North Road project is socially profitable.

IDENTIFYING BENEFITS AND COSTS OF THE NORTH ROAD PROJECT

Benefits

The staff identifies the following project-related benefits to motorists using North Road and alternative routes into Midway during morning and evening peak-hour commuting trips:

1. *Travel time savings.* The improvements to North Road will permit present users of the road to make their commuting trip at a higher average speed. Travel time savings will also accrue to peak-hour commuters currently using alternative routes, because some commuters will switch from these alternative routes to North Road—enough so that the average time to make the trip on all routes will be less than it is now. However, traffic counts conducted by the traffic engineering department indicate that usage is not high enough to increase average speeds during off-peak hours after the improvements are built. Thus, all travel time savings, and the associated vehicle operating cost savings, will accrue to peak-hour users.

2. *Vehicle operating cost savings.* Average speed during peak hours is currently 20 miles per hour; however, the speed limit is 35 miles per hour. Excessive stopping and starting during peak-hour traffic results in fewer miles per gallon of gasoline, more brake wear, and more wear and tear on vehicles than would occur with better traffic flow at a higher average speed during peak hours.

3. *Accident reduction.* Improved traffic flow on North Road and alternative routes during peak hours will result in fewer accidents.

Costs

Identifying the costs of the North Road project is fairly easy. The city already has information on the capital costs of the project, which include the following:

1. Right-of-way acquisition and clearance
2. Construction costs
3. Purchase and installation of traffic signals, signs, and the like. The only other identified social costs are the additional maintenance costs of the road once it is completed.

Frequently there will be social costs that are not incurred by the local government, costs that would not appear in the local budget. As discussed in the appendix, social costs are what the community gives up in undertaking a project. The social costs of a project would include, for example, environmental effects such as increased air or noise pollution and flooding from increased storm water runoff. Social costs would also include costs imposed on households that are dislocated by the project and inconvenience to users of an existing facility during the time that improvements are being made to it.

The planning department estimates that there are no significant environmental effects associated with the North Road project. In addition, no households are to be dislocated and the construction of the project will not have a significant effect on the ability of current users to travel on North Road during the construction time period.

MEASURING BENEFITS AND COSTS OF THE NORTH ROAD PROJECT IN DOLLARS

Now that the staff has identified the costs and the benefits of improving North Road, how can these factors be measured in dollars so that they can be compared with each other and with alternative uses of the funds required for this project?

The improvements to North Road will reduce the costs to motorists of using these routes during peak hours. If North Road were a toll road, we could expect that motorists would be willing to pay a higher price to use the road once it were improved. Knowledge of how much more motorists would be willing to pay for improved travel time at peak hours would represent a dollar value of the benefits received by peak-hour motorists. However, unlike private goods in the marketplace, many goods and services of local government such as roads are not priced. Thus, local government has no revenue measure of benefits as is available to the business firm.

In place of revenues, local government must find a substitute measure of the value of improvements. Three forms of cost savings were identified as resulting from the North Road improvements. The estimated dollar value of these cost savings substitutes for the price information, or the dollar measure of benefits; that is, motorists should be willing to pay an amount up to the cost savings they would obtain if it were a toll road. The data in table 1 are used to estimate the dollar benefits annually for two of the three cost-saving benefits: (1) reduced travel time and (2) reduced vehicle operating costs.

Travel Time Savings

What are some of the projected travel time savings for the improved North Road and for alternate routes? At present, there are 4,000 one-way daily peak-hour trips on North Road and 3,000 on alternative routes; however, once North Road is improved, the city street department (based on traffic count experience with past road improvement projects) estimates that 1,000 daily trips will switch to North Road, decreasing the number of trips by 1,000 on the alternative routes. Thus, as indicated in part I of table 1, there will be 5,000 trips per day on North Road: 4,000 by current users (line A, column 1) plus 1,000 by new users diverted from alternative routes (line B, column 1); 2,000 trips per day will remain on the alternative routes (line C, column 1).

The number of trips per year equals the number of users multiplied by 250 (the estimated number of work days in the year excluding holidays), as shown in column 2, table 1. Because of the increased average speeds on North Road and alternative routes, it is estimated that average trip time will be reduced for all of these users by three minutes per trip, as indicated in column 3. Column 4 gives the estimated number of travel hours saved per year by all peak-hour commuters, a total of 87,500 hours.

What is the value in dollars of 87,500 hours saved in travel time? (Remember that we need to state all benefits and costs in dollars in order to compare them; otherwise we have "apples and oranges," which cannot be added together.) Commuters on North Road will save one-half hour of travel time per week (three minutes per trip times ten trips); this time has value for commuters in terms of either additional work potential or leisure. While the subject of the valuation of travel time is very complex, it is

generally accepted by transportation economists that the value of travel time to a U.S. commuter ranges from one-half of the commuter's gross wage rate to his or her net wage rate (gross wages less income taxes and social security, or take-home pay).

