

Course Title

Engineering Economic Analysis

Chapter 3

Basic Methodologies of Engineering Economics

Lecture 5 (Week 5)

External rate of return (ERR), Benefit cost ratio method (B/C), Life cycle Cost, Economic and Financial Analysis

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Learning Objective

From studying this lecture the students will be able to understand on the topics:

- The concept of External rate of return (ERR)
- The concept of Public sector Project Analysis (Benefit Cost ratio method)
- The concept of Payback period method
- Life cycle cost
- The concept of Economic and Financial Analysis.

5.1 External rate of return

In the last lecture we dealt about the concept of internal rate of return (IRR). There is one serious drawback of IRR method i.e. “The recovered funds are reinvested at i^* % (IRR of a project) rather than MARR”. This drawback leads to the concept of external rate of return (ERR). The concept of external rate of return is based on the assumption of the reinvestment (excess money generated by the project).

The drawback of the IRR method (reinvestment assumption) may not be valid in the engineering economy. [1]For example, if a firm’s MARR is 10% per year and the IRR for a project is 18%, it may not be possible for the firm to reinvest net cash proceeds from the project at much more than 10%. The modified internal rate of return is a modification of the internal rate of return (IRR) formula, which resolves some issues associated with that financial measure. [2]. Possible multiple interest rates associated with the IRR method, has given rise to other rate of return methods that can remedy this weakness which is referred as *External rate of Return* or *Modified IRR*. [1]

The External Rate of Return (i^* %) is the unique rate of return for a project that assumes that net positive cash flows, which represent money not immediately needed by the project, are reinvested at the reinvestment rate (ϵ %). The reinvestment rate depends upon the market rate available for investments.

Steps of ERR calculation (Figure 3.5)

- All cash outflows are discounted to period zero (present) at ϵ % per compounding period
- All cash inflows are Compounded to period N at ϵ %
- ERR is the interest rate that equivalence between the two equation.

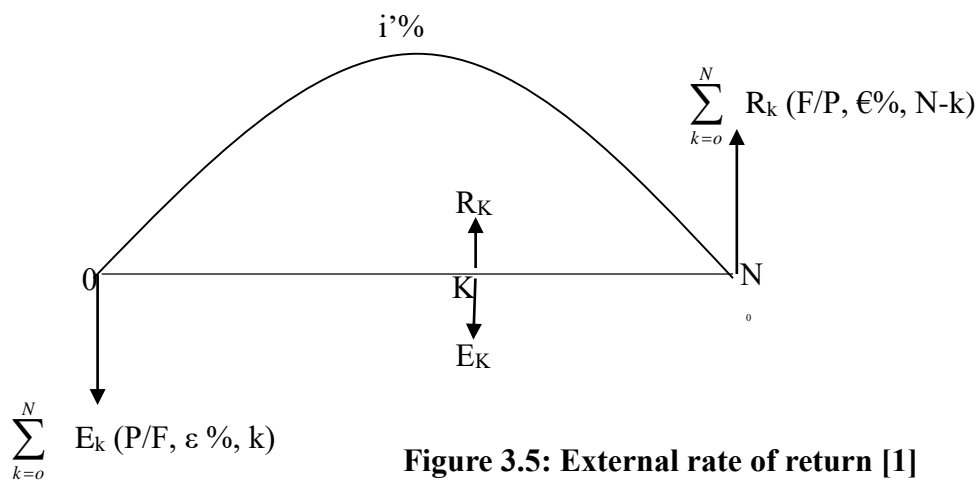


Figure 3.5: External rate of return [1]

$$\sum_{k=0}^N E_k (P/F, \epsilon \%, k) (F/P, i', N) = \sum_{k=0}^N R_k (F/P, \epsilon \%, N-k)$$

Where,

R_k = receipts in period k

- E_k = expenditures in period k
 N = project life or number of study period
 $\varepsilon \%$ = external reinvestment rate per period.

Accept /Reject Decision Rule

If $ERR > MARR,$ $ERR = MARR,$ $ERR < MARR,$	<i>accept the project</i> <i>remain indifferent</i> <i>reject the project</i>
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Advantages of ERR over IRR

- It does not need trial and error approach for determination of $i^*\%$
- There is no possibility of multiple rate of return.

5.2 Public Sector Project

According to the source of fund, project can be classified into two categories.

