B0684
Economic Engineering Analysis

Introduction

Contact details

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Instant response in class through DingTalk

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Please indicate clearly which module (e.g., Economic Engineering Analysis) your query is about.

Please bring your laptop

- **We will demonstrate economic calculations in Excel!**

Please engage actively in class!!

- **Answer questions**
- **Participate in polls**
- **Ask questions**

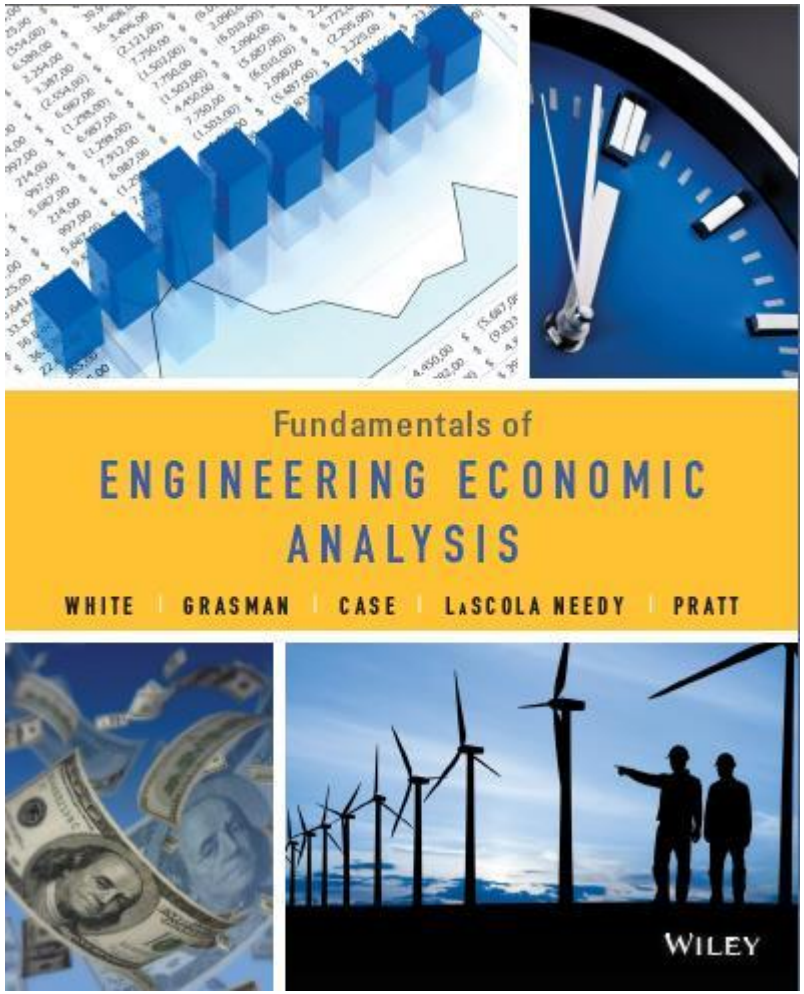
Assessment	Weighting	Due date
Participation	10%	Registered every lecture
Midterm Exam	30%	TBA (around Week 9)
Final Exam	60%	TBA (Week 18-20)

Exam

- **MCQ**
- **Short answer**
- **Calculation**

Textbook:

White et al. (2019). Fundamentals of Engineering Economic Analysis, Wiley.



- What is engineering economic analysis?

- Using a combination of quantitative and qualitative techniques to analyze economic differences among engineering design alternatives in selecting the preferred design.
- Purpose: to select preferred plan/project
- Criteria: certain desired economic outcomes
- Technique: cash flow approach
  - money received and money dispersed (spent or paid) constitutes a cash flow.

- What decides the value of money?
  - Someone is rich. Some country is affluent.
  - They have a great amount of money.

- What else?
  - What you bought with 100$ 10 years ago=what you buy with 100$ now?
  - 100$ 10 years ago is more valuable than 100$ now.

TIME VALUE OF MONEY

- Money has a time value.
- 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.
- Money has time value even in the absence of inflation.
- Money has "earning power"
  - If you own money and someone else needs it, you can loan it to them. And charge interest!
  - You can get from the bank on your deposit – interest.

Illustration

Suppose a wealthy individual approaches you and tells you,

"Because of your outstanding ability to manage money, I am happy 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." (assume that the guarantee is risk-free.)

In other words, you can choose to receive $1,000 today or receive $X 1 year from today.

Which would you choose if X equals

(A) $1,000,

(B) $1,200,

(C) $2,000,

(G) $10,000?

- Some may have a very strong need for money NOW. they do not believe they can wait a year to receive the money, even if they will receive significantly more at that time.
- Some may be skeptical regarding the guarantee of the money being available a year later — bird in the hand, versus many birds in the bush.
- Corporate managers/executives exhibit similar tendencies when faced with current versus deferred choices.

