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**DEPARTMENT OF CONSTRUCTION TECHNOLOGY
AND MANAGEMENT**

**FINANCIAL MANAGEMENT IN
CONSTRUCTION (HB)**

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CHAPTER THREE

METHODS OF INVESTMENT APPRAISAL/ METHODS OF COMPARING ALTERNATIVE PROPOSALS

The usual goal of engineering economy studies is to minimize costs or maximize profits or savings. In selecting among alternatives, there are two types of data input- those which can be expressed in economic terms (often called “reducible” or “tangibles”) and those which cannot be expressed in economic terms (often called “irreducible” or “intangibles”). For the most part of this course deals with those consideration that can be expressed in economic terms (Birr, interest, time), but intangibles are important and will be discussed where appropriate.

A decision alternative is a proposed course of action to be chosen from a set of mutually exclusive alternatives. But not all alternatives are attainable or feasible. A base for comparison is an index containing particular information about series of receipt and disbursements associated with an investment opportunity.

In comparing alternatives several methods are available including:

- a) Present worth method of Analysis
- b) Annual worth method of Analysis
- c) Future worth method of Analysis
- d) Rate of return method of Analysis
- e) Break-even comparison method or break-even Analysis
- f) Benefit-cost Analysis

Each of these methods has advantage and limitations. These are discussed, with examples, to assist in determining the preferred method in analyzing any particular problem.

2.7. PRESENT WORTH METHOD OF ANALYSIS

Present worth represents a measure of future cash flow relative to the time point “now” with the provisions that account for earning opportunities. In this method alternatives are compared on the basis of equivalent present worth. Very important elements in comparing mutually exclusive alternatives by using the present worth analysis method are **interest rate (i)** and **analysis period (n)**. To make such comparison the interest rate i must be known or assumed as resulting choice may depend upon the particular value of interest rate chosen to evaluate the problem. The second element, analysis period, is the time span over which the economic effect of an investment will be evaluated. Analysis period may also said to be the study period or planning horizon. We consider the analysis period to be the required service period; when it is not stated at the outset the analyst chose appropriate analysis period to study the alternative investment projects.

The length of life for each alternative also should be carefully considered, because in the case of present worth analysis method only alternatives with the save analysis period can be compared. In the practical conditions three different situations probably encountered.

Such as:-

- Each alternative has the same useful life span
- Alternatives with different life spans
- The lives are very long(perpetual life)

Describing Cash Flow

Most engineering economics problems involve two dissimilar types of accounts:

First, there is the investment, which is usually made in a lump sum at the beginning of the project. Although not literally made “today”, the investment made at a specific point in time that, for analytical purposes, is called today, or time 0.

Second, there is a stream of cash benefits that are expected to result from the investment over a period of future years.

An investment made and money lend by a bank have essential common characteristics in that funds are committed today in the expectation of their earning a return in the future. In the case of bank loan, the future return takes the form of interest plus payment of the principal. This is known as loan cash flow. In the case of the fixed asset, the future return takes the form of profits generated by productive use of the asset. The presentation of this future earning along with the capital..

Until the 1950's the **payback method** was widely used as a means of making investment decisions. As imperfections in this method were recognized, however, business people began to search for methods to improve project evaluation. The result was the development of discounted cash flow techniques (DCF), which take into account the time value of money. One of the DCF's is the Net Present Worth method (NPW). A capital investment problem is essentially one of determining whether the anticipated cash inflows from a proposed project are sufficiently attractive to invest funds in the project. As we observed, the most convenient point at which to calculate the equivalent values is often at time 0. Under the NPW criterion, the present worth of all cash inflows is compared against the present worth of all cash outflows associated with an investment project. The difference between the present worth of these cash flows, referred to as the net present worth (NPW), determines whether or not the project is an acceptable investment. When two or more projects are under consideration, NPW analysis further allows us to select the best project by comparing their NPW figures.

1. Initial project screening

The purpose of initial project screening to eliminate some alternatives that can be easily detected to be unfit by defining MARR (Minimum Attractive Rate of Return) and using a simple technique called payback period.

The Minimum Attractive Rate of Return (MARR) is a reasonable rate of return established for the evaluation and selection of alternatives. A project is not economically viable unless it is expected to return at least the MARR. MARR is also referred to as the hurdle rate, cutoff rate, benchmark rate, and minimum acceptable rate of return.

Payback period is the time required to accumulate a sum of money from a net cash flow which is equal to the initial investment. This method was used in the 1950s as the main comparison method. But nowadays it only employed in the initial screening of projects as a result of its significant drawbacks.

Number for years elapsed to make $\sum_{t=0}^{t=n} (C_t - B_t) = 0$ is said to be payback period. The pay back period is often used without discounting as a first short hand indication of alternatives of projects. For decision criteria we prefer a project with small payback period. This is because in case risk arises we could replace the investment very frequently.

This method is simple but has drawbacks. Such as:-

- ◆ It doesn't consider time value of money(undiscounted)
- ◆ Fail to measure profitability
- ◆ Neglect the return after the payback period

Example:-which project has the smaller pay back period between projects A&B.

Year	Project A	Project B	
0	-2400	-4000	Initial
1	1300	1000	
2	1100	1500	
3	1000	1500	
4	500	2500	
5	400	4000	

The payback period of the project A is 2 years and the payback period of the project B is 3 years.

2. Net Present worth Criteria

In present worth analysis, we assume that all the funds in a firm's treasury can be placed in investments that yield a return equal to MARR. We may view these funds as an investment pool. Alternatively, if no funds are available for the investment, we assume the firm can borrow them at the MARR from the capital market.