The city staff obtains U.S. Bureau of the Census data from which they estimate that the average salary and wage income of Midway commuters using the North Road and alternative routes is $12,000 per year, or about $6 per hour. So as not to overstate the travel time savings benefits, $3 per hour (one-half the gross wage rate, or the lower end of the potential range) is used to value travel time. At $3 per hour, the benefits of 87,500 hours in reduced travel time shown in part I of table 1 are worth $262,500 annually (87,500 hours times $3 per hour). This is the annual benefit carried over to column 2, table 2, where the dollar value of the benefits and costs of the North Road project are summarized.

Vehicle Operating Cost Savings

The second of the three identified benefits is the reduced operating costs to motorists resulting from higher average speeds and less stop-and-start driving. This will increase mileage per gallon (lower gasoline costs) and result in less wear and tear, especially on brake linings (reduced repair costs). These benefits are estimated in part II of table 1. As indicated in column 1, the North Road trip is 5 miles; the alternative routes average 3.75 miles (at a slower average speed than on North Road, however). The total miles driven annually by peak-hour commuters on all routes are given in column 2, which is equal to miles per trip (column 1) times the number of trips per year (column 2, part I, table 1). The staff has obtained estimates from the state highway department that the average per-mile reduction in operating costs (from lower gasoline and repair costs) would be $.3 if North Road is improved. This per-mile saving (column 3), multi-

Table 1

Benefits of the North Road improvement project: travel time and operating cost savings

I. TRAVEL TIME SAVINGS:	1 Number of One-Way Peak-Hour Trips: Per Day	2 Number of One-Way Peak-Hour Trips: Per Year	3 Reduced Travel Time Per Trip (Minutes)	4 Total Travel Time Savings (Hours Per Year) (2 x 3) ÷ 60
(A) Current Peak-Hour Users of North Road	4,000	1,000,000	3	50,000
(B) New Users Switching to North Road	1,000	250,000	3	12,500
(C) Peak-Hour Commuters Remaining on Alternative Routes	2,000	500,000	3	25,000
				87,500

II. VEHICLE OPERATING COST SAVINGS:	1 Miles Per Trip	2 Total Miles Per Year	3 Reduced Cost Per Mile	4 Total Vehicle Operating Cost Savings
(A) Current Peak-Hour Users of North Road	5	5,000,000	.3¢	$15,000
(B) New Users Switching to North Road	5	1,250,000	.3¢	3,750
(C) Peak-Hour Commuters Remaining on Alternative Routes	3.75	1,875,000	.3¢	5,625
				$24,375

plied by total miles annually (column 2), yields the estimated total vehicle operating cost savings shown in column 4, part II, table 1, or a total of $24,375. This is the annual benefit carried over to column 3, table 2, which summarizes the costs and benefits of the North Road improvement project.

Reduced Accident Costs

The last of the three benefits identified as resulting from the North Road project is a reduction of accidents because of improved traffic flow. The city staff has obtained accident report information from the police department for North Road and alternative routes. After consultation with accident analysts in the police and state highway departments, all parties conclude that reportable accidents would be reduced by fifty per year. An analysis of police accident reports and other available information leads to estimates that the average accident on these routes results in $400 of property damage, $200 in medical expenses, and about four days of absence from work due to injury. The average wage rate of these motorists has already been estimated at $6 per hour, so thirty-two hours times $6 would be $192; thus the staff estimates lost manpower from accidents at $192 per accident.

Adding property damage ($400), medical expenses ($200), and lost manpower or labor output ($192) gives an estimated cost per accident of $792. For the estimated reduction of fifty reportable accidents per year, the annual benefit from reduced accident costs is $39,600. This is the amount of benefit per year carried over to column 4, table 2. It represents a conservative estimate of the benefits of reduced accidents; time lost in getting cars repaired, for example, is not included.

Costs

Measuring the social costs of a project in dollars is usually much easier than measuring social benefits in

Table 2

Benefits and costs per year of the North Road improvement project

1	2	3	4	5	6	7	8	9
	Social Benefits				Social Costs			
Year	Travel Time Savings	Vehicle Operating Cost Savings	Reduced Accident Costs	Total	Projected Capital Costs	Increased Maintenance Costs	Total	Net Social Benefits (5 minus 8)
1					$1,000,000		$1,000,000	$(1,000,000)
2					1,500,000		1,500,000	(1,500,000)
3	$262,500	$24,375	$39,600	$326,475		$30,000	30,000	296,475
4	262,500	24,375	39,600	326,475		30,000	30,000	296,475
5	262,500	24,375	39,600	326,475		30,000	30,000	296,475
6	262,500	24,375	39,600	326,475		30,000	30,000	296,475
7	262,500	24,375	39,600	326,475		30,000	30,000	296,475
8	262,500	24,375	39,600	326,475		30,000	30,000	296,475
9	262,500	24,375	39,600	326,475		30,000	30,000	296,475
10	262,500	24,375	39,600	326,475		30,000	30,000	296,475
11 thru 50	262,500	24,375	39,600	326,475		30,000	30,000	296,475

Note: Numbers in parentheses are negative amounts.

dollars, because many of the social costs of local government projects are incurred through purchases in the marketplace. For example, all of the identified costs of the North Road project ultimately will show up as dollar amounts in Midway's accounting records, and these dollar amounts will be a satisfactory measure of the true cost to the community—that is, the social costs. Evaluation of environmental or other social costs of a project not incurred by government and therefore not reflected in government accounting records is more difficult.

