Engineering Economic Analysis(EEA) Chapter 1: An Overview of EEA

Dr. Lukun Zheng

Learning Objectives

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1. Apply the four discounted cash flow (DCF) rules to simple time value of money
2. Identify the 10 principles of engineering economic analysis that can be used by all engineers in analyzing the economic performance of the products, processes, and systems they design
3. Identify the seven steps of the systematic economic analysis technique (SEAT) used to perform engineering economic analyses.

Economics is the science that studies the production, distribution, and consumption of goods and services

Engineering Economic Analysis

Chapter 1: An Overview of EEA

- Section 1.1: Time Value of Money
- Section 1.2: Engineering Economy Principles
- Section 1.3: Economic Justification of Capital Investment

Definition

Definition (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.

The time value of money is a financial concept that holds that the value of a dollar today is worth more than the value of a dollar in the future. It means that a sum of money is worth more now than the same sum of money in the future. This is true

because money you have now can be invested for a financial return, also the impact of inflation will reduce the future value of the same amount of money.

Example

Example (1.1)

If a student's time value of money rate is 15%, then the student would be indifferent between $100 today and how much in 1 year?

Solution:

100 today

$100(1+0.15) = \$115$

TVOM rate may be different from person to person

Example

Example (1.2)

There are two options for you to choose:

A)
- receive \$1,000 today, or

B)
- receive \$X a 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.

It is up to your TVOM rate

Earning Power Versus Inflation

- Earning power: If you own money and someone else temporarily needs it, you can loan it to them and charge them interest.
- Inflation: a general increase in the prices of goods and services in an economy, causing a decrease in the purchasing power of money.
- **Discussion:** If you loan money to others, should your interest rate be always larger than the inflation rate? If not, what should you do instead?

Discounted Cash Flows

Definition (Discounted Cash Flow (DCF))

The movement of money forward or backward in time.

The Four DCF Rules

1. Money has a time value.
2. Quantities of money cannot be added or subtracted unless they occur at the same point 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

Example (1.3)

Assume that a student's TVOM is 20%. Suppose the student is guaranteed to receive $1,100 one year from today, and nothing thereafter, if $1,000 is invested today in a particular venture. Is the investment a good one for the student?

~~1100 - 1200 = 100~~ X

Solution: Hence it is NOT a good one.

For this student with TVOM at 20%, the future value of $1000 in a year is $1000(1+20\%) = \$1200$.

For this investment, $1000 today will lead to a payment of $1,100 in a year.

The difference of making this investment is $1,100 - 1200 = -100$ in a year.

Example

Example (1.4)

If your TVOM is 5% and your friend's is 10%, can the two of you work out mutually satisfactory terms for a 1-year, $1,000 loan? Assume the lender has the money available and neither of you wants to go outside your acceptable TVOM range. Be explicit about who is lending and what is the acceptable range of money paid back on the loan.

Solution:

Step1: Decide who is the lender and who is the borrower.

The Lender should be the one with a lower TVOM.

Hence you should be the lender and your friend is the borrower

Step2: Determine the minimum repayment for you in a year.

$1000 investment today should lead to a repayment of at least

$1000 \times (1 + 0.05) = \$1050$ in a year.

Example

step3. Determine the maximum payment your friend want to offer in one year.

$1000 \times (1+0.1) = \$1100$ is the maximum amount your friend want to pay in a year.

step 4. Determine the acceptable range:

1) you request a minimum repayment of \$1050 in a year to lend \$1000 to your friend.
2) your friend would pay at most \$1100 in a year to retrieve \$1000 from you.

Hence there is an acceptable range of $[1050, 1100]$.

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Engineering Economy Principles

Throughout this text, basic principles are presented that all engineers can use in analyzing the economic performance of the products, processes, and systems they design.

The 10 Principles

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.

1, 2, 3

Engineering Economy Principles

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.

The Use of These 10 Principles

This text emphasizes the use of these 10 principles in choosing the best investment to make and addresses specific kinds of engineering investments. What kind of investments do we consider?

- Replacing a production machine or process.
- Designing a new product.
- Expanding the production scale.

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The 7-Step SEAT

In performing engineering economic analyses, it is helpful to follow a consistent methodology. The following 7-step systematic economic analysis technique (SEAT) is recommended:

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.

SEAT Step 1 of 7

Identify the Investment Alternatives

Generally, the aim is to select the best investment from a feasible set of mutually exclusive and collectively exhaustive investment alternatives.

- “Mutually exclusive" as used here means “either/or but not both."
- “Collectively exhaustive" means that no other investment alternatives are available-all possible investments are considered.

Example

Example (1.5)

Four proposals (A, B, C, and D) are available for investment. Proposals A and C cannot both be accepted; Proposal B is contingent upon the acceptance of either Proposal C or D; and Proposal A is contingent on D.

(a) List all possible combinations of proposals and clearly show which are feasible.

(b) Of the ten principles, which one(s) is(are) well illustrated by this problem?

Solution: a) ~~A~~, ~~B~~, C, D

~~AB~~, ~~AC~~, AD, BC, BD, CD.

~~ABC~~, ABD, ~~ACD~~, BCD,

~~ABCD~~

b) (2)

The feasible combinations are:
C, D, AD, BC, BD, CD, ABD, BCD.