An investment pool is equivalent to a firm's treasury where all fund transactions are administered and managed by the firm's controller. The firm may withdraw funds from this investment pool for other investment purposes, but if left in the pool, these funds will earn at the MARR. Thus, in investment analysis, net cash flows will be net cash flows relative to this investment pool.

Let's summarize the basic procedure for applying the present worth criterion to a typical investment project.

- Determine the interest rate that the firm wishes to earn on its investment. The interest rate you determine represents the rate at which the firm can always invest the money in its investment pool. This interest rate is often referred to as either a required rate of return or a minimum attractive rate of return (MARR). Usually this selection is a policy decision made by top management. It is possible for the MARR to change over the life of a project, but for now we will use a single rate of interest when calculating NPW. One method of selecting MARR is to examine the proposal available for investment and to identify the maximum rate of return that can be earned if the funds are not invested. For example, an individual should avoid selecting a MARR that is less than the interest rates banks are paying on saving accounts.
- Estimate the service life of the project.
- Estimate the cash outflow over each service period
- Determine the net cash flows, i.e.

$$\text{Net cash flow} = \text{Cash Inflow} - \text{Cash Outflow}$$

Find the present worth of each net cash flow at the MARR. Add up these present worth figure; their sum is defined as the project's NPW.

$$P(i) = \frac{A_1}{(1+i)^1} + \frac{A_2}{(1+i)^2} + \dots + \frac{A_n}{(1+i)^n}, \quad \text{Where: } P(i) = \text{NPW calculated at } i$$

A_n = net cash flow at period n

i = MARR (or cost of capital)

n = service life of the project

“ A ” will be positive if the corresponding period has a net cash inflow or negative if there is a net cash outflow. In this context, a positive NPW means the equivalent worth of the inflows is greater than the equivalent worth of the outflows, so, the project makes a profit. Therefore, if the $P(i)$ is positive for a single project, the project should be accepted; if negative it should be rejected. **The decision rule is:**

If $P(i) > 0$, **accept** the investment

If $P(i) = 0$, **remain** indifference

If $P(i) < 0$, **reject** the investment

3. Comparison of Alternatives with Equal Life Span

In the case of analysis of alternatives with equal life span, the analysis period considered to be the useful life of the alternatives regardless of the planning horizon if any. And the computation is simple mathematical calculation. See the following illustration examples.

Example-1: Alternatives with equal life span:

An engineer is in need of an Excavator for business purposes, and finds that a suitable one can be obtained by either of two methods: (a) lease a car for \$10,000 per month for two years, paid monthly at the end of each month, or (b) purchase the same type of car for

\$500,000 now and sell it in two years for \$300,000. In either case, the engineer pays all operating maintenance and insurance costs. He can borrow fund for either alternative from the local bank at 9% interest. Which is the least costly alternative, assuming interest is compounded monthly?

Solution

Since the life spans of both alternatives are equal, the alternatives can be compared directly by finding the net present worth of each and selecting the one with least cost.

- i. Lease: The NPW of the lease alternative is present worth of the 24 payments of Birr 1,500 per month.

$$P_1 = \$10,000(P/A, 9/12\%, 24)$$

$$= \$10,000(P/A, 0.75\%, 24)$$

$$P_1 = -\$10,000 \frac{(1 + 0.0075)^{24} - 1}{0.0075(1 + 0.0075)^{24}}$$

$$NPW = -\$10,000 (21.889) = \$ -218,891.50$$

- ii. Purchase: The NPW of the purchase alternative is the present worth of the purchase price minus the present worth of the income from the resale at the end of two years.

$$P_2 = -\$500,000 \text{ purchase price}$$

$$P_3 = +\$300,000(P/F, 0.75\%, 24)$$

$$P_3 = +\$300,000 \frac{1}{(1 + 0.0075)^{24}} = +\$250,749.40 \text{ resale}$$

$$NPW = P_2 + P_3 = -500,000 + 250,749.4 = \$ -249,250.6$$

Comparing the present worth, it is apparent that the cost of the lease alternative is much less expensive than the cost of the purchase alternative. So, leasing the car is recommendable.

Exercise: Compare the two alternatives with equal lives.

Assume you are asked to compare current garbage pickup costs versus the cost of a new mechanical arm extending from the garbage truck which pickup garbage cans at curbside and empties them into the truck.

The estimated costs are:

New mechanical arm.....=B 22,000

Salvage value in 10years.....=B 2,000

O&M first year.....=B 500/year

Increase in O&M per year.....=B 100/yr/yr,

The mechanical arm will replace one person on the crew who now draws B 4,000/yr with anticipated increase of B 300/yr. Compare using present worth method for $i=6$ percent.

4. Comparison of alternative with different life spans

Frequently two or more alternatives occur that do not have identical life expectancies. These cannot be compared directly by means of present worth. For instance, alternative A with an NPW of B 20,000 and a life of ten years is probably less costly than alternative B with an NPW of B 15,000 and a life of five years. Even though alternative A has a higher NPW, the much longer life of A more than compensates for the higher cost (using a normal range of interest rates). Thus the life expectancy is an important factor and must be taken into account.

To account for the differences in life expectancy, two methods are available:

1. Assume future replacements for the shorter lived alternatives to obtain equal life spans. In the case of a ten-year A and five-year B, assume B will be replaced in five years with a similar installation. This compares one ten-year A with two sequential five year B alternatives. If A were ten years and B were four years, then two ten years A's (20 years) could be compared to five sequences of B at ten years. Each (also 20 years)
2. The second method involves shortening the comparison period to the expected life span of the shorter alternative and attributing a salvage value to the longer lived alternative. For instance, in comparing the ten-year A to be five-year B, the life of A would be shortened to five year and some estimated salvage value placed on A at the end of five years and credited to A in the comparison.

