IE201: Financial Engineering

Chapter 1: An Overview of Engineering Economic Analysis

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Spring 2026

Sections

- 1.1: Time Value of Money
- 1.2: Engineering Economy
- 1.3: Economic Justification of Capital Investments

1.1: Time Value of Money

- Time Value of Money (TVOM): The value of a given sum of money depends on both the amount of money and the point in time when the money is received or paid.

Example 1.1

Example

Suppose a wealthy individual approaches you and says, "Because of your outstanding ability to manage money, I am prepared to present you with a tax-free gift of $1,000. If you prefer, however, I will postpone the presentation for a year, at which time I will guarantee that you will receive a tax-free gift of $X." (For purposes of this example, assume that the guarantee is risk-free.) In other words, you can choose to receive $1,000 today or receive $X one year from today. Which would you choose if X equals (1) $1,000, (2) $1,050, (3) $1,100, (4) $1,500, (5) $2,000, (6) $5,000, (7) $10,000, (8) $100,000?

Calculate Your TVOM

Formula

(Minimum acceptable amount - $1,000)/1000

Example: Payroll Advance vs. Raise

Example

You can take **$1,000 today**, or **$X in one year** added to your salary. Which would you pick if $X = 1000, 1200, 1500, 2000$?

Formula

$$\text{TVOM} = \frac{X - 1000}{1000}$$

$$X = 1000: \quad \frac{1000 - 1000}{1000} = 0.00 = 0\% \qquad X = 1500: \quad \frac{1500 - 1000}{1000} = 0.50 = 50\%$$

$$X = 1200: \quad \frac{1200 - 1000}{1000} = 0.20 = 20\% \qquad X = 2000: \quad \frac{2000 - 1000}{1000} = 1.00 = 100\%$$

Other Terms Equivalent to TVOM

Note

- Interest rate
- Discount rate
- Hurdle rate
- Minimum attractive rate of return (MARR)
- Cost of capital

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- Return Rate$>$TVOM $\rightarrow$ Accept
- Return Rate$<$TVOM $\rightarrow$ Reject
- Return Rate$=$TVOM $\rightarrow$ Indifferent

Rules of Discounted Cash Flow (DCF)

Rules

Discounted cash flow: the movement of money forwards or backwards through time.

1. Money has a time value.
2. Quantities of money cannot be added or subtracted unless they occur at the same points in time.
3. To move money forward one time unit, multiply by 1 plus the discount or interest rate.
4. To move money backward one time unit, divide by 1 plus the discount or interest rate.

Example: Investment Decision with TVOM = 25%

Example

A student's TVOM is 25%. They are offered a riskless investment opportunity: invest \$1000 today, receive \$1100 one year from now (and nothing else).

Should the student accept this opportunity? Alternatives: **Don't Invest** or **Invest**.

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Note

We will analyze using both the **Future Worth Method** and the **Present Value Method**.

Future Worth Analysis

Formula

- Future worth of an alternative: value at end of time horizon

Future worth of keeping the money:

$$FW(\text{Don't Invest}) = 1000 \times (1 + 0.25) = 1250$$

Future worth of investment:

$$FW(\text{Invest}) = 1100$$

Note

Since the future worth of not investing is greater, the student prefers the alternative of **not investing**.

Present Value Analysis

Formula

Present value of \$1100 received in one year:

$$PV = \frac{1100}{1.25} = 880$$

Compare present values:

$$1000 > 880$$

Note

Because the present value of the investment (\$880) is less than the outlay (\$1000), the student again prefers the alternative of **not investment**.

FW vs. PV Methods

Example

Future Worth

$$FW : 1250 > 1110$$

Decision: **No**

Example

Present Value

$$PV_{invest} = 880 \quad \text{vs.} \quad PV_{dont} = 1000$$

Decision: **No**

Note

Both methods lead to the same conclusion.

Section 1.1: Examples and Conclusion

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  - His TVOM is 30%

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- Suppose two projects are mutually exclusive, each requiring $5,000 today. Project A returns $5,600 in one year, and Project B returns $5,700 in one year. Your TVOM is 12%. Which project should you pick?

