ECONOMIC EVALUATION

The economic evaluation of a proposed highway -- beyond a basic construction cost estimate -- may then be appropriate. The evaluation may be conducted by means of (a) benefit-cost ratio, (b) net present value, (c) comparison of annual costs, and (c) internal rate of return.

For these methods it is required to know or estimate the following inputs:

1. Construction or initial investment cost

2. Maintenance cost, usually expressed as an annual amount

3. User cost (fuel, oil, tires, repairs, maintenance, purchase price, and accidents) in using the highway

4. Economic analysis period

5. Traffic volume

6. Interest rate.

7. User time and accident costs if included as economic costs.

From a designer's point of view in determining the desired route, the ways in which the cost can be reduced relate primarily to items 1 through 3 above. The ways in which this can be done (bearing in mind the design designation and controls, and desirable practice) for each of these three items is as follows:

• In order to minimize construction and maintenance costs, the highway should be made as short as possible and amounts of cut and fill should be minimized.

• In order to minimize user costs (i.e., the cost of operating the vehicle) grades should be as flat as possible and horizontal alignment should avoid the use of sharp curves.

Clearly, the balance between these features can only result from considerable trial and error, and a change in one feature will invariably result in changes to the others.

An economic evaluation of a transportation project is completed using one of the following methods: present worth (PW), equivalent uniform annual cost (EUAC), benefit– cost ratio (BCR), or internal rate of return (ROR). The reason for selecting one over the other is preference for how the results will be presented. Since transportation projects are usually built to serve traffic over a long period of time, it is necessary to consider the time-dependent value of money over the life of a project.

Present Worth

The most straightforward of the economic evaluation methods is the present worth, (PW) since it represents the current value of all the costs that will be incurred over the lifetime of the project. The general expression for present worth of a project is

$$PW = \sum_{n=0}^{N} \frac{C_n}{(1+i)^n}$$

where

C_n = facility and user costs incurred in year n
N = service life of the facility (in years)
i = rate of interest

Net Present Worth

The present worth of a given cash flow that has both receipts and disbursements is referred to as the net present worth (NPW). The use of an interest rate in an economic evaluation is common practice because it represents the cost of capital. Money spent on a transportation project is no longer available for other investments. Therefore, a minimal value of interest rate is the rate that would have been earned if the money were invested elsewhere. For example, if \$1000 were deposited in a bank at 8 percent interest, its value in five years would be $1000(1+0.08)^5 =$ \$1469.33. Thus, the PW of having \$1469.33 in five years at 8 percent interest is equal to \$1000, and the opportunity cost is 8 percent. Discount rates can be higher or lower, depending on risk of investment and economic conditions. It is helpful to use a cash flow diagram to depict the costs and revenues that will occur over the lifetime of a project. Time is plotted as the horizontal axis and money as the vertical axis, as illustrated in Figure 13.3. Using Eq. 13.5, we can calculate the NPW of the project, which is

$$\text{NPW} = \sum_{n=1}^{N} \frac{R_n}{(1+i)^n} + \frac{S}{(1+i)^n} - \sum_{n=0}^{N} \frac{M_n + O_n + U_n}{(1+i)^n} - C_o$$

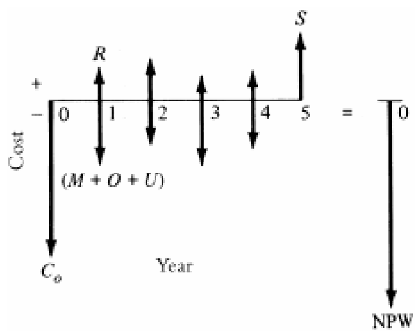

Figure 13.3 Typical Cash Flow Diagram for a Transportation Alternative and Equivalence as Net Present Worth

where

C_o = initial construction cost
n = a specific year
M_n = maintenance cost in year n
O_n = operating cost in year n
U_n = user cost in year n
S = salvage value
R_n = revenues in year n
N = service life, years

Equivalent Uniform Annual Worth

The conversion of a given cash flow to a series of equal annual amounts is referred to as the equivalent uniform annual worth (EUAW). If the uniform amounts are considered to occur at the end of the interest period, then the formula is

