

Chapter 1 Introduction

“Decision making is what you do when you do not know what to do.”

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1.1 Introduction

1.1.1 Decision Making in a Complex and Uncertain World

- Consider the following scenarios:

Scenario I

- A technology-based company is to decide if it should fund a 5-year R&D program to develop a new product. The company is not sure if the product will be successfully developed to meet its requirements. It also does not know for sure what would be total R&D cost but will be able to do an estimation of the figures.
- Depending on the outcomes above, the company will then decide if it should go into production and market the product. Again, the company does not know for sure what the production cost will be but can do an estimation of the figures.
- If the product is produced and launched into the market, the company does not know how it will perform in terms of sales and revenues, and also how long the product can stay relevant in the market.
- What should the company do now, and how should it act upon knowing the R&D results?

Scenario II

- Miss Chen has been invited by a book publisher to write a book on Introduction to Python Programming.
- She has two options on how to charge the publisher for her work:
 1. Fixed fee basis.
 2. Cost-plus-royalty basis and to retain part of the intellectual property rights to the materials.
- If she charges a fixed fee, she would compute her costs and add a profit margin to the fees. She will not need to worry about uncertainty over the sales of the book.
- On the other hand, if she charges on a cost-plus-royalty basis, she would only be able to recover most of her cost, but her final income would depend very much on the royalties received. This is subject to high uncertainty over the sales.
- What should Miss Chen do?

Scenario III

- Biotechno is a leading company performing cutting-edge R&D in biotechnology areas. Three years ago, the company purchased a high-performance computer for its R&D Department.
- Today, this computer has reached its maximum capacity though it has another two years of useful life. There is a need to double its capacity to meet the anticipated computational needs of new R&D projects that the company is expecting to launch in the coming year.
- The company has the following alternatives:
 1. Expand the system by purchasing a second computer to double the capacity of the entire computing system in its R&D Department.
 2. Replace the existing computer completely with a new one with higher capacities and performance. The old computer can be sold in the used computer market.
- Which option is best for the company?

Scenario IV

- Miss Lee, an attractive person with a graduate degree, must decide among many suitors. Among them include:
 1. Mr. A is a very competitive person, holds a high-paying job, and spends much of his free time networking with business associates and playing golf.
 2. Mr. B holds a reasonable job with a stable income and loves to do volunteer community work during weekends.
 3. Mr. C does not have a full-time job with a stable income, is very active in church activities, and goes on overseas missionary trips frequently.
- Who shall Miss Lee choose?
- If you were Miss Lee, what is our choice?

Decisions Are Hard to Make

- In all the above examples, the decision-makers are faced with the followings:
 1. **Complexity**
 - There are many competing alternatives or possible solutions.
 - There are many factors to be considered and many of these factors are interdependent.
 2. **Uncertainty**
 - The future outcomes are uncertain or difficult to predict.
 - Information and data may be vague, incomplete, or unavailable.
 3. **Multiple Conflicting Objectives**
 - The decision maker(s) may have many goals and objectives.
 - Many of these goals or objectives may be conflicting in nature.

Decision Analysis can help address the above issues.

What is Decision Analysis?

- Decision Analysis is a methodology and practice based on a set of probabilistic frameworks which facilitates systematic, high-quality, and logical conversation, possibility among multiple parties, for dealing with complex and difficult decision problems, leading to clear, compelling, and defensible action by the decision maker(s) or stakeholder(s).

The Goal of Decision Analysis

- The **Fundamental Goal** of Decision Analysis is to achieve **Clarity of Action**.

Decision Analysis Can Provide Answers to:

- What is my best or optimal course of action under my current risk attitude?
- What potentials are realizable in this project, and what are their chances?
- How risky is this project if I follow the recommended actions? What is the chance of having the worst-case scenarios?
- Which are the most important assumptions or sensitive factors in this decision? What if these assumptions are wrong?
- Are there more information or data, that can help to enhance my decision and how much is the information worth paying for?
- What is the value of embedding options or flexibility in the decision and how much are those options worth paying for?

What is a Decision?

- **Ronald Howard's Definition:**

A **decision** is a **commitment** to a specific course of **action** that **irrevocably** allocates valuable **resources**.

- **Examples of Decision:**

- Invest in a project.
- Purchase an item.
- Go to NUS for your graduate studies.
- Accept a job offer.
- Go on a holiday.
- Go for Covid-19 vaccination.

1.1.2 Approaches to Decision Making

Approaches to Study Decision Making

- The **Normative Approach** to decision-making is concerned with how **rational** decisions **ought** to be made. It is about
 - Optimality
 - Rationality
- The **Descriptive** (or Behavioral) **Approach** to decision-making is concerned with understanding how humans **actually** make decisions. It is about
 - Developing psychological models of human cognition and thinking
 - Explaining human behaviors
 - Predicting human behaviors

Which Approach to Follow?