- (a) Public Sector Project
- (b) Private sector Project

Private sector project are those project which is owned and financed by the individual person or a corporation or a group of people. The primary motive of the private sector project is to maximize profit and the methods like present worth (PW) and Internal rate of return (IRR) is used to calculate the worthiness of a project.

Public sector project are those project which is owned and financed by the federal, state or local government of a country. Public sector project has primary purpose to provide services to the citizenry for the public good at no profit. [3] Examples: schools, hospitals etc. Public sector project has very long project life and larger investments, the method Benefit/Cost analysis is used for the evaluation.

To perform an economic analysis of public alternatives, the cost (initial and annual), the benefits and the dis-benefits, if considered, must be estimated as accurately as possible in monetary units. It is difficult to estimate and agree upon the economic impact of benefits and dis-benefits for a public sector alternative. [3]. Dis-benefit may not be known at the time of economic analysis.

View Point for Public Sector Project Analysis

Following sample view point should be considered before estimating benefit, dis-benefits and cost of a project

- Citizens
- Tax base
- Creation and retention of jobs

- Economic development
- Specific industry

Valuation of Benefits and Costs

Benefits – advantages to be experienced by the owner, the public. (Favorable outcomes)

Dis-benefits – expected undesirable or negative consequences to the public, if the alternative is implemented. (Unfavorable outcomes)

$$\text{User's benefit} = \text{Benefits} - \text{dis-benefits}$$

Cost:

Estimated expenditures to the government entity for construction, operation and maintenance of the project, less any expected salvage value.

Includes capital investment and annual operating costs.

$$\text{Sponsor's Cost} = \text{Capital cost} + \text{operating and maintenance costs} - \text{revenues}$$

Benefit/Cost (B/C ratio) Method

Benefit cost analysis is a decision making method used to systematically develop useful information about the desirable and undesirable effects of public project. [4] It is a procedure for evaluating the desirability of a project by weighing benefits against costs. [5] The benefit/cost ratio is defined as the ratio of the equivalent worth of benefits to the equivalent worth of costs. The equivalent worth measure applied can be present worth (PW), future worth (FW), and annual worth (AW). It is also called the 'saving – investment ratio'.

Major Steps in Benefit/Cost Analysis

- Specify the set of alternative projects
- Decide whose benefits and cost counts (standing)
- Catalogue the impacts and select measurement indicator
- Predict the impacts quantitatively over the life of projects
- Monetize (attached money values to) all impacts
- Obtain equivalent values of benefit and cost
- Perform sensitivity analysis
- Make a recommendation

Two types of B/C ratio

- 1. Conventional B/C ratio**
- 2. Modified B/C ratio**

PW method

$$\begin{aligned}\text{Conventional B/C ratio} &= \frac{\text{PW (benefits of proposed project)}}{\text{PW (total cost of proposed project)}} \\ &= \frac{\text{PW (B)}}{(\text{I}) - \text{PW (S)} + \text{PW (O\&M)}}\end{aligned}$$

$$\text{Modified B/C ratio} = \frac{\text{PW (B)} - \text{PW (O\&M)}}{(\text{I}) - \text{PW (S)}}$$

Where,

PW (B) = Present worth of benefits of project.

PW (O&M) = Present worth of Operation and maintenance of project.

PW (S) = Present worth of Salvage value.

I = Initial investment of the project.

FW method

$$\text{Conventional B/C ratio} = \frac{\text{FW (B)}}{\text{FW (I)} - (\text{S}) + \text{FW (O\&M)}}$$

$$\text{Modified B/C ratio} = \frac{\text{FW (B)} - \text{FW (O\&M)}}{\text{FW (I)} - (\text{S})}$$

Where,

FW (B) = Future worth of benefits of project.

FW (O&M) = Future worth of Operation and maintenance of project.

(S) = Salvage value of investment.

FW (I) = Future worth of Initial investment of the project.

AW method

$$\begin{aligned}\text{Conventional B/C ratio} &= \frac{\text{AW (benefits of proposed project)}}{\text{AW (total cost of proposed project)}} \\ &= \frac{\text{AW (B)}}{\text{CR} + \text{AW (O\&M)}}\end{aligned}$$

$$\text{Modified B/C ratio} = \frac{\text{AW (B)} - \text{AW (O\&M)}}{(\text{CR})}$$

Where,

AW (B) = Annual worth of benefits of project.

CR = Capital Recovery.

