CENG 6108 Construction Economics

Investment Appraisal Methods

Abraham Assefa Tsehayae, PhD

May, 2017

TO DO

① Introduction

② Present Worth, Future Worth, or Annual Worth

③ Rate of Return

④ Payback Methods

⑤ Benefit-Cost Ratio

Introduction:

- An investment may be thought of as an exchange of resources now for an expected flow of benefits in the future.

- Economic comparison methods are used for evaluating and comparing projects.

- Basic assumptions:

  1. All costs and benefits are always measurable in terms of money.
  2. Future cash flows are known with certainty.
  3. Cash flows are unaffected by inflation or deflation.
  4. Sufficient funds are available to implement all projects.
  5. Taxes are not applicable.
  6. All investments have a cash outflow at the start. The first outflows are called First Costs.

Introduction:

- **Relation Among Projects**
- **Three types of connections among projects are often possible:**
  1. Independent,
  2. Mutually exclusive, or
  3. Related but not mutually exclusive

- **Independent Projects**
  - If the expected costs and benefits of each project do not depend on whether the other one is chosen.
  - Evaluation is simple, as each opportunity is considered one at a time, and project is accepted or rejected in its own merits.

Introduction:

- ## Mutually Exclusive Projects
  - If a situation where, choosing one project, will exclude all other alternatives.
  - E.g., Downtown building: Prefab or Cast In-situ
- ## Related but not Mutually Exclusive Projects
  - If the expected costs and benefits of each project does depend on whether the other one is chosen.
  - E.g., Ready Mixed Concrete Plant and Aggregate Crushing Plant
  - Simplification:
    - Do nothing: Neither RMC nor ACP
    - Just One: RMC
    - Just One: ACP
    - Both: RMC and ACP
    - 2^n set of combinations, n – number of related projects
  - Contingent Projects: $A \rightarrow B$

Minimum Acceptable Rate of Return (MARR)

- MARR represents the lower limit for investment acceptability or the rate of return required to get investors to invest in a business.

- MARR is an interest rate that must be earned for any project to be accepted.

- Minimum return can be determined by calculating the cost of capital.

- MARR is used in calculations involving Present Worth, Future Worth, Annual Worth, or Internal Rate of Return.

Present, Future, Annual Worth Comparisons

- Present Worth (PW) comparison method compares project A and Project B by computing the Present worth of the two projects at the MARR.

- Future Worth (PW) comparison method compares project A and Project B by computing the Future worth of the two projects at the MARR.

- Annual Worth (AW) comparison method compares project A and Project B by computing the Annual worth of the two projects at the MARR.

- The preferred project is the one with the greater worth.
  - For PW, PW > 0 is acceptable, PW = 0 is marginally acceptable, and PW < 0 is unacceptable.

Present, Future, Annual Worth Comparisons

- Example: An airline must purchase a new navigation equipment. It is considering four navigation equipments, each of which has a life of 10 years with no scrap value. Given MARR of 15%, which alternative should be take?

Equipment	1	2	3	4
Initial Cost	$100,000	$150,000	$200,000	$255,000
Annual Savings	$25,000	$34,000	$46,000	$55,000

Comparisons of Alternatives with Unequal Lives

- If the lives of the alternatives are not the same, we transform them to equal lives using one of the following methods:

A. **Repeated Lives**: Repeat the service life of each alternative, using least common multiple, to arrive at a common time period for all alternatives.

B. **Study Period**: Adopt a specified study period but taking into account the salvage values of the alternatives with longer lives.

Comparisons of Alternatives with Unequal Lives

- Example: A mechanical engineer has decided to introduce automated materials-handling equipment for a production line. She must choose between two alternative, building the equipment or buying the equipment off the shelf.

	Alternative 1	Alternative 2
Initial Cost	$15,000	$25,000
Labour per year	$3,300	$1,450
Power per year	$400	$600
Maintenance per year	$2,400	$3,075
Taxes and insurance per year	$300	$500
Service life	10 years	15 years

- If MARR is 9%, which alternative is better?

Rate of Return Comparisons

- One way to measure the return from an investment is as a rate of return per dollar invested, or in other words as an interest rate.

- Rate of return:

  - Internal rate of return (IRR):
    - Is the rate of return calculated for a project and depends only on the cash flows of investment.
    - IRR is the interest rate at which the project just breaks even.

  - External rate of return (ERR):
    - Is the rate of return calculated for a project, where any cash flows that are not invested in the project are assumed to earn interest at a predetermined explicit rate (usually the MARR).

- Example: Suppose $100 is invested today in a project that returns $110 in one year. What is the IRR?