The capital costs of the North Road project (as shown in column 6, table 2) were estimated by the city street department as part of the capital improvements budget. They include right-of-way acquisition costs, obtained from appraiser's estimates, and construction and traffic signalization costs. Construction costs are estimated from the costs of previous work performed by Midway's street department and from previous competitive bids of private contracting firms for road projects. Once the North Road project is completed, there will be a larger road surface, as well as more signals and signs to maintain. These estimated additional costs of maintaining the improved roads are shown in column 7, table 2.

Summary of Benefits and Costs

So far we have identified and measured in dollars the costs and benefits associated with the North Road project. The social benefits were measured in dollars for one year. These benefits, however, will occur for more than one year, since the road improvements will last many years. Therefore the benefits in table 2 are shown beginning in year three (allowing the first two years to complete the project) and occurring for forty-eight years thereafter.

How do we determine that benefits will flow for forty-eight years? The time period is somewhat arbitrary, because no one can predict with certainty how long the road improvements will last. It is certain, however, that roads do not lose their usefulness after just a few years. Physical improvements such as roads and buildings are usually assumed to have a useful life of about fifty years.

Why are the benefits estimated to be the same in each of the forty-eight years? Won't Midway's population increase during the next half century, thereby resulting in higher benefits with the passage of time? Possibly so, yet accurate projections of population growth and demand for the use of North Road fifty years into the future are extremely difficult to make. Thus, to err on the conservative side, constant annual dollar benefits are assumed.

For how many years are costs counted? If the decision to make improvements for North Road is made right now, the right-of-way, construction, and other capital costs will be incurred during the next two years, as shown in column 6. However, the additional maintenance costs will not begin until the North Road project is completed. They are therefore shown beginning in the third year, in column 7.

We began this chapter by defining social profitability as the difference between social benefits and social costs, with the result called the net social benefits. Net social benefits by year are shown in column 9 of table 2 for each year, and are computed by subtracting total social costs (column 8) from total social benefits (column 5). For example, in year one there are no benefits, but capital project costs are $1,000,000, for a net social benefit for year one of *minus* $1,000,000 (that is $0 minus $1,000,000). We cannot add up the net social benefits by year and reach a valid conclusion on the social profitability of this project, however. Before we can state whether the project is in the interest of Midway, we need to consider the third step of cost-benefit analysis: that is, incorporating the time dimension directly into the project evaluation.

BENEFITS AND COSTS OVER TIME

Given a choice between $100 today and $100 one year from now, most people would choose to have the money now. In general, consumption today is preferred to the same amount of consumption sometime in the future. It makes sense that the citizens of Midway would feel similarly about the social benefits to be received from the North Road project or any other project. Given two projects with equal costs today and the same dollar benefits, the project that generates the benefits earlier or the costs later would be preferred.

Computing Present Values

If you put $100 in the bank at 5 percent interest, at the end of a year you will have $105, if interest is compounded annually. Thus, the *future value* of the $100 (the amount that it will be worth in one year) is $105, or:

$$\$100\,(1 + 0.05) = \$105$$

One hundred dollars at the present time are thus equivalent to $105 next year at a 5 percent interest rate. A person's choosing not to put money in the bank tells us that $100 now are equivalent to an amount next year of at least $105 and maybe much more. If the person feels that having $100 today or $105 one year from now are equivalent, then the 5 percent interest rate represents the *opportunity cost of time*—of waiting one year for the money. The 5 percent interest rate measures the willingness to trade $100 today (*present value*) for $105 one year from now (*future value*).

If we know the interest rate that reflects the trade-off to the citizens of Midway between $100 in benefits today and some other greater level of benefits one year from now, we can convert the value of the future benefits into their worth if received today. If this interest rate is 7 percent, the $100 of benefits today are equivalent to $107 of benefits one year from now, or:

$$\$100\,(1 + 0.07) = \$107, \text{ or:}$$

$$\text{Present value} \times (\text{one} + \text{interest rate}) = \text{future value}$$

This equation can also be used to determine the present value of future values, if we know the future value and the interest rate. To do this, divide both sides of the equa-

tion by one plus interest rate:

$$\text{Present value} = \frac{\text{future value}}{\text{one + interest rate}}$$

or:

$$\$100 = \frac{\$107}{1 + 0.07}$$

In other words, if we know future values and the interest rate, we can compute the present value easily. In this process the interest rate is referred to as the *discount rate.* Future values are discounted (given a smaller weight) to convert them to present values.