AW (O&M) = Annual worth of operation and maintenance cost

Accept /Reject Decision Rule

For the project to be feasible

Benefit (B) > Cost (C)

Or B/C > 1

If	$B/C > 1,$	<i>accept the project</i>
	$B/C = 1,$	<i>remain indifferent</i>
	$B/C < 1,$	<i>reject the project</i>

5.3 Payback Period Method (PB)

The payback period is the time required for an initial investment to be recovered. [6] The payback period method screens project on the basis of how long it takes for net receipts to equal investment outlays without including any time value of money. [4] Payback method doesn't account for savings after the initial investment is paid back from the profits (cash flow) generated by the investment (project).

Two types of payback period

(a) Simple and (b) Discounted

(a) Simple payback period

Simple payback period doesn't consider the time value of money ($i \% = 0$). It indicates the required time period to break even on an investment. [7] Simple Payback period is calculated using the following equation if the annual savings are equal:

$$\text{Simple Payback Period} = \frac{\text{Initial Investment}}{\text{Annual savings (cash Inflow)}}$$

Advantages of simple payback period

- Easy to calculate
- It is interpreted in tangible terms (in years)
- It doesn't require any assumptions about the project in terms of timing, life time or interest rates.

Disadvantages of simple payback period

- It takes no account of any savings after the payback period.
- It takes no account of the residual value in the capital asset.
- It takes no account of the time value of money.

(b) Discounted payback period

Discounted payback period considers the time value of money ($i \% > 0$). It is the number of years required to recover the investment from discounting cash flow, considering time value of money. [7] It can overcome the major shortcoming of simple payback period.

Advantages of discounted payback period

- Considers the time value of money
- Considers the riskiness of the project's cash flow (through the cost of capital)

Disadvantages of discounted payback period

- No concrete decision criteria that indicate whether the investment increases the firm's value.
- Requires an estimate of the cost of capital in order to calculate the payback.
- Ignores cash flows beyond the discounted payback period

5.4 Life Cycle Cost

The Life cycle cost, as its name implies is commonly applied to alternatives with cost estimates over the entire system life span. [3] This means that costs from the very early stage of the project (initiation) through the final stage (phase-out and disposals) are estimated. The life cycle begins with identification of the economic need and ends with retirement and disposable activities. [7]

Component of Life Cycle Cost

1. Acquisition phase cost

- Land purchase cost
- Engineering design and development cost
- Basic machine and installation cost
- Training and special tooling cost
- Cost of supporting equipment
- Manufacturing and fabrication costs. Etc.

2. Operation Phase Cost

- Labour cost
- Material cost
- Consumable materials (fuel, water, electricity, etc.)
- Overhead items (tax, insurance, administrative etc.)
- Transportation cost

3. Disposal Cost

- Labour cost for removal of item
- Recycling of the old items

5.5 Introduction to Financial and Economic Analysis

Financial analysis performs business activities from investor's point of view. Cash flow, profit and loss account and balance sheet are the main financial statements. The purpose of financial analysis is

1. To provide financing plan for proposed investment.

2. To determine the profitability of a project from investor's perspective.

The objective of economic analysis is to determine if a project represents the best use of resources over the analysis period. The analysis is done from the perspective of society or nation. The purpose of economic analysis is

1. To provide information for the decision rule.
2. To improve the design of the project and to know impact on various sectors the economy. [7]

References:

[1] *Engineering Economy*: William G. Sullivan, James A. Bontadelli & Elin M. Wicks, Eleventh Edition, Pearson Educations, Inc. 2000.

[2]<https://corporatefinanceinstitute.com/resources/knowledge/finance/modified-internal-rate-of-return-mirr/> (Viewed September 2022)

[3] *Basics of Engineering Economy*: Leland Blank and Anthony Tarquin, Indian Edition, McGraw Hill Education Private Limited, New Delhi, India, 2013.

[4] *Contemporary Engineering Economics*, Chan S. Park Second Edition, Addison-Wesley Publishing Company, 1997.

[5] *Engineering Economics and Costing*: Dr. K.K. Patra & Dhiraj Bhattacharjee, First Edition, S. Chand and Company Ltd, 2013.

[6]*Engineering Economics*: Jose A. Sepulveda, William E. Souder and Byron S. Gottfried, Tata McGraw – Hill Publishing Company Limited, New Delhi, India, 2005.

[7] *A Textbook of Engineering Economics*: Damodar Adhikari, First Edition, Dreamland Publication Pvt. Ltd. Kathmandu, Nepal, 2019.