Example

SEAT Step 2 of 7

Define the Planning Horizon.

As noted in the eighth principle of engineering economic analysis, it is important to compare investment alternatives over a common period of time. In this text, this period of time is referred to as the planning horizon.

Definition (planning horizon)

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

Setting the Planing Horizon

When the lives of investment alternatives differ, five general approaches are used to determine the planning horizon's length:

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 a standard length horizon equal to the period of time that best fits the organization's need, such as 10 years.
5. Use an infinitely long planning horizon.

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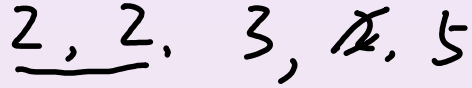
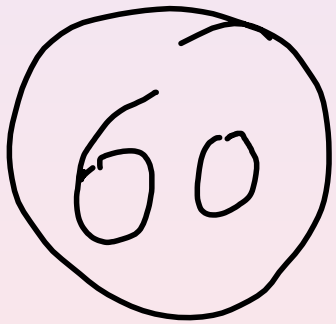
Example

Example (1.6)

A Payne County commissioner has $20,000 remaining in the budget to spend on one of three worthy projects. Each is a one-time investment, and there would be no follow-on investment, regardless of which project is chosen.

- Project A involves the placement of gravel on a rough and often muddy road leading to a public observatory, providing net benefits (consider this as net revenue-in-kind) of $8,000 per year for 4 years, at which time the road will again be in disrepair.
- Project B involves the building of a water-retention dam to hold water during big rains, thereby lessening damage due to flash flooding; the benefits are expected to be worth $6,000 for each of 6 years, after which silt will have made the pond ineffective.
- Project C is to provide water, sewer, and electrical hookups for recreational vehicles at the fairgrounds; net benefits of $4,000 per year would be realized for 10 years, after which the system would need to be replaced.





Example

Example (1.6 continue)

No matter which alternative is selected, once its useful life is over, there will be no renewal.

a) What is the planning horizon if we use the shortest life among the alternatives? 4 years

(b) What is the planning horizon if we use the longest life among the alternatives? 10 years

(c) What is the planning horizon if we use the least common multiple of the lives among the alternatives? 60 years

(d) Of the ten principles, which one(s) is(are) well illustrated by this problem? 1, 2, 3, 8

SEAT Step 3 of 7

Specifying the Minimum Attractive Rate of Return

The chapters that follow will examine many investment opportunities, always using an interest rate to compound (move forward in time) or discount (move backward in time) cash flows. This interest rate is commonly referred to as the **minimum attractive rate of return or MARR**. The value used for the minimum attractive rate of return matters -a lot!

Definition

The **minimum attractive rate of return (MARR)**, Also referred to as the hurdle rate or discount rate, 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.

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Weighted Average Cost of Capital (WACC)

Generally, a company has multiple sources of capital: loans, bonds, stocks, and so on. they typically calculate the weighted average cost of capital (WACC) and use it to establish a lower bound on the MARR.

Definition

The WACC is a value calculated to establish the lower bound on the MARR and to take into account that most firms have multiple sources of capital.

Capital available to a corporation can be categorized as either debt capital or equity capital.

- Examples of debt capital are bonds, loans, mortgages, and accounts payable.
- Examples of equity capital are preferred stock, common stock, and retained earnings.

Typically, capital for a particular investment consists of a mixture of debt and equity capital.

SEAT Step 4 of 7

Estimate the Cash Flows

Once the planning horizon is determined, cash flow estimates are needed for each investment alternative for each year of the planning horizon. For instance, most of the companies need to estimate the costs for each year of the planning horizon.

Cost estimating is not an exact science. Rather, it is an approximation that involves the availability and relevancy of appropriate historical data, personal judgments based on the estimator's experience, and the time frame available for completing the estimating activity.

SEAT Step 5 of 7

Comparing Alternatives

After the investment alternatives are identified, the planning horizon is defined, the discount rate is specified, and the cash flows are estimated, it is time to evaluate the alternatives in terms of their economic performance. When doing the comparison, it is necessary to select a criterion to use.
For instance, we can use the present value(PV) as a criteria and calculate the PV's of different alternatives .

SEAT Step 6 of 7

Performing Supplementary Analyses

The sixth step in comparing investment alternatives is performing supplementary analyses. The intent of this step is to answer as many “what if " questions as possible.

Up to this point, it has been assumed that the cash flow estimates, the length of the planning horizon, and the TVOM used were error free. Obviously, that will not always be the case. Conditions change, errors are made, and risks and uncertainties exist. In this step, risk and uncertainty are explicitly considered.

SEAT Step 7 of 7

Select the Preferred Investment

Selecting the preferred investment is the final step in a systematic engineering analysis. Because many factors must be considered in making the selection, the preferred investment may not be the one that performs best when considered using only the economic criteria. Typically, multiple criteria exist rather than a single criterion of maximizing, say, present worth. The presence of multiple criteria coupled with the risks and uncertainties associated with estimating future outcomes makes the selection process quite complicated.

The text concentrates on economic factors throughout. Keep in mind, however, that management's ultimate choice may be based on a host of criteria rather than a single monetary criterion.