TIE2140 Engineering Economy
Tutorial #6 Lab 2
Engineering Financial Decision Process

Objectives and Learning Outcomes

In this lab-based tutorial, you will learn how to apply the engineering-financial decision-making process to a case study using MS Excel and additional add-on software. At the end of the session, you will be able to do the followings:

1. Develop cash flow models based on the base case scenario using Excel financial functions.
2. Perform Break-Even Analysis by plotting Rainbow Diagrams.
3. Perform One-Way Range Sensitivity Analysis to generate Tornado and Spider Diagrams.
4. Perform Probabilistic Risk Analysis using Monte Carlo Simulation.
5. Interpret Risk Profiles and make final recommendations.

Problem Description

ISEM Company has recently successfully developed a new product. The market demand of this product is estimated to be 15,000 units per year at a sale price of $10 per unit. The product life is expected to be 10 years. The product can be manufactured using two alternative methods using different manufacturing technologies as follows:

Alternative A: Advanced manufacturing technology

This involves adopting a recently developed advanced manufacturing technology and requires expensive automatic machine tools with intelligent sensors system. Relevant data for this alternative are given below:

- Initial cost: $230,000.
- Useful life: 10 years.
- Salvage value: $10,000

- Manpower requirements and costs:
  - Production output: 8 units per hour
  - Number of operators needed: 1
  - Skill level: High
  - Manpower cost: $12 per hour per operator

- Annual maintenance and other costs:
  - Maintenance manpower: $25,000
  - Moldings & Tooling: $5,000
  - Spare parts: $5,000

- Direct material costs: $3 per unit.

Alternative B: Conventional manufacturing technology

This involves using an existing manufacturing technology that requires cheaper conventional machine tools operated low-skill workers. Relevant data for this alternative are given below:

- Initial cost: $90,000.
- Useful life: 5 years.
- Salvage value: $1,000

- Manpower requirements and costs:
  - Production output: 6 units per hour
  - Number of operators: 3
  - Skill level: Low
  - Manpower cost: $8 per hour per operator

- Annual maintenance and other costs:
  - Maintenance manpower: $10,000
  - Moldings & Tooling: $3,000
  - Spare parts: $2,000

- Direct material costs: $3 per unit.

Your Mission

ISEM management is not sure which of the two alternatives to select, and you have been engaged as a consultant to advise the company.

ISEM's CEO has instructed you to use a before-tax *MARR* 12% and a study period of 10 years in the analysis. In addition, you may use the repeatability assumption where needed. Income tax does not need to be considered in this analysis as the company has been granted special tax exemption by the Economic Development Board for this investment project.

1. Base Model Development & Analysis

Use Excel to perform before-tax cash flow analysis on the two alternatives based on the base case scenario data. You may use the Excel template provided.

Some useful formulas:

- Annual Revenue = Annual production volume × Unit selling price
- Annual direct manpower cost = Annual production volume × Variable manpower cost per piece
- Annual Direct Material cost = Annual production volume × Direct material cost per unit
- Annual Overheads = Annual Maintenance Manpower + Annual Moldings & Tooling + Annual Spare parts
- $AW(12\%)$ = - Initial Investment [A/P, 12%, N]
  + (Annual revenue – Annual direct manpower cost
  – Annual Direct Material cost – Annual Overheads)
  + Salvage value [A/F, 12%, N]

Q1.1 What are the AW for the two alternatives under base case scenario?

$AW(12\%)$ of Alternative A = _____

$AW(12\%)$ of Alternative B = _____

Q1.2 Are the two alternatives economically feasible under base case scenario?

Alternative A is economically feasible / infeasible

Alternative B is economically feasible / infeasible

Q1.3 Which alternative is preferred under base case scenario?

Alternative A / Alternative B / None

2. Break-Even Analysis on Annual Production Volume

Uncertainty in Annual Production Volume has been identified by the company as a major concern.

Using Excel Table function, compute the *AW* of the two alternatives when the Annual production volume is varied from 13,000 to 17,00 in step of 500.

Plot a rainbow diagram and determine the followings:

Q2.1 Alternative A is economically feasible when the Annual production volume is in the following range:

_____

Q2.2 Alternative B is economically feasible when the Annual production volume is in the following range:

_____

Q2.3 Alternative A is preferred to Alternative B when the Annual production volume is in the following rate:

_____

3. Break-Even Analysis on Unit selling price

Unit selling price of the product has also been identified by the company as a major concern.

Using Excel Table function, compute the *AW* of the two alternatives when the unit selling price is varied from $9.00 to $11.00 in steps of $0.10.