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  - Pick Project B. Both exceed 12%, but B has greater economic worth. (A has return of 12%, B has 14%)

1.2: Engineering Economy Principles

Rules

1. Money has a time value.
2. Make investments that are economically justified.
3. Choose the mutually exclusive investment alternative that maximizes economic worth.
4. Two investment alternatives are equivalent if they have the same economic worth.
5. Marginal revenue must exceed marginal cost.
6. Continue to invest as long as each additional increment of investment yields a return that is greater than the investor's TVOM.
7. Consider only differences in cash flows among investment alternatives.
8. Compare investment alternatives over a common period of time.
9. Risks and returns tend to be positively correlated.
10. Past costs are irrelevant in engineering economic analyses, unless they impact future costs.

1.3: Economic Justification of Capital Investments

Steps

1. Identify the investment alternatives.
2. Define the planning horizon.
3. Specify the discount rate.
4. Estimate the cash flows.
5. Compare the alternatives.
6. Perform supplementary analyses.
7. Select the preferred investment

1) Identify the investment alternatives

Note

- Select the best investment from a feasible set of mutually exclusive and collectively exhaustive investment alternatives.
- The "do nothing" alternative is often considered.

2) Define the planning horizon

Note

- The period of time or width of the "window" over which the economic performance of each investment alternative will be viewed.

Rules

When the lives of the investment alternatives differ, consider the following:

1. Set the planning horizon equal to the shortest life among the alternatives.
2. Set the planning horizon equal to the longest life among the alternatives.
3. Set the planning horizon equal to the least common multiple of the lives of the various alternatives.
4. Use an infinitely long planning horizon.

3) Specifying the Minimum Attractive Rate of Return

Note

- It is the minimum rate of return on an investment that a decision maker is willing to accept, given the associated risk and the opportunity cost of other forgone investments.
- Weighted average cost of capital (WACC) is used to establish a lower bound for the MARR.

3) Specifying the Minimum Attractive Rate of Return (cont.)

Formula

$$\text{WACC} = (\text{E}/\text{V})\ i_e + (\text{D}/\text{V})\ i_d\ (1 - i_{tr})$$

- E = a firm's total equity (considered as an opportunity cost), expressed in dollars (examples of equity capitals: preferred stocks, common stocks, retained earnings)
- D = a firm's total debt and leases, expressed in dollars (examples of debt capitals: bonds, loans, mortgages)
- V = E + D, a firm's total invested capital
- i_e = cost of equity or expected rate of return on equity, expressed in percent
- i_d = cost of debt or expected rate of return on borrowing, expressed in percent
- i_{tr} = corporate tax rate

4) Estimate the Cash Flows

- Cost estimating is not an exact science.

Example

The Association for the Advancement of Cost Engineering International (AACEI) defines cost estimating as a predictive process used to quantify, cost, and price the resources required by the scope of an asset investment option, activity or project. As a predictive process, estimating must address risks and uncertainties. The outputs of estimating are used primarily as inputs for budgeting, cost or value analysis, decision making in business, asset and project planning, or for project cost and schedule control processes.

5) Comparing Alternatives

- Select criterion such as present value, future value, payback period, or rate of return.
- Depreciation, income taxes, replacement, and inflation may need to be considered.

6) Perform Supplementary Analyses

Example

Answer as many "what if" questions as possible such as the following:

- Are the cash flow estimates correct?
- Is the timing of the cash flows correct?
- What happens if the planning horizon changes?
- What happens when I vary my MARR?

7) Select the Preferred Investment

Note

- The preferred investment may not always be the one that performs best when considering only the economic criteria.
- Multiple criteria typically exists such as the following:
  - Safety
  - Cycle time
  - Quality
  - Flexibility
  - Customer service
  - Employee morale
  - Market share

Math discussion

Formula

$$X = P(1 + r)^n$$

- If $r > 0$ and $n > 0$: is $X > P$, $X < P$, or $X = P$?

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- What if $r < 0$?

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  - $X > P$
- What if $r < 0$?
  - $X < P$
- If $r = 0$: then $X = P$ (no change).

Behavior as n Increases

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  - , $X \to \infty$ (unbounded growth).
- If $r < 0$ (so $0 < 1 + r < 1$), then as $n \to \infty$, $X \to 0$ (decay).

Why might $n < 0$ when describing a cash flow?

Formula

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- Negative n corresponds to moving cash flows *backward in time*.
- Example: The present value of \$1000 received in one year is

$$PV = 1000(1 + r)^{-1} = \frac{1000}{(1 + r)}$$

- Here $n = -1$ discounts the future cash flow back to today.