Example An engineer has a choice of paving with either type A pavement or type B pavement. Type A pavement has a life expectancy of ten years, after which part of the material can be salvaged and reused. Type B pavement only lasts for five years but is much less expensive. Which is the better alternative? Two sequential five-year installations of type B are compared to one ten-year life of type A.

Description	Pavement cost(\$)/ Km	
	Type A	Type B
Purchasing price	20,000	5,000
Annual maintenance cost	1,000	2,000
Salvage value	2,500	0
Useful life, n	10	5
Interest, i	6%	6%

Solution:

Find present worth of each

Type A

Cash items	Formula	Present worth value
Purchasing price	-----	-\$20,000

Annual maintenance cost	$-\$1,000(P/A, 6\%, 10)$	$-\$7,360$
Salvage value	$+\$2,500(P/F, 6\%, 10)$	$+\$1,396$
Net Present worth (NPW)		$-\\$25,964$

Type B

Cash items	Formula	Present worth value
Purchasing price	$-\$5,000 + -\$5,000(P/F, 6\%, 5)$	$-\$8,736.29$
Annual maintenance cost	$-\$2,000(P/A, 6\%, 10)$	$-\$14,720$
Salvage value	0	0
Net Present worth (NPW)		$-\\$23,456.29$

Comparing the two alternatives, type B is the less expensive. Notice that the assumption was made that the second application costs the same as the first. This is usually not the case due to inflation. If inflation raises prices by 3 percent compounded every year, the price of the second application could be computed as:

$$F = \$5,000(F/P, 3\%, 5) = \$5,000 \times 1.159 = \$5,795$$

The present worth of the second application then becomes

$$P = \$5,795(F/P, 6\%, 5) = \$5,795 \times 0.74373 = \$4,330$$

And the total PW for type B becomes \$24,050, still the lower of the two options. If the annual maintenance also rises for the second five year period for e.g. To \$2,500 per year, the present worth may be found as:

$$P = \$2,500(P/A, 6\%, 5)(P/F, 6\%, 5) + \$2,000(P/A, 6\%, 5)$$

$$P = \$2,500 \times 4.212 \times 0.7473 + \$2,000 \times 4.212 = \$16,293$$

The total present worth for type B becomes \$25,623 still the lower of the two options.

Note

In the comparison alternatives of different useful life it is compulsory to meet the investment's target in the planning horizon or analysis period which set by organizations. Unless and otherwise omitted in the analysis process we stick to the given planning horizon. If it is unstated in the investment's plan, we use LCM of the alternatives' useful life as analysis period.

Nomenclature:

PTZ = problem time zero, present time according to the statement of the problem narrative.

ETZ = Equation time zero, with reference to a particular payment series, the time at which $n=0$. Where the beginning or end of a series does not conveniently correspond with PTZ, a separate ETZ may be used to designate the beginning point in time for a particular series under consideration. For a periodic series of equal payment; the ETZ is always either one period before the payment occurs (P/A) or at the time to the last payment (F/A),

Problems involving the present worth of a periodic series can be divided into three groups, as listed below:

Group I: Periodic series of payments begins at the present time,

$$PTZ = ETZ$$

- a) Periodic series consider with economic life
- b) Periodic series is divided into two or more parts, a or b.

$$P_a = A_1 (P/A_1, a)$$

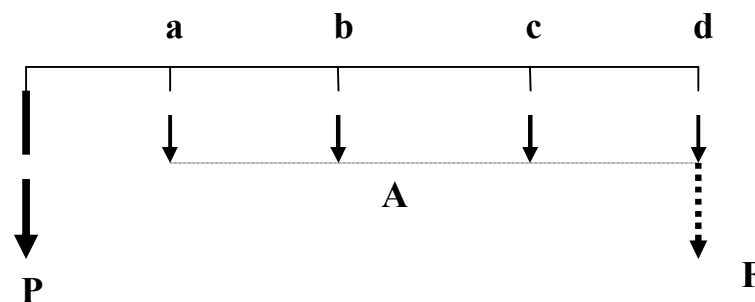
$$P_b = A_2 (P/A_2, b) (P/F_1, a)$$

Group II: Periodic series of payments begins in the past; the ETZ is earlier than the PTZ

$$\rightarrow ETZ > PTZ$$

Group III: Periodic series of payments will begin sometime in the future, PTZ earlier than ETZ

$$\rightarrow ETZ < PTZ$$



Note: the letters, a, b, c, d represent some numbers of time periods; as shown in the above Cash flow diagrams. For the periodic series the number of payments is always equal to the number of time periods and the last payment always occurs at the end of the last period. All payments in a given series are of equal amounts, designated A thus ETZ always occurs either one period before the first payment in the series for P/A or at the time of the last payment for F/A .

Example: Find the cost of excavation in terms of Birr per cubic meter over the 60-months life of the excavator whose data are listed below. Use $i = 1\%/month$

Excavation cost new = -B 2,000,000

Resale value at EOM 60 = + 500,000

O&M = -40,000/month

Gradient on O&M = -500/month/month

Periodic overhaul every 6 months = -120,000/each

Gradient in periodic overhaul = -8,000/each/6month

Expected production = 200,000m³/month

The first periodic overhaul occurs at EOM 6 and the last at EOM 60.