Rate of Return Comparisons

- Internal rate of return (i^*) is formally defined as, when all cash flows associated with the project are discounted at i^*, the present worth of the cash inflows equals the present worth of the cash outflows (break even):

$$\sum_{t=0}^{T} \frac{(R_t - D_t)}{(1 + i^*)^t} = 0$$

where

R_t = the cash inflow (receipts) in period t

D_t = the cash outflow (disbursements) in period t

T = the number of time periods

i^* = the internal rate of return

Internal Rate of Return Comparisons

- Calculation of IRR:

$$\sum_{t=0}^{T} \frac{(R_t - D_t)}{(1 + i^*)^t} = 0$$

$$\sum_{t=0}^{T} R_t(1 + i^*)^{-t} = \sum_{t=0}^{T} D_t(1 + i^*)^{-t}$$

Calculate for i^* using either of:

$$PW\ (disburesement) = PW\ (receipts)$$
$$AW\ (disburesement) = AW\ (receipts)$$
$$FW\ (disburesement) = FW\ (receipts)$$

- IRR is usually positive, but can be negative as well. Negative IRR means the project is losing money.

- Solutions are based on trail and error or Spreadsheets

- We will invest in any project that has an IRR equal to or exceeding the MARR.

- If IRR = MARR, we marginally accept the investment.

- For several independent projects, the IRR for each is calculated separately, and those having IRR $\geq$ MARR are all chosen.

- Example:

  - A construction company is considering a new paving equipment. The paver costs $120 000, and will have a scrap value of $5 000 after 10-years life. The total savings due to the new paver, compared with continuing with the current machine, will be $15 000 the first year, increasing by $5 000 each year thereafter. Total extra cost of due to the complexity of the new paver will be $10 000 per year. The MARR for the company is 12%. Should they invest in the new paver?

Internal Rate of Return Comparisons: Mutually Exclusive

- Choice among mutually exclusive projects using the IRR is a complicate process.

- Example:
  - Consider two investments. The first costs $1 today and returns $2 in one year. The second costs $1000 and returns $1900 in one year. Which is the preferred investment? MARR is 70%.

- In such cases we can not make decisions on the basis of the IRRs of individual and mutually exclusive alternatives, we must take the IRRs of the incremental investments into consideration.

Internal Rate of Return Comparisons: Mutually Exclusive

- Analysis Steps:
  - Step 1: Order the alternatives from the smallest first cost to the largest first cost.
  - Step 2: Since one alternative must be chosen, accept the alternative with the smallest first cost as the current best alternative regardless of its IRR exceeding the MARR.
  - Step 3: Select the next higher first cost alternative (Challenger), and determine the incremental investment to implement the challenger.
  - Step 4: Check the IRR of the challenger, if it does not have IRR at least equal to the MARR, the challenger is excluded from further consideration. However, if its IRR is at least equal to the MARR, then challenger replaces the current best.
  - Step 5: Challenge the second alternative by the alternative ranked third, and repeat the process until all ranked alternatives are compared.

- Example: An airline must purchase a new navigation equipment. It is considering four navigation equipments, each of which has a life of 10 years with no scrap value. Given MARR of 15%, which alternative should be take?

Equipment	1	2	3	4
Initial Cost	$100,000	$150,000	$200,000	$255,000
Annual Savings	$25,000	$34,000	$46,000	$55,000

- A problem of implementing the Internal Rate of Return method is that there may be more than one IRR.
- Example:
  - A project pays $1000 today, costs $5000 a year from now, and pays $6000 in two years. What is its IRR?
- Consider a project that has cash flows over T periods. The net cash flow, A_t, associated with period t is the difference between the cash inflows and outflows for the period:

$$A_o + A_1(1 + i)^{-1} + A_2(1 + i)^{-2} + \ldots + A_T(1 + i)^{-T} = 0$$

$A_o + A_1 x + A_2 x^2 + \cdots + A_T x^T = 0$, where $x = (1 + i)^{-1}$

- Solving for the Tth polynomial gives the IRR.
- As this is a polynomial equation, many positive real solutions for x can exist as the sign changes in the $A's$.

External Rate of Return Comparisons

- To resolve the multiple IRR difficulty for **non simple investments**, we need to consider what return is earned by money associated with a project that is not invested in the project.

  - The usual assumption is that the funds are invested elsewhere and earn an explicit rate of return equal to MARR.

- External rate of return (i_e^*):

  - Is the rate of return calculated for a project, where any cash flows that are not invested in the project are assumed to earn interest at a predetermined explicit rate (usually the MARR).

  - For a given explicit rate of return, a project can have only one value for its ERR.

- Example: A project pays $1000 today, costs $5000 a year from now, and pays $6000 in two years. What is the rate of return, if MARR = 25%.

External Rate of Return Comparisons

- In general, computing a precise ERR is complex, due to the difficulty of determining when the explicit interest rate should be applied.

  - In periods when project balances are positive for trial ERR, the project is a source of funds and funds will be invested outside the project at MARR.

  - When the project balance is negative for trial ERR, any receipts would be invested in the project and will typically yield more that the MARR.

- Analysis Procedure:

  - Step 1: Take all net receipts forward at the MARR to the time of the last cash flow.

  - Step 2: Take all net disbursements forward at an unknown interest rate, i_{ea}^*, also to the time of the last cash flow.

  - Step 3: Equate the future value of the receipts from Step 1 to the future value of the disbursements from Step 2 and solve for i_{ea}^*.

  - Step 4: The value for i_{ea}^* is the approximate ERR for the project.

