Engineering Economic Analysis

FOURTEENTH EDITION

Chapter 1

Making Economic Decisions

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Chapter Outline

- Types of Problems
- Role of Engineering Economic Analysis
- Decision-Making Process
- Ethics
- Engineering Decision Making for Current Costs
- When More than Economics is Involved

Learning Objectives

- Distinguish between simple & complex problems
- Understand the role & purpose of engineering economic analysis
- Apply the economic decision making process
- Understand common ethical issues of decision making
- Solve engineering problems with current costs
- Solve problems with multiple objectives

Vignette: Delivered Food & Decision Making

- Will you order food for delivery?
- Order directly from restaurant or use delivery service?
- Restaurants are partnering with delivery services
- Facilities are changing for mixed use: dine in & take out

- Deliveries can squeeze profits
- Who to blame for late arrival?
- Customer loyalty may shift
- Many restaurants delivering themselves to limit risk

Vignette: Delivered Food & Decision Making

- What operating issues are created when using 3rd party platforms? Can they affect financial viability?
- What are other businesses where delivery services are desired?
- Did you ever think that how you ordered could have an economic impact?
- What are concerns/questions that consumers may have about 3rd party platforms for restaurant delivery?
  - Economic
  - Non-economic

Making Economic Decisions

Course is about making decisions

- Develop tools to properly
  - analyze &
  - solve

  economic problems that are commonly faced by engineers
- Focus is on problems facing firms
- Many examples affect personal finances

A Sea of Problems

- Simple problems
  - Cash or credit card?
  - Semester parking pass or use parking meters?
- Intermediate problems
  - Buy or lease?
  - Which equipment should be purchased?
- Complex problems
  - Feasibility study of a new automobile plant
  - Planning for new highways

Role of Engineering Economic Analysis

- Most suitable for problems
  - Important enough to justify serious study
  - Requires organized analysis
  - Economic aspects are important
- Engineers determine how money is spent
  - Cost savings
  - Increase revenues & benefits
  - Long term: years
  - Focus on money & value

A Decision Making Process

1. Recognize problem
2. Define the goal or objective
3. Assemble relevant data
4. Identify feasible alternatives
5. Select the criterion to determine the best alternative
6. Construct a model
7. Predict each alternative's outcomes or consequences
8. Choose the best alternative
9. Audit the result

Decision-Making Process
1. Recognize Problem

Recognize problem or opportunity exists

- Often clear due to accident, out of parts, new product available, etc.
- Identified via TQM (total quality management) or CPI (continuous process improvement)

Decision-Making Process
2. Define Goals/Objectives

- General or specific goals
- Systems perspective
- Limiting factors
- Multiple goals
- Conflicting goals

Decision-Making Process
3. Assemble Relevant Data

- Importance of data collection
- Relevance of info
- Dollar amount & time horizon
- Sources of info
  - Financial accounting system
  - Cost accounting records
  - Market research
  - Quotations
  - Economic indicators
  - Other published info

Example 1-1

To make 30,000 copies, in-house charges are: Direct labor $228, Materials $294, Overhead $271; Total cost $793. Commercial printer charges $688. Where do you print?

1. Direct labor. If you don't use your people, will you really save money? Likely that people will be paid anyway.

2. Materials. If you use commercial printer, $294 would not be spent.

3. Overhead. No reduction in overhead costs. Firm will pay these whether you use their services or not.

Cheaper to use in-house printing, because labor & overhead will be a fixed cost; paid whether you use them or not.

Student Loan

An engineering student is offered a loan of $5000 per year for 4 years. The loan must be repaid after graduation, paying $5000 each year for 4 years. Is this a good deal?

A. Yes
B. No
C. Neither yes or no
D. I have no idea

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B. No
C. Neither yes or no
D. I have no idea

Yes! This is an interest-free loan for 8 years, due when the student has an income and better able to repay.

Decision-Making Process
4. Identify Feasible Alternatives

- Include as many alternatives as possible:
  - Do Nothing is an option often overlooked
  - Look for simple solutions
- Brainstorming
- Keep it rational – analyze only feasible alternatives

Decision-Making Process
5. Select the Criterion

- Multiple criteria
- Conflicting criteria
- Integrating criteria
- Most common criterion – maximize profit

Category	Economic Criterion
Fixed input	Max benefits or other outputs
Fixed output	Min costs or other inputs
Neither input nor output fixed	Max profits (value of outputs – cost of inputs)

Decision-Making Process
6. Construct Models

- Real systems & models
- Models describe links among relevant data to predict outcomes of alternatives
- Can be physical or math

Decision-Making Process
7. Predict Alternatives' Outcomes

- Alternatives are comparable
  - Single criterion
  - Single composite criterion
- Monetary & nonmonetary outcomes
  - Market consequences (established market prices)
  - Extra-market consequences (no direct market prices)
  - Intangibles (valued by judgement)

Decision-Making Process
8. Choose Best Alternative(s)

- Based on selected criterion
- Include intangible considerations

Decision-Making Process
9. Audit the Results

- Did actual outcome match prediction?
- Results of analysis agree with projections?
- If audit will occur ➔ projections likely to be more accurate

Engineering Economics

In which of the following problems do you need engineering economics?