Solution

The effective interest rate for a six month interval is determined first as

$$i_e = (i+1)^m - 1 = (1.01)^6 - 1 = 6.15\%$$

Then the present worth of each cost item is calculated and summed as follows:

Cost new, $P_1 = -\text{Birr } 2,000,000$

Resale $P_2 = +500,000 (P/F, 1\%, 60) = +500,000 (0.5505) = +275,230$

$$\text{O\&M, } P_3 = -40,000 (P/A, 1\%, 60) = 40,000 (44.055) = 1,798,200$$

$$\text{O\&M, } P_4 = -500 (P/C, 1\%, 60) = 500 (1192.81) = 596,400$$

$$\text{Periodic overhaul, } P_5 = -120,000 (P/A, 6.15\%, 10) = 87,720$$

$$\text{Periodic overhaul, } P_6 = -8,000 (P/C, 6.15\%, 10) = -8,000 (29.82) = -234,560$$

$$\text{NPW} = P_7 = -\text{Birr } 5,231,140$$

$$\text{Monthly equivalent, } A = 5,231,140 (A/P, 1\%, 60)$$

$$= \text{Birr } 116,340/\text{month}$$

$$\text{Unit cost} = \frac{\text{Birr } 116,340/\text{month}}{200,000\text{m}^3/\text{month}}$$

$$= 200,000\text{m}^3/\text{month}$$

$$= \underline{\underline{0.5817 \text{ Birr/m}^3}}$$

Merits and Demerits of Present Worth Analysis

Merit of Present worth analysis

- It is a criterion for deciding a single project whether to funded or not;
- It is a criterion of choosing the best alternative among the mutually exclusive projects.

Demerit of present worth analysis

- It is sensitive to the choice of an interest rate or discounting rate;
- It is sensitive to the choice of base year;

Example: Assume $F = 1000$ and $n = 10$

$$\text{For } i = 10\% \quad P = 386$$

$$\text{For } i = 15\% \quad P = 247$$

$$\text{For } i = 20\% \quad P = 162$$

For the same value of **F**uture value and **A**nnual values we may have different value of **P**resent worth based on the interest used. The same is true if we use different base year **n** for the fixed vale of interest rate.

- It doesn't give information about the degree of acceptability, especially if there are many investment alternatives for limited budget.

Example: assume that the available budget is \$800,000 only and five alternative investments are given below with their present value of costs and benefit expected.

<u>Project</u>	<u>PVC</u>	<u>PVB</u>	<u>NPV(10%)</u>	<u>B/C(10%)</u>
A	10,000	13,000	3,000	1.3
B	40,000	43,300	3,300	1.08
C	20,000	30,300	10,300	1.52
D	40,000	49,400	9,400	1.24
E	50,000	55,800	5,800	1.11

When the projects ranked based on NPV and B/C approach, it looks like as follow:

NPV	C, D, E, B and A
B/C	C, A, D, E and B

If we use the NPW ranking, we will get a net amount of Birr 22,000. And if the budget invested according to B/C ranking the net amount expected to be Birr 23,900. This implies that the NPW ranking couldn't lead to the profitability of investments compared to B/C ratio method.

Capitalized cost of perpetual lives ($n \rightarrow \infty$)

This term has two popular meanings. Accountants use capitalized cost to describe expenditures that may be depreciated over more than one year, as contrasted to expenditures that may be written off entirely in the year they were made. The second meaning for capitalized cost is found in the traditional literature of engineering economy. Here capitalized cost refers to the lump sum amount required to purchase and maintain a project in perpetuity (present worth for $n = \infty$). Capitalized cost problem involve one or more of the following categories of payment:

In order to make the best possible use of their available resources, many people spend a great deal of time analyzing, managing, operating, buying, selling, or trading property. This property may consist of machines, vehicles, structures, or real estate, whatever happens to be of great use or value to the interested party at the time. Property ownership and operation usually involves cash flows of income and/or cost, both periodic series and lump sums occurring at various points in time. The basic approach is to separate the problem into simple components, solve each component, transform each component into an equivalent present worth and then sum the results to determine the net present worth of the entire investment. It is a present worth of a project that is assumed to last forever.

Example: Public worth projects such as Dams, Irrigation systems, railroads, permanent universities, etc. analyzed by using Capitalized cost.

$$\text{Capitalized cost} = A/i$$

The relation obtained from the equation $P = A \frac{[(1+i)^n - 1]}{i * (1+i)^n} \Rightarrow \frac{A}{i} \left[\frac{(1+i)^n}{(1+i)^n} - \frac{1}{(1+i)^n} \right]$, when n

goes to infinity $CC = \frac{A}{i}$

Procedures

- i. Draw cash flow diagram showing all recurring (one-time) costs/incomes and at least 2 cycle of non-recurring (periodic) costs/receipts.
- ii. Find the present value of all non-recurring costs/receipts.
- iii. Find equivalent uniform annual worth (value) through one life cycle of all recurring amounts and add it to all other uniform amounts occurring in year 1 through infinity. This results in a total equivalent uniform annual worth (Aw).
- iv. Divide the annual worth obtained in step (iii) by the interest rate (i) to get capitalized costs.
- v. Add the value obtained in step (ii) to the value obtained in step (iv). The result of this step is the Present worth of the project/investment.

3.2. THE FUTURE WORTH METHOD OF ANALYSIS

The future worth (FW) of an alternative may be determined directly from the cash flows, or by multiplying the PW value by the FP factor, at the established MARR. The n value in the FP factor is either the LCM value or a specified study period. Analysis of alternatives using FW values is especially applicable to large capital investment decisions when a prime goal is to maximize the *future wealth* of a corporation's stockholders.

Future worth analysis over a specified study period is often utilized if the asset (equipment, a building, etc.) might be sold or traded at some time before the expected life is reached. Suppose an entrepreneur is planning to buy a company and expects to trade it within 3 years. FW analysis is the best method to help with the decision to sell or keep it 3 years hence. Another excellent application of FW analysis is for projects that will come online at the end of a multiyear investment period, such as electric generation facilities, toll roads, airports, and the like. They are analyzed using the FW value of investment commitments made during construction.

The selection guidelines for FW analysis are the same as for PW analysis; $FW \geq 0$ means the MARR is met or exceeded. For two or more mutually exclusive alternatives, select the one with the numerically largest FW value.