If $100 of benefits to the city of Midway today are equivalent to $107 received one year from now, what would be the equivalent amount of the benefits if they were not received until two years from now? Obviously, the amount would be more than the $107 to be received in one year. Let us calculate the future value of $107 in yet another year:

Future value = $107 (1 + 0.07) = $114.49, or:

$107 = $100 (1 + 0.07), so

$114.49 = $100 (1+ 0.07) (1 + 0.07) = $100 $(1 + 0.07)^2$

This gives us a formula for computing the present value of benefits received two years from now:

$$\text{Present value} = \frac{\text{future value}}{(1 + r)^2}$$

where r is the discount (interest) rate.

But what about thirty years in the future? Then the exponent in the formula becomes 30 instead of 2, or:

$$\text{Present value} = \frac{\text{future value}}{(1 + r)^{30}}$$

In general, when n = the number of years in the future at which the benefits will occur, the formula is:

$$\text{Present value} = \frac{\text{future value}}{(1 + r)^n}$$

We have explained the concept of present value in terms of benefits. The same principles apply also to costs. In other words, the present value of costs is computed using this same formula, but the future value of costs is substituted in the formula for the future value of benefits.

Present Value of the North Road Project

Table 2, column 9, showed the next social benefits by year of the North Road project stated in dollars of *future* value. What is the *present* value of the net social benefits of the project? Table 3 shows that the total present value of the net social benefits of the project, over fifty years, at a discount rate of 7 percent, is $951,018. A discount rate of 7 percent is used to reflect the opportunity cost of time because this is the interest rate that the city of Midway paid on general obligation bonds issued in recent months. (Other justifications for a choice of discount rates may be used, as discussed later.)

The present value of the net social benefits occurring in each year in table 3 is computed by the formula established above. Future value (column 2) is divided by $(1.07)^n$ (the time discount factor

Table 3

Present value of net social benefits of the North Road improvement project

1 Year	2 Net Social Benefits (Future Value) (column 9, table 2)	3 Time Discount Factor (at 7% Discount Rate)	4 Present Value (column 2 divided by column 3)
1	$(1,000,000)	1.0700	$ (934,579)
2	(1,500,000)	1.1449	(1,310,158)
3	296,475	1.2250	242,020
4	296,475	1.3108	226,179
5	296,475	1.4026	211,375
6	296,475	1.5007	197,558
7	296,475	1.6058	184,628
8	296,475	1.7182	172,550
9	296,475	1.8385	161,259
10	296,475	1.9672	150,709
20	296,475	3.8697	76,614
30	296,475	7.6123	38,947
40	296,475	14.9745	19,799
50	296,475	29.4570	10,065
Total			**$ 951,018**

shown in column 3) to yield the present value (column 4). Thus, for benefits received ten years from now, the discount factor shown in column 3 is $(1.07)^{10}$ or 1.9672; \$296,475 (future value in column 2) divided by 1.9672 equals \$150,709 (present value in column 4). The present value of net social benefits is shown in table 3 for only the first ten years and then for every tenth year thereafter. The procedure is identical for computing the present value for all the years not shown, however. The present values of the net social benefits occurring in each of the fifty years are added together, yielding the total \$951,018 present value of the North Road project as shown at the bottom of column 4.

It may appear that it would take considerable time to compute the present value of the project as done in table 3. With a hand calculator that repeats a multiplication factor, the values shown in column 3 can be obtained quickly by multiplying 1.07×1.07, and multiplying this result by 1.07 as many times as required for the appropriate year in the future. It is easier, however, to use available published tables which give the discount factors for all interest rates. The calculation of all the present value amounts in table 3 took about ten minutes using *Financial Compound Interest and Annuity Tables.*[1]

Three of the four steps in cost-benefit analysis have now been presented. The North Road project is socially profitable to the extent that the present value of the net social benefits exceeds zero. But does this mean that the city council should go ahead and approve the funding of this project, given its limited funds? This is the last step to consider.

SHOULD THE CITY OF MIDWAY UNDERTAKE THE NORTH ROAD PROJECT?

Suppose that the present value of the net social benefits of the North Road project shown in table 3 were \$1 million less; thus the net social benefits would be negative (\$951,018 − \$1,000,000 = \$−48,982). In this case, the city council would not consider the North Road project further, because negative net social benefits indicate that the benefits of the improved road are less than the costs of improving the road. Therefore, the present road is preferable to the improved road, given the costs of improvement.

However, the results of the cost-benefit analysis shown in table 3 indicate that the North Road project has benefits greater than costs, for the present value of the net social benefits (\$951,018) is greater than zero. This finding indicates that the North Road project is preferred to the alternative of leaving North Road as it is now. In other words, this project is preferable to the status quo. But this is not enough information for the city council to make a final decision for going ahead with the project. For one thing, there are other possible ways of improving North Road, such as constructing turn lanes in lieu of total widening. Also, the widening of roads other than North Road could be considered. And we can take an even broader view—perhaps there are other capital improvement projects, including parks, sewers, or new public buildings, that the council might want to consider.