Recovery factor (k) = yearly amount required to discharge a debt of (1 unit) in (N) years with interest (*i*)

$$EUAW = NPW\left[\frac{i(1+i)^N}{(1+i)^N - 1}\right] = NPW(A/P - i - N)$$

Similarly,

$$NPW = EUAW\left[\frac{(1+i)^N - 1}{i(1+i)^N}\right] = EUAW(P/A - 1 - N)$$

Where:

EUAW= equivalent uniform annual worth

NPW= net present worth

i = interest rate, expressed as a decimal = 8%

N = number of years (design life) { 20 year for asphalt pavement

40 years for concrete structures

The term in the brackets in above Equation is referred to as the capital recovery factor and represents the amount necessary to repay $1 if N equal payments are made at interest rate i. For example, if a loan is made for $5000 to be repaid in equal monthly payments over a five-year period at 1 percent /month, then the amount is

$$EUAW = 5000\left[\frac{0.01(1+0.01)^{60}}{(1+0.01)^{60} - 1}\right] = 5000(0.02225) = 111.25$$

Thus, 60 payments of $111.25 would repay a $5000 debt, including both principal and interest. The NPW of a cash flow is converted to an EUAW by multiplying the NPW by the capital recovery factor. The inverse of the capital recovery factor is the present worth factor for a uniform series. Thus, the present value of 60 payments of $111.25, at 1 percent per month, is

$$\text{NPW} = 111.25\left[\frac{(1 + 0.01)^{60} - 1}{0.01(1 + 0.01)^{60}}\right] = 111.25(44.96) = 5000$$

Benefit–Cost Ratio

The ratio of the present worth of net project benefits and net project costs is called the benefit– cost ratio (BCR). This method is used in situations where it is desired to show the extent to which an investment in a transportation project will result in a benefit to the investor. To do this, it is necessary to make project comparisons to determine how the added investment compares with the added benefits. The formula for BCR is

$$\text{BCR}_{2/1} = \frac{B_{2/1}}{C_{2/1}}$$

$B_{2/1}$= reduction in user and operation costs between higher-cost Alternative 2 and lower-cost Alternative 1, expressed as PW or EUAW

$C_{2/1}$ = increase in facility costs, expressed as PW or EUAW

If the BCR is 1 or greater, then the higher cost alternative is economically attractive. If the BCR is less than 1, this alternative is discarded.

$$\mathbf{H} = \sum \boldsymbol{C.K} \quad + \boldsymbol{M}$$

H= annual highway costs ($/year)

C= costs of various items

K= recovery factor

M= annual maintenance cost ($/year)

Annual user costs (R) = 365* A* U* L ($/year)

Where:

A= average daily traffic (ADT) (veh./day)

U= road user cost (e.g. vehicle operation cost, travel time cost) ($/veh.km)

L= length of the road (km)

$$B/C = \frac{R1 - R2}{H2 - H1} \quad \text{if } \geq 1 \quad \text{Ok.}$$

$$< 1 \quad \text{not Ok.}$$

Example:

It is recommended to improve an existing road. The characteristics of the road before and after improving are shown in the table below. Find the economic feasibility using benefit to cost ratio (B/C). Assume: Interest ratio (*i*) =8%, design life for concrete structure=40 years, asphalt pavement=20.

Information	Existing road	Improved road
Length (km)	50	50
ADT (vpd)	8000	8000
Maintenance cost ($/km.year)	10	5
Road user costs ($/veh.km)	0.040	0.025
Construction costs ($)	----------	13,000,000
concrete structure	----------	8,000,000
asphalt pavement		

Solution:

By using H=$\sum C.K \quad + M$

H_1=maintenance cost = 50 *(10) = 500 ($/year)

Recovery factor (k)

H_2= 13,000,000*(0.083) +8,000,000*(0.1015) +50*(5) =1,891,250 ($/year)

By using Annual user costs (R) = 365* A* U* L

R_1=365 (8000)* (0.040)*50= 5,840,000 ($/year)

R_2= 365*(8000)*(0.025)*50= 3,650,000 ($/year)

$$B/C = \frac{R1 - R2}{H2 - H1} = \frac{5{,}840{,}000 - 3{,}650{,}000}{1{,}891{,}250 - 500} = 1.158 > \mathbf{1} \quad \text{Ok.}$$

H.W …. Find the solution of the above example by using **NPW**