A. To compare a 4-year and a 5-year car loan
B. To decide whether a new or a used car is cheaper
C. To decide whether to pay your car insurance quarterly or annually
D. All of the above
E. None of the above

Engineering Economics

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D. All of the above
E. None of the above

All involve cash flows at different times, and involve enough money to make analysis worthwhile.

Ethics

- Distinguishing between right & wrong in decision making
- Ethics includes:
  - Establishing systems of beliefs, moral obligations
  - Defining values & fairness
  - Determining duty & guidelines for conduct

Code of Ethics
National Society of Professional Engineers

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health, welfare of the public
2. Perform services only in areas of competence
3. Issue public statements in an objective and truthful manner
4. Act for each employer as faithful agents or trustees
5. Avoid deceptive acts
6. Conduct themselves honorably, responsibly, ethically, lawfully to enhance the honor, reputation, & usefulness of the profession.

(http://www.nspe.org/resources/ethics/code-ethics)

Ethical Dimensions in Engineering Decision Making

Decision Process Step	Example Ethical Lapses
1. Recognize the problem	• "Looking the other way"; to not recognize problem due to bribes or fear of retribution
2. Define goals/objectives	• Favoring one group of stakeholders
3. Assemble relevant data	• Using faulty or inaccurate data
4. Identify feasible alternatives	• Leaving legitimate alternatives out
5. Select criterion to determine best alternative	• Considering only monetary consequences when other significant consequences exist

Ethical Dimensions in Engineering Decision Making

Decision Process Step	Example Ethical Lapses
6. Construct a model	• Using a short time horizon that favors one alternative
7. Predict alternative's outcomes	• Using optimistic estimates for one alternative, pessimistic ones for others
8. Choose the best alternative	• Choosing an inferior alternative, one that is unsafe, adds unnecessary cost for user, harms the environment
9. Audit the result	• Hiding past mistakes

Ethics: Sources of Possible Dilemmas

- Building a working relationship
  - At extreme includes bribery
  - Know guidelines for meals, events, etc.
- Cost, quality, functionality
  - Trade-offs always exist
- Environment
  - Societal costs are project's negative impacts
  - Reducing societal costs is an ethical goal
- Safety

Ethics in Engineering

- It’s important
  - Unethical decisions routinely occur
  - Can damage or destroy a company or a career
    - Lots of examples
  - Can cause lasting damage to people or environment
- Foundation for success: professional integrity

Example 1-2
Decision-Making for Current Costs

A concrete aggregate mix must contain at least 31% sand by volume for proper batching. One source of material, which has 25% sand and 75% coarse aggregate, sells for $3 per cubic meter ($m^3$). Another source, which has 40% sand and 60% coarse aggregate, sells for $4.40/$m^3$. Determine the least cost per cubic meter of blended aggregates.

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Assuming X is Price of Sand in $/$m^3$.
Assuming Y is Price of Coarse aggregate in $/$m^3$.

$$0.25x + 0.75y = \$3 \quad -(1)$$
$$0.40x + 0.60y = \$4.40 \quad -(2)$$

8x (1) − 5 (2)

$$8 \times 0.25x + 8 \times 0.75y = 24$$
$$-\ 5 \times 0.40x + 5 \times 0.60y = 5 \times 4.40$$

$$2x + 6y = 24$$
$$-\ 2x + -3y = -22$$

$$3y = 2$$

$$\boxed{y = \frac{2}{3} \$/m^3}$$

Subsituting y in eq (1) gives

$$0.25x + 0.75 \times \frac{2}{3} = 3$$

(0.25)

$$0.25x + 0.5 = 3$$
$$0.25x = 2.5$$

$$\boxed{x = \frac{2.5}{0.25} = 10 \$/m^3}$$

$$0.31 \times 10 + (1 - 0.31) \times \frac{2}{3}$$

$$3.1 + \cancel{0.69}^{\,0.23} \times \frac{2}{\cancel{3}}$$

$$\boxed{= \$3.56}$$

Example 1-2
Decision-Making for Current Costs

Minimize cost of aggregate mix

- X = portion from $\$3/m^3$ source
- Y = portion from $\$4/m^3$ source
- $X + Y = 1$

Least cost blend has just enough \$4 material to meet min 31% sand, so

$$X(0.25) + (1 - X)(0.40) = 0.31$$

$$X = 0.60$$

The 60%/40% blend will cost

$$0.60(\$3) + 0.40(\$4) = \$3.56/m^3$$

Example 1-3
Decision-Making for Current Costs

A machine part is manufactured at a unit cost of 40¢ for material and 15¢ for direct labor. An investment of $500,000 in tooling is required. The order calls for 3 million pieces. Halfway through the order, managers learn that a new method of manufacture can be put into effect that will reduce the unit costs to 34¢ for material and 10¢ for direct labor—but it will require $100,000 for additional tooling. This tooling will not be useful for future orders. Other costs are allocated at 2.5 times the direct labor cost. What, if anything, should be done?