Ideally, cost-benefit analysis would be performed on every alternative capital project that the city believes is worth considering. The projects to the chosen would be those having the highest net social benefits, subject to the amount of funds available. It takes time and effort to perform cost-benefit analysis, however, so that if the city council were to wait for a cost-benefit analysis on all potential projects, a decision on the capital improvements budget might be delayed for years.

Practically speaking, the city council can begin with a list of projects that it believes have positive net social benefits. Then, the staff performs cost-benefit analyses on those projects involving the largest expenditure of funds. This analysis of high expenditure projects will indicate which prospects have the highest net social benefits and will also exclude from further consideration those shown to be socially unprofitable (having negative net social benefits). The elected officials can use this cost-benefit in-

formation on major projects to make their final evaluation and choice among all projects.

The situation is more manageable when the choice to be made is from among potential projects of the same nature. Suppose that the Midway City Council has decided to budget $4.3 million of its capital funds during the next two years for major road improvement projects. The city staff has completed the cost-benefit analysis of the North Road project but has not evaluated any alternative road improvement projects. The identification and measurement of benefits and costs for alternative projects involve similar procedures. Based on the information obtained for the North Road cost-benefit analysis, the staff is asked by the city council to estimate roughly the net social benefits of several alternative major road projects that the council thinks might be socially profitable. The staff evaluates ten other potential road projects and concludes that six of them have negative net social benefits, thereby not warranting further consideration. However, in addition to the North Road project, they estimate that four other projects, shown in table 4, have the net social benefits shown in column 4 and the capital costs shown in column 6.

While all five projects in table 4 are judged to be worthwhile, undertaking all of them would require $7,850,000 from the capital improvement budget, as indicated by the total of column 6, table 4. Yet the city council has only a $4.3 million budget for major road improvement projects for the next two years. Thus, the question becomes, "Which of the five projects should be undertaken subject to a spending limit of $4.3 million?" The criterion to use is to choose those projects that give the largest combined net social benefit without exceeding the budget. The bottom part of table 4 shows three combinations of projects that could be undertaken without exceeding the $4.3 million budget. As indicated, undertaking the North Road project (A) plus the Central Avenue and Adams Street Bridge projects (B and E) yields the highest net social benefit subject to the spending limit of $4.3 million. Accordingly, these are the three major road projects to undertake during the next two years.

In contrast, compare the projects that would be chosen using the criterion of highest cost-benefit ratio—a frequently mentioned criterion for choosing projects. The cost-benefit ratio for each of the five projects is obtained by calculating the ratio of the present value of the social benefits (column 2) and the social costs (column 3), instead of the present value of net social benefits (social benefits minus social costs as shown in column 4). Dividing the present values of social benefits by social costs yields the cost-benefit ratio shown in column 5. A cost-benefit ratio greater than one means that net social benefits are positive. According to the cost-benefit ratio criterion, projects with the highest cost-benefit ratio are chosen, subject to the budget constraint. In the case of the five projects in table 4, project B would be chosen first, followed by projects E and C. These three projects would have total capital costs of $4,150,000 (as shown in the bottom part of table 4) and would be within the budget constraint of $4.3 million. Note, however, that the combination of projects chosen using the cost-benefit ratio criterion (B + C + E) is not the same combination of projects chosen under the criterion of largest combined net social benefit (A + B + E). In this case the cost-benefit ratio criterion should not be used, because the combination of projects with the highest cost-benefit ratio does not give the community the largest net social benefits.

DIFFICULTIES IN PERFORMING COST-BENEFIT ANALYSIS

This section discusses a number of difficulties and subjective elements involved in performing the four steps of cost-benefit analysis. The preceding discussion of the North Road project indicates that cost-benefit analysis is not a totally objective procedure that can be mechanically applied to guarantee without error the best use of local government funds. For example, the results of the North Road analysis depend in part on the discount rate chosen for computing the present value of net social benefits; moreover, the choice of the discount rate is somewhat subjective, as discussed in this section.

The objective of cost-benefit analysis is not to make decisions or choices but to assist elected officials in making them by providing better information on which they can base their decisions. The quality of decisions depends on the quality of available information on which decisions are based; the role of cost-benefit analysis is to provide better quality information to elected officials. At an early point in a cost-benefit analysis, the staff should point out to elected officials the difficulties and subjective elements that are involved in the analysis. The officials should decide how these subjective elements and difficulties will be treated in the cost-benefit analysis. Once this has been done, the staff can complete the cost-benefit analysis for presentation to elected officials with its results reflecting the opinions of elected officials instead of those of the staff.