Plot a rainbow diagram and determine the followings:

Q3.1 Alternative A is economically feasible when the Unit selling price is in the following range:

_____

Q3.2 Alternative B is economically feasible when the Unit selling price is in the following range:

_____

Q3.3 Alternative A is preferred to Alternative B in the following range:

_____

4. One-Way Range Sensitivity Analysis

ISEM management is not very comfortable with the results based on the base case data as the company does not have much experience in advanced manufacturing. In addition, there are still many uncertainties in the data to be considered.

You proposed that one-way range sensitivity analyses be performed on the base model to better understand the key uncertainties and hence raise the company's confidence in adopting the best alternative.

Expert's estimates of the possible range of values for each of the uncertain variables are given in the table below:

		Alternative A Advanced Manufacturing			**Alternative B Conventional Manufacturing**		
	Uncertain Variable	Low	Base	High	Low	Base	High
1	Annual production quantity	13,000	15,000	17,000	13,000	15,000	17,000
2	Unit selling price	$9	$10	$11	$9	$10	$11
3	Annual maintenance Cost	$24,000	$25,000	$26,000	$9,000	$10,000	$11,000
4	Annual moldings & tooling cost	$4,500	$5,000	$5,500	$2,500	$3,000	$3,500
5	Annual Spare parts cost	$4,500	$5,000	$5,500	$1,500	$2,000	$2,500
6	Manpower cost/worker/hour	$9.00	$12.00	$15.00	$7.00	$8.00	$9.00
7	Output per hours (pieces)	7.5	8	8.5	5.5	6	6.5
8	Variable material cost per unit	$2.80	$3.00	$3.20	$2.80	$3.00	$3.20
9	Salvage value	$6,000	$10,000	$14,000	$0	$1,000	$2,000

Using the Sensit Excel add-on, generate Tornado and Spider Diagrams for AW of the two alternatives.

Q4.1 The following variables are sensitive:

Q4.2 The following variables are not sensitive:

5. Risk Analysis using Monte Carlo Simulation

To better understand and assess the risk associated with each alternative, you recommended that the probabilistic behavior of the sensitive variables identified in the previous section be fully studied and Monte Caro Simulation is performed on these variables to determine the risk profiles for the two alternatives.

Expert's assessments of the probability distributions of the sensitive variables are given in the table below:

	Alternative A	**Distribution**	**Parameters**
1	Annual volume	Uniform Integer	min=13,000; max=17,000
2	Unit selling price	Truncated Normal	mean=10; sd=0.5; min=9; max=11
3	Annual Maintenance cost	Uniform	min=24,000; max=26,000
4	Manpower cost/worker/hour	Truncated Normal	mean=12; sd=1.5; min=9; max=15
5	Output per hours (pieces)	Triangular	min=7.50; mode=8.00; max=8.50
6	Variable material cost per unit	Triangular	min=2.80; mode=3.00; max=3.20

	Alternative B	**Distribution**	**Parameters**
1	Annual volume	Uniform Integer	min=13,000; max=17,000
2	Unit selling price	Truncated Normal	mean=10; sd=0.5; min=9; max=11
3	Annual Maintenance cost	Uniform	min=9,000; max=11,000
4	Manpower cost/worker/hour	Truncated Normal	mean=8; sd=0.5; min=7; max=9
5	Output per hours (pieces)	Triangular	min=5.50; mode=6.00; max=6.50
6	Variable material cost per unit	Triangular	min=2.80; mode=3.00; max=3.20

Q5.1 Mean and Variance Analysis

Expected AW of Alternative A = _____

Standard Deviation of AW of Alternative A = _____

Expected AW of Alternative B = _____

Standard Deviation of AW of Alternative B = _____

Is there any Mean-Variance Dominance? Yes / No

Q5.2 Downside Risk:

What is the probability that Alternative A will be infeasible? _____

What is the probability that Alternative B will be infeasible? _____

Q5.3 Upside Potentials:

What is the probability that Alternative A will achieve $AW \geq$ \$10,000? _____

What is the probability that Alternative A will achieve $AW \geq$ \$20,000? _____

What is the probability that Alternative A will achieve $AW \geq$ \$30,000? _____

What is the probability that Alternative B will achieve $AW \geq$ \$10,000? _____

What is the probability that Alternative B will achieve $AW \geq$ \$20,000? _____

What is the probability that Alternative B will achieve $AW \geq$ \$30,000? _____

Q5.4 Value-at-Risk:

What is the Alternative A equivalent annual value-at-risk at 90% confidence? _____

What is the Alternative A equivalent annual value-at-risk at 95% confidence? _____

What is the Alternative B equivalent annual value-at-risk at 90% confidence? _____

What is the Alternative B equivalent annual value-at-risk at 95% confidence? _____

Q5.5 Stochastic Dominance Analysis:

Is there any first order stochastic dominance? Yes / No

6. Conclusion

What is your final recommendation to the company?