Example: - An investment of \$10,000 can be made that will produce a uniform annual of \$5,500 for five years and then have a market (salvage) value of \$2,000. Annual expenses will be \$3,150 each year. The company is willing to accept any project that will earn 10% per year or more, on all invested capital. Show whether this is a desirable investment by using the FW method.

Solution:

$$\begin{aligned} FW (10\%) &= -10,000 (F/P, 10\%, 5) + 2,350 (F/A, 10\%, 5) + 2,000 \\ &= -10,000 (1.6105) + 2,350 (6.1051) + 2,000 \\ &= -16,105 + 14,347 + 2,000 = 242 \end{aligned}$$

Since $FW (10\%) > 0$, it is a good project.

Example: - A piece of new equipment has been proposed by engineers to increase the productivity of a certain manual welding operation. The investment cost is \$25,000, and the equipment will have a market value of \$5,000 at the end of a study period of five years. Increased productivity attributable to the equipment will amount to \$8,000 per year after extra operating costs have been subtracted from the revenue generated by the additional production. If the firm's MARR is 20% per year, is this proposal a sound one? Use the FW method.

Solution

$$\begin{aligned} FW (20\%) &= -\$25,000 (F/P, 20\%, 5) + \$8,000 (F/A, 20\%, 5) + \$5,000 \\ &= -\$25,000 (2.4883) + \$8,000 (7.4416) + \$5,000 \\ &= -\$62,207.5 + \$59,532.8 + \$5,000 \\ &= \$2,325.3 \end{aligned}$$

3.3. THE ANNUAL WORTH METHOD OF ANALYSIS

One common method of comparing alternative proposals is to reduce all cash flows involved in each proposal to an equivalent series of periodic payment.

The alternative with least costly may be the better selection provided that productivity, safety, appearance and other factors are at least equal to the other alternative. The period selected for this example yearly, but any suitable interval that fits the problem will do (quarterly, monthly, weekly, daily, biennially, etc.) This method may be used for even the most sophisticated analysis. However, since the results of this method are intuitively understandable, it is particularly useful when making presentations to the public or to other decision-making groups with limited background in time-value of money. Where as present worth (PW) might be a difficult concept to present without lengthy preparation, a simple comparison annual payment is often grasped by even the most casual audience with relative ease.

The major advantage of the annual worth method of comparing alternatives on the basis of periodic payments is that the complication of unequal lives between alternatives is automatically taken into account without any extra computations. This automatic feature is predicated on the assumption of equal replacement cost. With this assumption, the Aw technique will yield the same decision as the PW technique.

Basic Approach

The recommended approach to solving even the most complex problems involves a three-step approach:

- a) Subdivide into simple components,
- b) Solve the components and,
- c) Fit together the component solutions into a solution for the original problem.

Applying this basic procedure to annual worth problems involves the recognition of the standard types of cash flow typically encountered. These cash flows occur in three basic types:

1. Single-payment lump sum
2. Periodic series of equal payments
3. Periodic series of equal payments
 - a. Arithmetic gradient
 - b. Geometric gradient
 - c. Irregular amounts

In addition to the types of cash flows, the relative points in time at which the cash flows occur must be considered. For instance, when converting a single payment to an equivalent annual series, the single payment may occur before or after the beginning or end of the annual worth series. The period series of one component of the problem may not coincide in beginning or ending date with the periodic series needed for solution of the entire problem.

Evaluating Alternatives

The annual worth method is typically the easiest to apply of the evaluation techniques when the MARR is specified. The AW is calculated over the respective life of each alternative, and

the selection guidelines are the same as those used for the PW method. For mutually exclusive alternatives, whether cost- or revenue-based, the guidelines are as follows:

- **One alternative:** If $AW \geq 0$, the requested MARR is met or exceeded and the alternative is economically justified.
- **Two or more alternatives:** Select the alternative with the AW that is **numerically largest**, that is, less negative or more positive. This indicates a lower AW of cost for cost alternatives or a larger AW of net cash flows for revenue alternatives.

Example: - Two roofs are under consideration for a building needed for 20yrs. Their anticipated costs and life's are:

	Roof C	Roof D
Cost new (Birr)	50,000	25,000
Replacement cost (Birr)	-	rise 8 %/yr
Life of roof (yr.)	20	10
Salvage value (Birr)	0	0
Interest rate (%)	10	10

Solution

Roof C

$$A_1 = -B \ 50,000 (A/P, 10\%, 20) = -B \ 5,875/\text{yr.}$$

Roof D

$$A_2 = -B \ 25,000 (A/P, 10, 20) = -B \ 2,937/\text{yr.}$$

$$A_3 = -B \ 25,000 (F/P, 8\%, 10)(P/F, 10\%, 10)(A/P, 10\%, 20) \\ = -B \ 2,445/\text{yr}$$

$$\text{Net annual worth of roof D} = A_2 + A_3 = -B \ 5,382/\text{yr}$$

Therefore, Roof D alternative is selected because of its list cost.

3.4. RATE OF RETURN METHOD OF ANALYSIS

The rate of return (ROR) for a series of cash flows is that particular value, $i\%$, of the interest rate for which the NPV vanishes ($NPV = 0$). A return of Birr 6 interest per year on a deposit of birr 100 is easily understood to imply a rate of return of 6%

In order to apply the rate of return method each alternative investment must have a numerically measurable return of income or some equivalent value. Then the rate of return is calculated as the percent interest at which the present worth of the cost equals the present worth of the income. This, of course, is also the percent interest at which the equivalent annual cost equals the annual income, as well as the percent interest at which the future worth of cost equals future worth of income.