Identifying Benefits and Costs

Because we are interested in the social (or opportunity) costs of a project, we want to include all relevant project costs, without regard to whether they show up in the local

Table 4

Choosing road projects with largest net social benefits subject to budget constraint
($ thousands)

1	2	3	4	5	6
	Present Value of				
Potential Road Improvement Projects with Estimated Positive Net Social Benefits	**Social Benefits**	**Social Costs**	**Net Social Benefits (col. 2 – col. 3)**	**Benefit Cost-Ratio (col. 2 ÷ col. 3)**	**Capital Costs**
(A) North Road (see table 3)	$3,556	$2,605	$ 951	1.37	$2,500
(B) Central Avenue	758	410	348	1.85	1,000
(C) Lee Boulevard	1,764	1,050	714	1.68	2,600
(D) Fifth Street	1,010	690	320	1.46	1,200
(E) Adams Street Bridge	1,060	610	450	1.74	550
TOTAL			**$2,783**		**$7,850**

Project Combinations	**Net Social Benefits of Combined Projects**	**Capital Costs of Combined Projects**
A + B + E	$1,749	$4,050
B + C + E	1,512	4,150
A + D + E	1,721	4,250

government accounting records or who incurs them. Similarly, we are interested in identifying and including all relevant benefits. By contrast, we want to make sure when we count social benefits that we do not ignore costs somewhere else, as discussed below.

Offsetting benefits and costs. Earlier sections indicated that the North Road project will increase traffic volume on North Road. The greater number of vehicles traveling on North Road may mean that retail establishments (such as quick food operations and service stations) will increase their sales and profits. Should these increased profits of business firms be included as a social benefit of the North Road project? No, if the increased profits of business firms on North Road are offset by decreased sales and profits of retail establishments located on other roads in Midway from which traffic is diverted by the North Road project. In other words, the increased sales and profits in one location are offset by decreased sales and profits in other locations. Therefore, including one result as a benefit by itself is invalid because of the offsetting cost somewhere else. These offsets are called transfers because they result from the transfer of activity from one place to another with no extra benefit guaranteed. Transfer items should not be included.

As another example of this idea of not including transfer items as benefits, consider an education program that will increase the future earnings of its students. These increased earnings are a social benefit, but it is not proper to include the additional taxes they will pay to government as an added benefit, because these taxes will come out of the increased future earnings that have already been counted. In other words, the increased taxes to the public sector are offset by decreased income (take-home pay) to spend in the private sector.

Local versus social benefits and costs. Another aspect of the transfer

concept applies to funds received by local government from outside sources—state or federal grants. The construction costs of the North Road project shown in table 2 are $2.5 million, and all of these costs were included in the cost-benefit analysis of the project. But suppose that $1 million of these construction costs will be financed by grants received from the state highway department. Then, from the local standpoint, the cost is only $1.5 million. Should only $1.5 million be included in the cost-benefit analysis? If so, the present value of the net social benefits of the North Road project will be much higher than those shown in table 3. If nonlocal costs (outside sources of funds for projects) are excluded in cost-benefit analysis of local projects, many projects will appear profitable or show positive net benefits. Yet if social or total costs were included, the projects may not be socially profitable. The cost of the North Road project to society is $2.5 million, not $1.5 million. It would be invalid to consider the $1 million state highway grant as a benefit (or saving in construction costs). Instead, at the local government level, it is a transfer item that is offset by $1 million in costs to the state government and taxpayers of the state.

Admittedly, Midway's elected officials will be more concerned with those costs and benefits of a local project that accrue within the city of Midway as opposed to outside its boundaries. Practically speaking, cost-benefit analysis should include the social (total) costs and benefits, but these may be divided into local and nonlocal components for presentation to local decision makers. For example, the construction costs of the North Road project might be shown as follows:

Local costs	$1,500,000
Nonlocal costs	1,000,000
Social costs	$2,500,000

With this information, local decision makers can determine for themselves whether to proceed with projects that are locally profitable but perhaps not socially profitable.

The preceding discussion of which costs and benefits are relevant to a cost-benefit analysis points out that cost-benefit analysis is concerned with whether a project is socially profitable. Cost-benefit analysis is concerned with achieving economic efficiency in the use of resources, regardless of who derives the benefits and who bears the costs. In other words, the concern in cost-benefit analysis is whether the social benefits outweigh the social costs—not whether the distribution of costs and benefits among communities (or members of a single community) is considered to be fair or equitable. This is the distinction between economic efficiency and equity that is addressed in the appendix. Questions of fairness can usually be dealt with separately so that the efficient use of resources is not totally sacrificed for the sake of equity.

Placing Dollar Values on Benefits and Costs

Government goods and services such as North Road are not normally sold in a competitive market. Thus, prices at which government goods and services can be sold are not available as measures of the value (benefits) that the consumer places on the good or service. Even if market prices were available, they may not be the best measure of social benefits, because a market price measures what people have to pay for a good or service in the market, rather than what they willingly would have paid rather than go without the good or service. An individual will usually be willing to pay more for the first few units of a good or service than for successive units of the same item. This is reflected in market prices by the fact that if price is lowered, the quantity that any and all individuals will purchase will increase.

Measuring benefits in terms of cost reductions. When there are no market prices to refer to directly or indirectly, benefits are frequently computed by measuring reductions in social costs (cost savings) as proxies for social benefits. This approach was taken in the North Road cost-benefit analysis, because there were no market prices for reference. The cost reductions involved the value of time, life, and health saved. The value of the travel time saved by commuters from improving North Road was estimated to equal one-half of their gross wage rate. It was also suggested that the maximum value of travel time was the gross wage rate, net of income taxes. The conceptual difficulties in valuing travel time illustrate the problem of attaching precise dollars to social benefits. To highlight the range of possible benefit values, high and low estimates for travel time savings could be included in a cost-benefit analysis to determine what effect alternative valuations have on resulting social profitability.