- If a student is indifferent when X equals $1,200, then we conclude that $1,200 received 1 year from now has a present value or present worth of $1,000 for that particular student in his/her current circumstances.
- F_0=1000 = F_1=1200
- We would conclude that this student's TVOM is 20%, that is (1200-1000)/1000.

TVOM is sometimes referred to as

- opportunity cost
- interest rate
- discount rate
- hurdle rate
- minimum attractive rate of return
- cost of capital

- Please remember these terms!
- They mean the same thing!!

Discounted Cash Flow (DCF)

- Using the TVOM to convert all future cash flows to a present single sum equivalent.
- Or more broadly, any movement of money backward or forward in time.

Four DCF rules

1. Money has a time value.
2. Quantities of money can NOT 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/interest rate.

   $F_1=F_0*(1+TVOM)$
4. To move money backward one time unit, divide by 1 plus the discount/interest rate.

   $F_0=F_1/(1+TVOM)$

Example

Recall in the previous example, the student's TVOM was 20%.

Suppose the student is guaranteed to receive $1,100 one year from today, if $1,000 is invested today in a particular venture.

What is the return on the student's investment? (How much does he earn)

100$? WRONG

It would be a mistake to subtract the $1,000 investment from the $1,100 return, and conclude that the investment yielded a net positive return of $100.

Why?

Rule 1 establishes that money has a time value; for this student, it can be represented by a 20% annual rate.

Rule 2 establishes that the $1,000 investment cannot be subtracted from the $1,100 return, because they occur at different points in time.

Using Rule 3, the student would conclude that the future value/worth of the $1,000 investment, based on a 20% TVOM, equals $1,000*(1+20%), or $1,200 one year later.

- Because the $1,000 was an expenditure or investment, it is a negative cash flow, whereas the $1,100 return on the investment was a positive cash flow.
- Hence, the net future worth of the investment is -$1,200+ $1,100, or -$100.
- Because the *future worth* is negative, the investment would not be considered a good one by the student.
- Here we move money forward in time, or compound.

Or using Rule 4, the student would conclude that the present value or present worth of $1,100 a year from now equals $1,100/(1+20%), or $916.67.

- Therefore, the $1,000 investment yields a negative net *present value* of -83.33$ (-1,000+916.67).
- Likewise, the student should conclude that the investment was not a good one.
- Here we move money backward in time, or discount.

What if the student's TVOM had been 8% instead of 20%? Please calculate.

S1: compounding

F1'=-1000*(1+8%)=-1080, F1=-1080+1100=20

Alternatively,

S2: discounting

F0'=1100/(1+8%)=1018.5, F0=-1000+1018.5=18.5

Both answers are correct.

As the net present worth F0 (or the net future worth F1) is positive, the investment is considered a good one!

10 principles of engineering economic analysis

1. Money has a time value.
   - we prefer to receive a fixed sum of money sooner rather than later; we prefer to pay a fixed sum of money later.
2. Make investments that are economically justified
3. Choose the mutually exclusive investment alternative that maximizes economic worth.
   - mutually exclusive: when multiple investment alternatives exist and only one can be chosen.
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.
   - It is important to compare the alternatives over the same length of time.
9. Risks and returns tend to be positively correlated.
   - An investment with a high return and low risk is highly questionable!!
10. Past costs are irrelevant, unless they impact future costs.
    - Past costs, also called sunk costs, must be ignored when performing an engineering economic analysis

Example of EEA Questions

- The principles provided can be used to identify the best engineering design, product, process, or system, and to assist in personal investing
  - Whether investments in existing equipment—such as overhauling the equipment or adding new features to extend its useful life or to add new production capability
  - Whether to use standardized parts that can be purchased or specially designed parts that must be produced;
  - Whether to enclose the product in a molded plastic case or a formed metal case;
  - Whether to use standard, replaceable batteries or a specially designed rechargeable battery;
  - Whether to perform the manufacturing and assembly in-house versus outsourcing the manufacturing and assembly;
  - Decisions regarding mergers, acquisitions, and disposition of manufacturing plants

Systematic Economic Analysis Technique (SEAT)

Seven 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.

SEAT Step 1 of 7: Identify the Investment Alternatives

- To select the best investment from a feasible set of mutually exclusive and collectively exhaustive investment alternatives.
- Mutually exclusive — either/or (NOT both)
- Collectively exhaustive —all possible investments are considered, no other investment alternatives are available
- A ‘‘do nothing’’ (business as usual) alternative often is used as a baseline against which other investment alternatives are compared.
  - It is often the most expensive alternative: while the firm is doing nothing (forego the opportunity to influence future events), its competitors are generally doing something.

SEAT Step 2 of 7: Defining the Planning Horizon

- To compare investment alternatives over a common period of time.
- Planning Horizon: the period of time or width of the "window" over which the economic performance of each investment alternative will be viewed.