Step-by-step procedure for finding ROR Analysis

Step 1- Make a guess at a trial rate of return.

Step 2- Count the costs as negative (-) and the income or savings as positive (+). Then find the equivalent net worth of all costs and income. Use present worth, annual or future worth.

Step 3- If the equivalent net worth is positive, then the income from the investment is worth more than the cost of the investment and the actual present return is higher than the trial rate (i).

Step 4- Adjust the estimates of the trial rate, of return and proceed with steps 2 and 3 again until one of (i) is found that results in a positive (+) equivalent net worth, and another higher value of (i) is found with a negative (-) equivalent net worth.

Step 5- Solve for the correct value of (i) by interpolation.

Example: - Assume a bond sells for Birr 950. The bond holder will receive Birr 60 per year interest as well as \$1,000 (the face amount of this bond) at the end of ten years. Find the rate of return

Solution:- Find the interest rate at which the present worth of the income equals the present worth of the cost.

Step 1. Let trial $i = 7\%$

Step 2. Income $P_1 = B\ 60/\text{yr}$ ($P/A, 7\%, 10$) = \$421.44

Income $P_2 = B\ 1000$ ($P/F, 7\%, 10$) = 508.30

Cost $P_3 =$ = - B950

Net present worth = - B 20.26

Step 3. The present worth is negative so the trial rate, 7% is too high

Step 4. Adjust the estimate downward to, say, 6%. Then,

$P_1 = B\ 441.60$

$P_2 = B\ 558.40$

$P_3 = B\ 950.00$

+B 50.00

i value	NPW
6%	+50
ROR I	0
7%	-20.26

Interpolating for (ROR) I we can find 6.7% to be the internal rate of return.

Example: - An entire fleet of earthmoving equipment may be purchased for 2,600,000. The anticipated income from the equipment is 920,000/yr with direct expenses of 420,000/yr. the market value after five years is expected to be 1,000,000. What is the rate of return?

Solution:

1. Assume $i = 10\%$ 1st trial.

2. Find present worth of all income and costs

Income = 920,000/yr

Expenses = -420,000/yr

Net annual income = 500,000/yr

The present worth of this net income for five years is:

$500,000/\text{yr}$ ($P/A, 10\%, 5$) = 1,895,500

The present worth due to income from market value is:

$1,000,000$ ($P/A, 10\%, 5$) = 620,900

Total PW of income = \$ 1,985,500 + 620,900 = +2,516,400

Cost = - 2,600,000

3. The result is a negative NPW, so that trial estimate is too high.
4. Revise the trial to 8%

$$\begin{aligned}
 \text{PW of net income} &= 1,996,500 \\
 \text{PW of market value in 5yrs} &= 680,600 \\
 \text{Total PW of income 8\%} &= +2,677,100
 \end{aligned}$$

$$\text{Cost} = -2,600,000$$

The result is a positive NPW, so that the rate of return is higher than 8% percent interpolation will give

$$\text{Rate of return} = \frac{8\% + 77,108 * 2\%}{160,708} = \underline{8.96\%} = 9\%$$

Obviously, for comparing alternatives the one with higher rate of return is the best alternative.

3.5. INCREMENTAL RATE OF RETURN

The incremental rate of return (IROR) is defined as the rate of return for additional initial investment when comparing against a lower cost investment. Two types of investment decision occur. The first type involves costs only. Under such conditions the rate of return for each investment is negative and, thus need not be calculated. The second type involves both costs and revenues, and rise the question to be answered is “which alternatives yields the lowest equivalent cost?”

To determine the following procedure should be followed;

1. list alternatives in order of ascending first cost;
2. Step wise determine IROR for each difference in alternatives compared. *(the same procedure used as IRR)*

Decision rule

The decision of selecting the desirable alternative using IROR method is based on the MARR.

- a. If $\text{IROR} > \text{MARR}$, discard the lower cost alternative (defender)
- b. If $\text{IROR} < \text{MARR}$, discard the higher initial cost alternative (challenger)

Even though PW, Fw or Fw usually yields the answer for selecting the best alternative in such less effect; IROR is required for the following two reasons. The first is, when the MARR is not known thus each alternative must be examined to determine over what range (if any) of interest rate (i) it will be the best alternative. And the second is, the client wishes to know the anticipated rate of return on the proposed investment and incremental investment.

Example: Suppose that a cement production company need to compare five alternatives for equipment purchase. Assumed that each had the first cost and IROR of each challenger with respect to their defender are listed below. Which alternative is best by using $\text{MARR} = 15\%$.

Alternatives verses First cost

Alternatives	First cost
A	1,000,000
B	1,200,000
C	900,000
D	1,150,000
E	1,400,000

IROR values of the incremental values of alternatives

Incremental	A-C	D-C	D-A	B-C	B-A	B-D	E-C	E-A	E-D	E-B
IROR , %	24.1%	14%	5.2	20.8	13.9	10.1	11.2	7.9	8.2	9.6

Solution

List the alternatives in order of ascending first cost.

C 900,000
 A 1,000,000
 D 1,150,000
 B 1,200,000
 E 1,400,000

Assuming the additional information on operating cost, salvage value etc. are provided implicitly. From these the term IROR values are derived list in matrix table as shown below.

	A	D	B	E
C	24.1%	14%	20.8%	11.2%
A		5.2%	13.9%	7.9%
D			10.1%	8.2%
B				9.6%

Way of selecting the best alternatives

- From the first row of the matrix, take the larger value of IROR and check whether it exceed MARR or not. If it is greater than MARR the challenger is accepted temporarily and check the row of the challenger where it considered as defender by the same procedure compare each alternatives.
- The IROR values on the row to the right of C are examined and the largest one is 24.1%. Since it is greater than the MARR the challenger alternative is selected temporarily. Then when we check the row of A the maximum value is 13.9% which is less than MARR, so the defender alternative A selected.