One benefit of the North Road project is the decrease in accidents and resulting medical expense and lost work time. Valuation of health and life is frequently required, because many programs result in the reduction of sickness or death—for example, traffic safety measures or health clinics. There are two basic approaches to measuring the benefits of reduced accidents or sickness. The first is to determine the loss of wages that would be avoided because of a reduction in accidents or sickness. This approach, which was used in the cost-benefit analysis of the North Road project, gives a lower limit to benefits measurement, because it does not measure such personal factors as pain and suffering. Under this approach, death is treated as a complete sickness resulting in a loss of work equal to the earnings from the time of death to the normal life expectancy. While objections may be made to valuing human life in terms of lost work income, this valuation method is used in civil courts. Its objectivity is preferable to methods that value human life in less explicit terms. A second approach (which would measure pain and suffering as well) is to determine what individuals are willing to pay to prevent sickness or accidents. Obviously such information is much more difficult to obtain.

Inflation. What about inflation? The future and present values of the costs and benefits of the North Road project shown in tables 2 and 3 were stated in dollars of current purchasing power. Recent history demonstrates that a dollar next year will have less purchasing power than a dollar today. Should benefits in the future be shown in inflated dollars rather than in current dollars as shown in table 2?

If prices in general increase (i.e., there is inflation), the money values of benefits do not rise at a different rate than costs, and the relative relationship between costs and benefits has not changed. Thus, cost-benefit analysis can correctly proceed on the basis of current prices and not actual future prices. In any event, it is extremely difficult to forecast differential movement of prices of various resources.

Intangibles. For some projects, it will be impossible to convert some costs and benefits into dollar values. These are usually referred to as intangible benefits and costs, which should be included in the presentation of the cost-benefit analysis so that decision makers include them in their deliberations. For example, suppose that a project presented to the city council of Midway contains the following information (with all dollar amounts stated in present value terms):

Measurable benefits	$100,000
Intangible benefits: improved scenic view	
Social costs	120,000
Net social benefits	($20,000)

The measured net social benefits are negative $20,000. But if the city council concludes that the intangible benefits are worth at least $20,000, the net social benefits are then positive, and the project warrants further consideration. Possibly additional information can be provided describing intangible benefits (other than dollar amounts) that will assist elected officials in deciding whether the intangible benefits are sufficient to make a project socially profitable. In any event, when intangible benefits and costs are identified, they will at least be con-

sidered together with the measurable benefits and costs.

What Is the Proper Discount Rate?
A discount rate of 7 percent was used to calculate the present value of the net social benefits of the North Road project in table 3. Seven percent was used because this is the rate at which the city of Midway can currently issue general obligation bonds. But does 7 percent represent the real cost of time? For one thing, the reason that municipal bonds can be issued for 7 percent is that they are exempt from federal income taxation; if they were not, the interest rate on the bonds would have been higher —probably around 10 percent.

There is no general agreement on what to use (for example, municipal bond interest rate, corporate bond interest rate, or rate of return on investment in the private sector) as the local government discount rate. Thus, the discount rate chosen for local government cost-benefit analysis will ultimately be decided by local elected officials. The staff can assist in this decision by showing what the present value of the North Road project (and alternative projects) would be at various discount rates. This information is shown for the North Road project in table 5 for a range of discount rates from 7 percent to 15 percent. The North Road project has positive net social benefits from 7 percent through 11 percent. Thus, if elected officials determine that any discount rate below 12 percent is appropriate, the North Road project should be considered further. If it is decided, however, that the appropriate rate is greater than 11 percent, the North Road project would not receive further consideration, because the net social benefits of the project are negative for discount rates above 11 percent.

Table 5

Present value of the North Road project at discount rates of 7 percent to 15 percent

Discount Rate	Present Value of Net Social Benefits
7%	$951,018 (see table 3)
8	885,790
9	548,016
10	276,110
11	54,433
12	(128,143)
13	(279,578)
14	(405,464)
15	(511,458)

Note: Numbers in parentheses are negative amounts.

A word of caution is in order. The above discussion does not mean that elected officials should choose a low discount rate for evaluating popular projects and a higher discount rate for evaluating less attractive projects. Instead, whatever discount rate is chosen should be consistently applied in evaluating all projects under consideration at any one time. In the above example, if it is decided that the appropriate discount rate is 12 percent, then the North Road project and all other projects under consideration should be evaluated at a 12 percent rate of discount.

TIME, COST, AND EXPERTISE

It is readily apparent that considerable time and cost, as well as expertise, may be required to perform the four steps of cost-benefit analysis. Just how much of each will depend on the project under consideration. As indicated earlier, it is not feasible to perform cost-benefit analysis for every conceivable project; therefore, it is important to decide which projects are worth analyzing. Several suggestions follow.