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 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.

- Assume Alternative A has a useful life of 4 years, Alternative B has a useful life of 5 years, and Alternative C has a useful life of 6 years.

- Using the shortest life approach (#1): the planning horizon = 4 years.
  - With a 4-year planning horizon, one must estimate the value of the one remaining year of useful service for Alternative B, and the value of the 2 years of useful service available with Alternative C.

- Using the longest life approach (#2): the planning horizon = 6 year.
  - In this case, decisions must be made about the salvage value of the 2-year gap for Alternative A, and the 1-year gap for Alternative B.

- Using the least common multiple of lives (#3): the planning horizon = 60 year. This is the most popular approach.
  - Least common multiple: the smallest positive integer that is divisible by the numbers concerned (in this case, 4, 5 and 6).
  - Each alternative's cash flow profile is assumed to repeat in the future until all investment alternatives under consideration conclude at the same time.
  - However in this case, the planning horizon is *too long*. It does not seem realistic to assume that identical cash flow profiles will repeat over a period of 60 years.

SEAT Step 3 of 7: Specifying the Minimum Attractive Rate of Return

- Minimum Attractive Rate of Return (MARR): 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.
- = TVOM = hurdle rate = discount rate
- Firms have multiple sources of capital (loans, bonds, stocks etc.), and each has a different cost associated with it.
- Firms typically calculate the Weighted Average Cost of Capital (WACC) and use it to establish a lower bound on the MARR.
- WACC covers unprofitable investments (e.g., to comply with governmental regulations, to enhance employee morale, to protect lives etc.) which have to be met, and thus it's a lower bound of the MARR.

- Capital can be categorized as debt capital or equity capital.
- Debt capitals include bonds, loans, mortgages, and accounts payable (something you owe).
- Equity capitals include preferred stock, common stock, and retained earnings (something they owe you).

SEAT Step 4 of 7: Estimate the Cash Flows

- Cash flow estimates are needed for each investment alternative for each year of the planning horizon

SEAT Step 5 of 7: Comparing Alternatives

- The investment is evaluated on the basis of its present value/worth, or future value/worth.

SEAT Step 6 of 7: Performing Supplementary Analyses

- To answer as many ‘‘what if’’ questions as possible, as 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

- Multiple criteria exist rather than a single criterion of maximizing, say, present worth.
- The text concentrates on economic factors.
- Despite attempts to quantify all benefits in economic terms, some intangible factors or attributes probably will not be reduced to dollars.
  - improved safety, reduced cycle times, improved quality, increased flexibility, increased customer service, improved employee morale, being the first in the industry to use a particular technology, and increased market visibility…

Review – Multiple Choice Question (MCQ) – Only one correct answer!

1. The fact that one should not add or subtract money unless it occurs at the same point in time is an illustration of what concept?

a. Time value of money
c. Economy of scale
b. Marginal return
d. Pareto principle

a

2. If a set of investment alternatives contains all possible choices that can be made, then the set is said to be which of the following?

a. Coherent
c. Independent
b. Collectively exhaustive
d. Mutually exclusive

b

Review

3. Risks and returns are generally _____ correlated.

a. inversely c. not

b. negatively d. Positively

d

4. The “discounting” in a discounted cash flow approach requires the use of which of the following?

a. An interest rate

b. The economic value added

c. The gross margin

d. The incremental cost

a

Review

5. Answering “what if” questions with respect to an economic analysis is an example of which step in the systematic economic analysis technique?

a. Identifying the investment alternatives

b. Defining the planning horizon

c. Comparing the alternatives

d. Performing supplementary analysis

d

6. If a student’s time value of money rate is 30 percent, then the student would be indifferent between $100 today and how much in 1 year?

a. $30 c. $103

b. $100 d. $130

d

Review

7. Which of the following best represents the relationship between the weighted average cost of capital (WACC) and the minimum attractive rate of return (MARR)?

a. WACC and MARR are unrelated.

b. WACC is a lower bound for MARR.

c. WACC is an upper bound for MARR.

d. MARR ≤ WACC.

b

Review – Calculation

1. RT is about to loan his granddaughter Cynthia $20,000 for 1 year. RT's TVOM, based upon his current investment earnings, is 8 percent. Cynthia's TVOM, based upon earnings on investments, is 12 percent.

a. Should they be able to successfully negotiate the terms of this loan?

Yes.

b. If so, what range of paybacks would be mutually satisfactory? If not, how far off is each person from an agreement?

Interest rate range [8%, 12%];

payback = 20,000*interest rate = [1,600, 2,400]

In this way, RT receives equivalent or more than her TVOM, so it's profitable for RT. Cynthia pays equivalent or less than her TVOM, so it's profitable for Cynthia too (as she can use this loan to yield more profit).