3.6. BREAK EVEN COMPARISONS

The break-even point may be found by following the logical three-step procedure, as follows:

1. find the annual equivalent of the capital costs
2. Find the independent variable and set up an equation for each alternative cost combination. The equation usually takes the form of

$$\text{Total annual cost} = \text{equivalent capital Cost} + (\text{cost/ variable unit}) * (\text{Number of variable units/yr})$$

$$\text{TAC} = \text{FAC} + \text{VAC}$$
3. Find the breakeven point.

Example:- A contractor is thinking of selling his present dump truck and buying a new one. The new truck costs 30,000 and is expected to incur O&M costs of 0.10 per ton-mile. It has a life of 15 years with no significant salvage value. The presently owned truck can be sold now for 10,000. If kept it will cost 0.15 per ton-mile for O&M, and have an expected life of five years, and no salvage value. Use $i = 10\%$, find the break-even point in terms of to-miles per year.

Solution

The annual equivalent to the capital investment cost is

$$A (\text{new truck}) = 30,000 (A/P, 10\%, 15) = 3,944/\text{yr}$$

$$0.13147$$

$$A (\text{present truck}) = 10,000 (A/P, 10\%, 5) = 2,638/\text{yr}$$

$$0.26380$$

The total annual cost for each year for each alternative is simply the annual equivalent capital cost plus the annual O&M cost as follows:

$$\text{Total annual cost (new truck)} = A_1$$

$$A_1 = 3,944/\text{yr} + (0.10/\text{ton-mi}) (X \text{ ton-mi}/\text{yr})$$

$$\text{Total annual cost (present truck)} = A_2$$

$$A_2 = 2,638/\text{yr} + (0.15/\text{ton-mi}) (X \text{ ton-mi}/\text{yr})$$

The break- even value to x - may be found by solving the equations simultaneously.

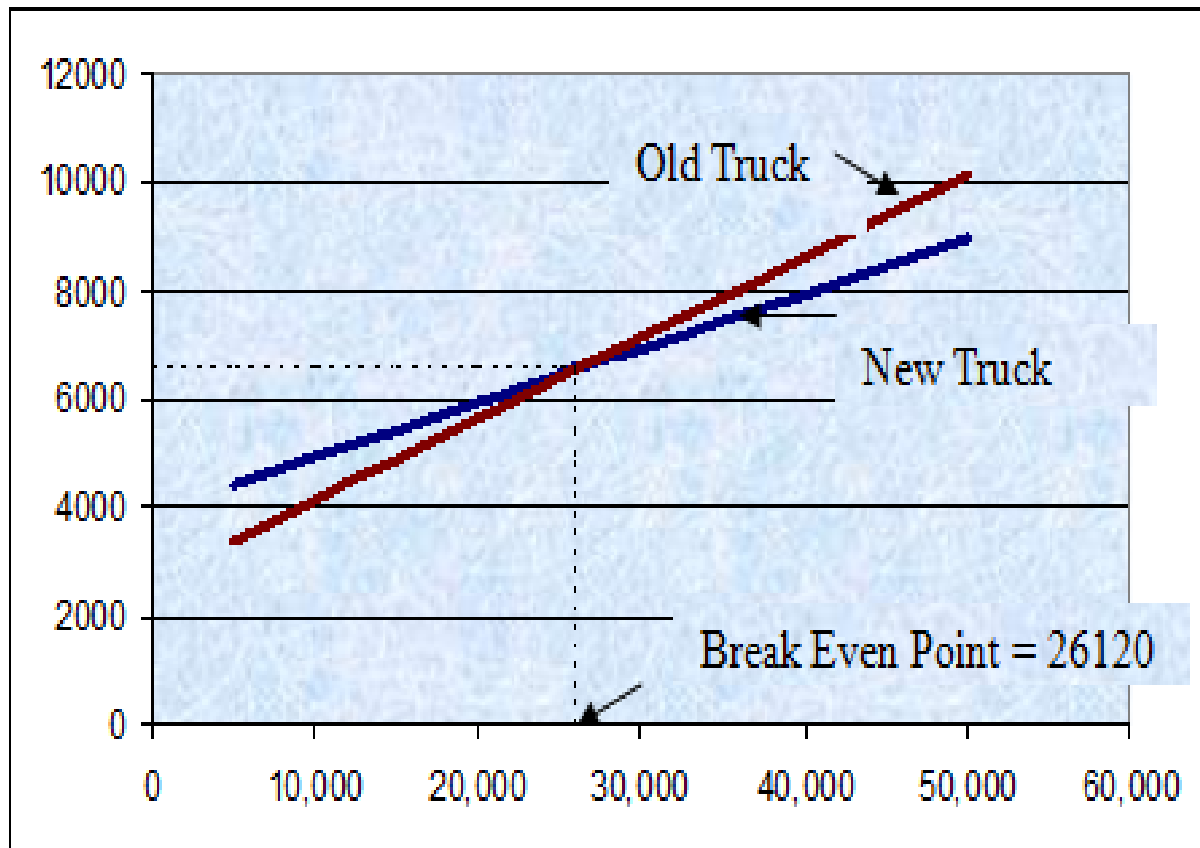
$$\text{For new truck } y = 0.10x + 3,911$$

$$\text{For present truck } y = 0.15x + 2,638$$

$$X = \frac{3,944 - 2,638}{0.15 - 0.10} = \underline{26,120 \text{ ton-mi/yr}}$$

$$0.15 - 0.10$$

Graphical solution is also possible by drawing the graphs of the two equations, see the result in the graph below.