1,500,000	Number of Pieces			
2.5	Other Cost $/direct labor $			
	A: Present Method		B: New Method	
Costs	Unit	Total	Unit	Total
Material	0.4	600,000	0.34	510,000
Labor	0.15	225,000	0.1	150,000
Other		562,500		375,000
Added Tooling			100,000	100,000
Total		1,387,500		1,135,000
		Possible Savings		252,500

Example 1-3
Decision-Making for Current Costs

- Original costs
  - \$0.40 per unit material cost
  - \$0.15 per unit labor cost
  - \$500,000 tooling
  - 3 million pieces
- Half way thru order
  - \$0.34 per unit material cost
  - \$0.10 per unit labor cost
  - \$100,000 additional tooling
- Other costs = 2.5 × labor cost
- Should you invest?

Example 1-3
Create a Data Block

	A	B	C	D	E
1	1,500,000	Number of pieces			
2	2.5	Other cost $/direct labor $			
3		A: Present Method		B: New method	
4	Costs	unit	total	unit	total
5	Material	0.4		0.34	
6	Labor	0.15		0.1	
7	Other				
8	Added tooling			$ 100,000	

Example 1-3
Complete Information

	A	B	C	D	E	F
1	1,500,000	Number of pieces				
2	2.5	Other cost $/direct labor $				
3		A: Present Method		B: New method		
4	Costs	unit	total	unit	total	
5	Material	0.4	$ 600,000	0.34	510,000	=D5*$A$1
6	Labor	0.15	$ 225,000	0.1	150,000	=D6*$A$1
7	Other		$ 562,500		375,000	=E6*$A$2
8	Added tooling			$ 100,000	$ 100,000	
9	Total		$ 1,387,500		$ 1,135,000	
10				Possible savings	$ 252,500	
11						

Do other costs vary as direct labor costs vary?
If yes, change manufacturing method

Example 1-4
Decision-Making for Current Costs

EXAMPLE 1-4

Two different liquid filter systems are being studied to clarify a liquid stream. A traditional filter will operate for one 8-hour shift before being replaced. A special pleated design can last one full week, operating 24 hours a day (3 shifts), 5 days per week. Labor cost to change a filter is estimated to be worth $10.00 for each filter change because a mechanic would work overtime to change the filter. The traditional filters cost $3.50; the special pleated filters cost $90.00. Which filter should be chosen?

Traditional filter

Total Cost = 3 x 5 x 3.5 +

↑ units, ↑ days, ↑ cost of the filter

3 x 5 x 10

↑ units, ↑ day in a week, ↑ cost of labor

Total cost = 52.5 + 150 = $202.5

Special Pleated Design filter

$90 + $10 = $100

↑ for a week, ↑ cost of labor

Example 1-4
Decision-Making for Current Costs

Two filter systems

- Life: Traditional = 1 shift (8 hrs.), Special = 1 week
- Labor cost to change filter: $10 per change
- Material: Traditional = $3.50 each, Special = $90.00 each
- 24 hours/day, 5 days/week
- Which should be chosen?

Example 1-4
Decision-Making for Current Costs

- Material costs
  - Traditional: (\$3.50/change)(3 changes/day)(5 days/week) = \$52.50/week
  - Special: (\$90.00/change)(1 change/week) = \$90.00/week
- Labor cost
  - Traditional: (\$10/change)(3 changes/day)(5 days/week) = \$150.00/week
  - Special: (\$10/change)(1 change/week) = \$10/week
- Total
  - Traditional: \$52.50 + \$150.00 = \$202.50/week
  - Special: \$90.00 + \$10.00 = \$100.00/week
- Choose lower total cost: special pleated filter

Multiple Objectives

More than economics is often involved

- Include all important objectives
- Weight importance of each
- Select objective & rate alternatives
  - Repeat for all objectives
- Disqualify alternatives not meet min requirements

Example 1-5
Decision-Making for Current Costs

Using a weighted average for multiple objectives

	A	B	C	D	E
1		Job	Family	Livability	
2	Weight	50%	30%	20%	
3	Offer				Total
4	A	4	9	5	5.7
5	B	8	5	4	6.3
6	C	6	3	8	5.5
7					
8		=SUMPRODUCT($B$2:$D$2,B4:D4)			

More Engineering Economics

Engineering economics should be used in which of the following comparisons?

A. A robot's and a person's cost per part produced
B. Overhauling a forklift or buying a new one
C. Leasing or buying a tractor trailer
D. Buying a new drill press to make a part or buying the part
E. All of the above

More Engineering Economics

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All involve cash flows at different times, and involve enough money to make analysis worthwhile.