When Should Cost-Benefit Analysis Be Used?
First, projects that involve a major expenditure of local government funds are prime candidates for cost-benefit analysis. Assuring a socially profitable investment is more important when the expenditure equals 10 percent of the capital budget than when 1 percent of the budget is concerned. For major projects, involving complexities of cost-benefit analysis that are beyond staff capabilities, it may be advisable to hire an outside consultant to work with the staff. In many cases, it may not be necessary to pay a consultant to do the entire

job, because staff members could collect data to quantify the benefits and costs with the guidance of a consultant. Local governments employ outside consultants for financial analysis on bond issues and engineering feasibility studies, yet they infrequently seek consultation on economic analysis. Local government officials and staff who become familiar with the steps required to perform cost-benefit analysis, as contained or referenced in this chapter, should be able to recognize when they can perform cost-benefit analysis without a consultant and when one is needed.

The previous section emphasized that there are elements of cost-benefit analysis on which subjective decisions have to be made. It also emphasized that these subjective elements should be brought to the attention of local decision makers at an early stage of the analysis, so that they can make the required decisions on these subjective matters. Once these judgments have been made and incorporated into the cost-benefit analysis, they should also be clearly stated as part of the final report. When outside consultants perform cost-benefit studies of major projects, it may be advisable to hire another, independent consultant to review the study and make a presentation to local government officials.

A second set of projects worth analyzing with cost-benefit analysis includes those of a recurring nature. For example, the methods and procedures used in identifying and measuring the costs and benefits of the North Road project would be applicable to other, comparable road improvement projects that local government considers from time to time. Once a cost-benefit analysis on this sort of project has been performed, the experience gained will be valuable in assessing the social profitability of similar future projects. Also, if outside consultants assist with a cost-benefit analysis of a project of a recurring nature, replication of the analysis for later projects might be done in-house, or at least with a minimum of assistance from consultants.

Other considerations in choosing projects for cost-benefit analysis include the feasibility of quantifying most of the important costs and benefits of a project. When many of the important benefits are intangible (such as those involving important visual or aesthetic considerations), it is probably not worthwhile to engage in a major cost-benefit effort. This does not mean, however, that the cost-benefit approach—that is, identifying and listing the costs and benefits, even if they cannot be readily quantified—is not worthwhile. This information is better than relying on "seat of the pants" decision-making. Another consideration in choosing projects is the availability of relevant information for identifying and quantifying costs and benefits. If the information is not available at reasonable cost within the time period in which a decision must be made, a major cost-benefit effort is probably not worthwhile.

The Benefits to Local Government of Cost-Benefit Analysis

Project evaluations using cost-benefit analysis, and the related technique of cost-effectiveness analysis discussed in chapter 6, are more important today than ever. In the past, state and federal grants restricted how they could be used. There was little incentive for local government to evaluate projects, because grant funds had to be spent in a predetermined manner. Today, however, Community Development Block Grants and other federal and state programs have become less restrictive. As a result, local government has much greater latitude in the expenditure of such funds, and getting the most social profitability out of these funds requires objective appraisal of alternatives.

As discussed before, the objective of cost-benefit analysis is not to make decisions or choices but to assist by providing better information as input into final decisions. Even when formal cost-benefit analysis is not performed in making a decision, the four steps of cost-benefit analysis constitute a useful framework for thinking about alternative uses of funds. If local government officials think in cost-benefit terms about all of their expenditure decisions, an objective appraisal of investment projects will replace more subjective evaluations. In minor cases, useful cost-benefit analysis can literally be done with a pencil on the back of an envelope, which is better than doing nothing at all.

FOOTNOTES

1. *Financial Compound Interest and Annuity Tables*, Fourth Edition (Boston: Financial Publishing Company, 1966). The introduction to this book gives a short and simple explanation of how to use tables that is readily understandable by the lay reader.

E. J. Mishan. *Cost-Benefit Analysis.* New York: Praeger Publishers, 1976.

This text discusses the steps in performing cost-benefit analysis with extensive detail on the underlying concepts and difficulties involved. While very detailed and thorough, the book is understandable by a reader familiar with basic economic concepts, such as those taught in a sophomore-level "principles of economics" course in college.

Robert Dorfman (ed). *Measuring the Benefit of Government Investments.* Washington, D.C.: The Brookings Institution, 1965.

Several case studies applying cost-benefit analysis to health, education, transportation, recreation, and other projects are included here. Some of the cases are more readily comprehensible than others—see especially the chapter by Burton Weisbrod, "Preventing High School Dropouts."

Trevor Newton. *Cost-Benefit Analysis in Administration.* London: Allen & Unwin, 1972.

As stated on the first page, "This book is primarily concerned with practical applications of cost-benefit analysis in public administration. It has been written for the reader who wishes to understand the nature of cost-benefit analysis, but who does not have a grounding in economic theory that underlies it." The book contains applications to transportation, environment, education, recreation, urban redevelopment, and flood relief, all at the local government level.