**Note:**

- If the contractor's annual production is below 26,120 mile-tone, the old truck is more economical and if it is greater than 26,120, the new truck is economical.
- At the break-even point both truck have the same economical value.

3.7. BENEFIT COST RATIO ANALYSIS

General equation of Benefit- cost analysis is;

$$B/C = \frac{\sum \left(\frac{B_t}{(1+i)^t} \right)}{\sum \left(\frac{C_t}{(1+i)^t} \right)}$$

Strong side

- i. Criteria can be used to rank projects According to degree of acceptability
- ii. Criteria can be used to decide whether a project should be financed or funded.

Remember the example below;

Assume that the available budget is \$800,000 only and five alternative investments are given below with their present value of costs and benefit expected.

<u>Project</u>	<u>PVC</u>	<u>PVB</u>	<u>NPV(10%)</u>	<u>B/C(10%)</u>
A	10,000	13,000	3,000	1.3
B	40,000	43,300	3,300	1.08
C	20,000	30,300	10,300	1.52
D	40,000	49,400	9,400	1.24
E	50,000	55,800	5,800	1.11

When the projects ranked based on NPV and B/C approach, it looks like as follow:

NPV	C, D, E, B and A
B/C	C, A, D, E and B

If we use the NPW ranking, we will get a net amount of Birr 22,000. And if the budget invested according to B/C ranking the net amount expected to be Birr 23,900. This implies that the NPW ranking couldn't lead to the profitability of investments compared to **B/C ratio method**.

Weak side

- i. In case of mutually exclusive projects or projects different size and if one want to decide in favour of the project with the highest NPV, the B/C ratio doesn't give information on that.

Example: If the benefit-cost ratio of alternative A, B, and C are 1.5, 1.7 and 1.65 respectively, the highest value 1.7 corresponding to alternative B doesn't necessarily mean it has the highest NPV.

- ii. Sensitive to discounting rate.
- iii. When a project generates cost saving, such as cost saving can be either be represented as a net benefit or a negative cost. By using the latter we can increase the B/C ratio.

Example: Analysis of several mutually exclusive road way alignments yield the following information. (i=7%)

	Alternative A	Alternative B	Alternative C
Annual benefit	375,000	460,000	500,000
Annual cost	150,000	200,000	250,000
B/C	2.5	2.3	2.0

Solution

Comparison of A&B

$$B/C = \frac{460,000 - 375,000}{200,000 - 150,000} = \frac{85,000}{50,000} = 1.7 > 1, \text{ Discard A (the defender) and accept B}$$

(the challenger) temporally

Comparison of C and B

$$B/C = \frac{500,000 - 460,000}{250,000 - 200,000} = \frac{40,000}{50,000} = 0.8 < 1, \text{ Discard the challenger C}$$

Therefore, B is the better alternative even though the benefit cost ratio is less than that of A. Alternative A offers a greater benefit for the total expenditure.

Method of calculating B/C ratio

The most common approaches to compute the benefit-cost ratio are;

1. The conventional B/C ratio system
2. The modified B/C ratio method

Both of these methods involve in a comparison of a proposed facility with an existing facilities. If there is no existing facility, use present cost of reaching the same objectives. For instance, if the proposed facility is a bridge over a river and there is no existing method of crossing the river at this point, the present cost is the cost of whatever route must be taken to reach the other side.

1. **Conventional B/C ratio:-** the benefits (usually annual) are determined for users. Thus the benefits are defined as;

$B_n = U_n =$ net annual benefit (saving cost = the cost saved by the implementation of the new project).

The net benefits are equal to the users cost of the present facility minus the users cost of the proposed facility.

$$\text{Conventional } B/C = \frac{\text{Net Saving to users}}{\text{Owners Net capacity} + \text{Owner's net O \& M Cost}}$$

2. **Modified B/C ratio method:-** This method uses the same input data but not operating and maintenance cost (M_n) is treated as negative benefits they are placed in the nominator rather than in the denominator.

$$\text{Modified } B/C = \frac{U_n - M_n}{C_n} = \frac{B_n - M_n}{C_n}$$

C_n = Net capital cost of replacing the present facility with the future facility

Example: A flood control project is proposed for a certain area. There is a question as to the location of the dam and the numbers of alternative sites have been narrowed down to two, site A and site B. estimate of the costs associated with each of the site are listed below. The funds to construct the projects are available from bonds bearing interest rate of 6%. The expected life of the project at either site is 40 years and no salvage value is expected.

Cash Flow descriptions

Description	Existing Situation	Site A	Site B
Cost of construction	0	3,000,000	8,000,000
Annual O&M cost	0	56,000	94,000
Annual cost of flood damages	620,000 Birr	290,000	120,000
Annual loss due to land is lost to reservoir	0	20,000	46,000

Solution

Site A

$$\begin{aligned} U_n &= 620,000 - 290,000 - 20,000 \\ &= 310,000 \\ M_n &= 56,000 \\ \underline{C_n} &= 3,000,000 (A/P, 6\%, 40) \\ &= 199,384.6 \end{aligned}$$

$$\begin{aligned} \text{Modified } B/C &= \frac{U_n - M_n}{C_n} \\ &= \frac{310,000 - 56,000}{199,384.6} \\ &= 1.274 \end{aligned}$$

Site B

$$\begin{aligned} U_n &= 620,000 - 120,000 - 46,000 \\ &= 454,000 \\ M_n &= 94,000 \\ \underline{C_n} &= 8,000,000 (A/P, 6\%, 40) \\ &= 531,692.3 \end{aligned}$$

$$\begin{aligned} \text{Modified } B/C &= \frac{U_n - M_n}{C_n} \\ &= \frac{454,000 - 94,000}{531,692.3} \\ &= 0.677 \end{aligned}$$

Therefore, Site A is selected because of its higher value of B/C ratio.