Benefit to Cost Ratio Comparisons

- Another method of assessing the viability of a system or comparing several systems is to calculate the net present value of the costs and the benefits and obtain the benefit-cost ratio (B/C).

- If this ratio is greater than one, then the project is profitable.

- If two or more projects have to be compared with the B/C method, then the lives should be equalized as in the case of the present worth method. We also have to calculate the B/C of their differential cash flows in pairs and perform incremental analysis to ensure that the extra initial cost justifies the extra benefit.

- The B/C ratio is a difficult comparison method when more than one alternative is considered.

Payback Period Comparisons

- Payback method is the simplest method for judging the economic viability of projects.

- Usually project with payback period of 2 to 4 years are filtered for further analysis.

- Payback period is the number of years it takes for an investment to be recouped when the interest rate is assumed to be zero. If annual saving is constant:

$$Payback\ period = \frac{Initial\ Cost}{Annual\ Saving}$$

- If annual saving is not constant, we calculate the payback period by deducting each year of savings from the first cost.

- A project with shorter payback period is preferred.

- Discounted payback period can also be used.

Internal Rate of Return versus Net Present Value

- NPV (net present value) and IRR (internal rate of return) are the two most common and important indicators for capital investments.

  - IRR is more cognitively efficient that NPV.

  - NPV is more theoretically sound, as IRR does not rank some projects in the same orders as NPV does.

- Assume two alternatives A and B: Ranking could be done using

  - Highest IRR criterion

  - Highest NPV criterion

- It is important to note that the results of the two criteria may be consistent with each other or may be not.

- The NPV or IRR curve against i is plotted to review the differences:

Internal Rate of Return versus Net Present Value

- Alternative A is better that Alternative B, if highest IRR criteria is used, since IRR_A is greater that IRR_B.
- For $i > r$ (e.g. MARR), $NPV_A > NPV_B$, so according to highest NPV criteria is used, Alterative A is better that Alternative B.
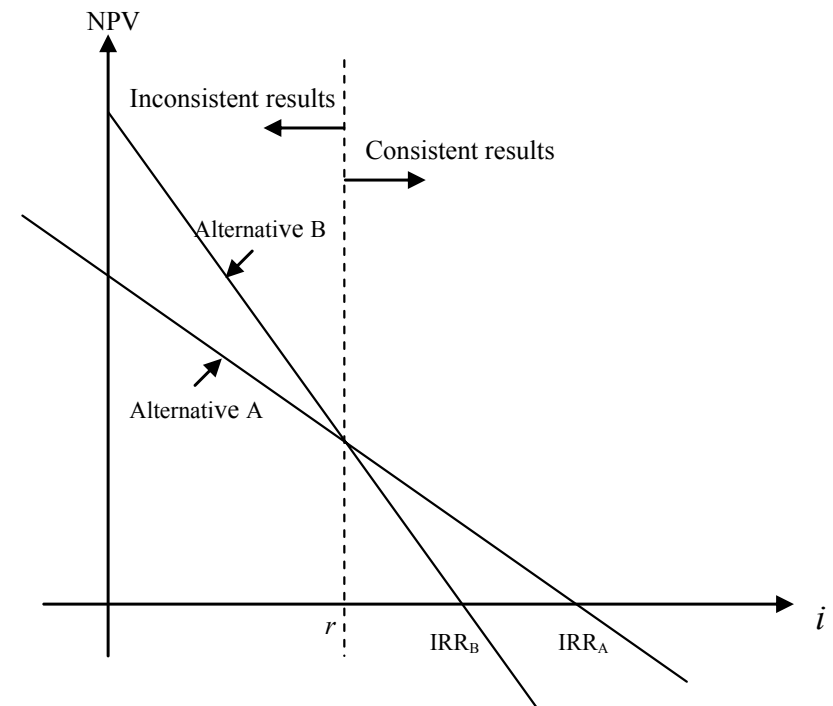- For $i < r$ (e.g. MARR), $NPV_B > NPV_A$, but, $IRR_A > IRR_B$, hence the two criteria give inconsistent ranking.

Figure 4.1 – Potential inconsistency of NPV and IRR

Choice of Comparison Method

- The choice of method may depend on the way the results are to be used and the sort of data the decision makers prefer to consider. In most cases, by policy, several methods will have to be applied so that a complete picture of the investment is presented.

Method	Advantageous	Disadvantages
IRR	- Facilitates comparisons of projects of different sizes - Commonly used	- Relatively difficult to calculate - Multiple IRRs may exit
Present Worth	- Gives explicit measure of profit contribution	- Difficult to compare projects of different sizes
Annual Worth	- Gives familiar meaning to decision maker	- Difficult to compare projects of different sizes
Payback Period	- Very easy to calculate - Take into account the need for quick capital recovery	- Discriminates against long-term projects - Ignores time value of money and the expected service life

References:

- Fraser, N.M., Jewkes, E., Bernhardt, I., Tajima, M. (2006). *Engineering Economics in Canada*. 3rd edition, Prentice Hall.

- Economic and Financial Analysis for Engineering and Project Management, Abol Ardala, Technomic, 2000.

- *Construction Financial Management,* Tang, bookboon, 2014.