- The normative approach is ideal for a person or organization facing a complex decision situation because it ensures that rational decisions are made.
- However, psychological experiments have found that humans do not follow the norms prescribed by the normative approach. They also found that humans are not very good at estimating probabilities.
- Hence, the normative approach alone is insufficient for dealing with complex real-world applications.

The Prescriptive Approach

- The **Prescriptive Approach** is Normative in nature taking into account the Descriptive approach concerning human limitations.
- The **Prescriptive Approach** subscribes fundamentally to the normative approach but it also prescribes procedures for decision modeling and analysis that take into account the limitation of human thinking and reasoning as revealed by the descriptive approach.
- For example, in the assessment of probability by human experts, deliberate procedures are included to avoid various forms of biases in the estimation.

Decision Analysis is based on the Prescriptive Approach.

1.2 Demonstrations of Some Basic Decision Analysis Concepts

1.2.1 The Coin-Tossing Game or Deal

Description

- You are invited to **bid for the right to play** the coin-tossing game as follows:
 - A coin (shown to you) is to be tossed.
 - If you call the outcome (e.g., head or tail) correctly, you will be paid \$20, otherwise \$0.
 - You have to pay some money to play the game.
 - The game is offered to you only once regardless of the outcome.
- What is the maximum you are willing to pay to **play the game once**?
- Write down the amount: \$ _____

Personal Indifferent Buying Price

- The maximum you are willing to pay to play the game is called your **Personal Indifferent Buying Price (PIBP)** for the game.
- How did you arrive at your personal indifferent buying price?
- Did you perform any calculations to arrive at it? What was it?
- Did everybody in the class have the same personal indifferent buying price? Why?

Option to Sell the right to play the game

- Suppose you outbid everybody and paid $\$X$ for the right to play the game.
- Note that $\$X$ should not be more than your personal indifferent buying price for the game.
- You now have 2 alternative courses of action:
 1. Play the game immediately and resolve the outcomes. You get either \$0 or \$20.
 2. Sell the right to play the game to another person for a sum of money.
- What is the minimum amount for which you will sell the right to play the game to another person?
- Write down the amount: \$ _____

Personal Indifferent Selling Price or Certainty Equivalent

- The above minimum selling price for the game is called your **Personal Indifferent Selling Price (PISP)**.
- It is also called your **Certainty Equivalent** for the game.

PIBP = PISP?

- Is your Personal Indifferent Selling Price for the game equal to your Personal Indifferent Buying Price for the game?
Yes/No

Risk Attitude

- Is your personal indifferent selling price above or below \$10?
- What is so special about \$10?
- Expected Value (EV) of the game = $0.5 (\$20) + 0.5 (\$0) = \$10$.
 - PISP < \$10: Risk Adverse in attitude
 - PISP > \$10: Risk Seeking in attitude
 - PISP = \$10: Risk Neutral in attitude
- What is your risk attitude within the range of possible outcomes for the game?

Value of Information

- While you are still thinking about selling the game and pondering about your uncertain future prospects, a person comes along and offers to tell you the outcome of the toss.
- Suppose this person already knows the outcome (i.e., head or tail) and will not lie to you, what is the maximum amount you are willing to pay him for the perfect information?

\$ _____

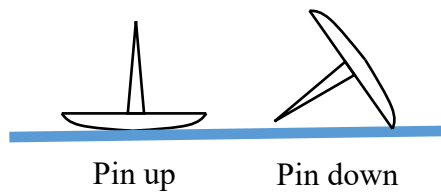
- The above amount is called the **Value of Perfect Information** for the outcome of the game.

Higher Stakes: Does everything scale up?

- The game is now played for a payoff of \$100 or nothing.
- What is now your new Personal Indifferent Buying Price? \$ _____
- Is it 5 times that of the \$20 case? Yes/No
- Suppose you have purchased the right to play the game. What is now your personal indifferent selling price? \$ _____
- Is it 5 times that of the \$20 case? Yes/No

1.2.2 The Thumb Tack Tossing Game: Exploiting Asymmetry

- If instead of tossing a coin, a thumb tack is used:



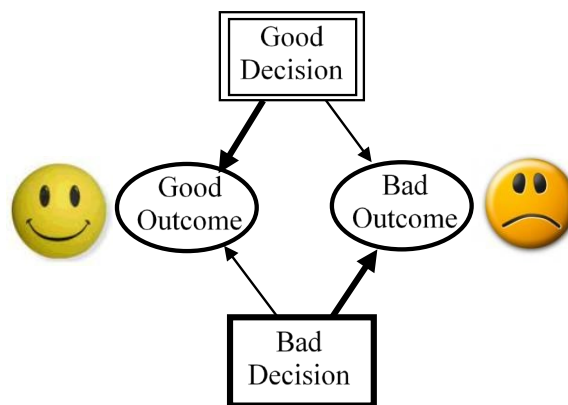
	<u>Thumb-Tack Tossing</u>	<u>Coin-Tossing</u>
\$20 or nothing:		
My personal indifferent buying price =	_____	_____
My personal indifferent selling price =	_____	_____
\$100 or nothing:		
My personal indifferent buying price =	_____	_____
My personal indifferent selling price =	_____	_____

- Conclusions: _____

1.3 More Concepts in Decision Analysis

1.3.1 Good Decisions versus Good Outcomes

- Suppose a decision is made and the outcome is known. It would be easy to judge if the outcome is **GOOD** or **BAD**.
 - If the outcome is **Good**, does it mean that a **Good** decision was made?
 - If the outcome is **Bad**, does it mean that a **Bad** decision was made?
- We must make the distinction between a **Good Decision** and a **Good Outcome**.
 - A **Good Decision** is one that is made properly with a decision analysis process. But it can result in either a good outcome or a bad outcome due to bad luck.
 - A **Bad Decision** is one that had not been properly considered. But it can also result in either a good outcome due to good luck or a bad outcome.



- Hence, a good decision does not guarantee a good outcome – it only enhances the chance.
- Similarly, a bad decision may result in a good outcome purely due to luck.

1.3.2 The Different Roles in Conducting Decision Analysis

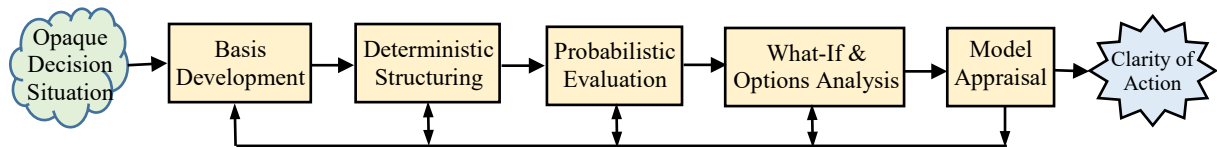
- In a typical decision analysis process, many roles are involved:
 1. **The Decision Makers:**
 - These are the stakeholders or the people who will make the final decision and will be held accountable for it.
 2. **The Decision Analysts or the Consultants:**
 - This is the person or the team who facilitates the decision-making process.
 - This course will train you to be a decision analyst or consultant.
 - The analyst must not assume the role of the decision maker (unless he is also the decision maker).
 3. **The Domain Experts:**
 - These are the people called in to provide expert opinions, judgment, etc.
- It is possible that a person can play more than one of the above roles.

1.3.3 The Sunk Cost Principle

- Review of a concept from Engineering Economic Analysis.
- You paid \$10 for a movie and found it pretty boring halfway through.
- What should you do?
 1. Stay on no matter what since you have already paid \$10.
 2. Sleep in the cinema hall and enjoy the air-conditioning
 3. Walk out and do something more satisfying?
- What you have already paid and is non-refundable is called a sunk cost.
- It should not be considered in deciding the best alternative.
- In financial cash flow analysis, if the \$10 were included in the cash flow analysis, it would be a common term in computing the net present value for all three alternatives. Hence sunk cost is redundant in the analysis as it will not affect the final decision.

1.4 Overview of the Decision Analysis Process

- This course will teach you how to make real-world complex decisions using the **Decision Analysis Process** building upon the foundational topics.
- The Decision Analysis Process or Cycle comprises the following iterative steps:



Step 1: Basis Development

1. The problem is defined and framed.
2. A Decision Model or Basis comprising the followings, is developed:
 - Alternatives: What can we do?
 - Information: What do we know?
 - Preferences: What do you want for value?

Step 2: Deterministic Structuring

1. Value (Business, Discounted Cash Flow) models for the alternatives are developed.
2. One-Way Sensitivity Analysis is done to identify the uncertain factors that have a significant impact on the consequences.

Step 3: Probabilistic Evaluation

1. Probability distributions of sensitive factors (found in the previous step) are assessed.
2. Risk profiles of each alternative are generated.
3. Stochastic dominance analysis is performed.
4. Risk aversion analysis is performed.
5. Best alternative is determined.
6. Expected value of information and control analyses are performed

Step 4: What-If, Options and Other Analysis

1. Sensitivity analysis on key factors is performed.
2. Option Valuation Analysis is performed.
3. Consideration of Qualitative factors (if any)

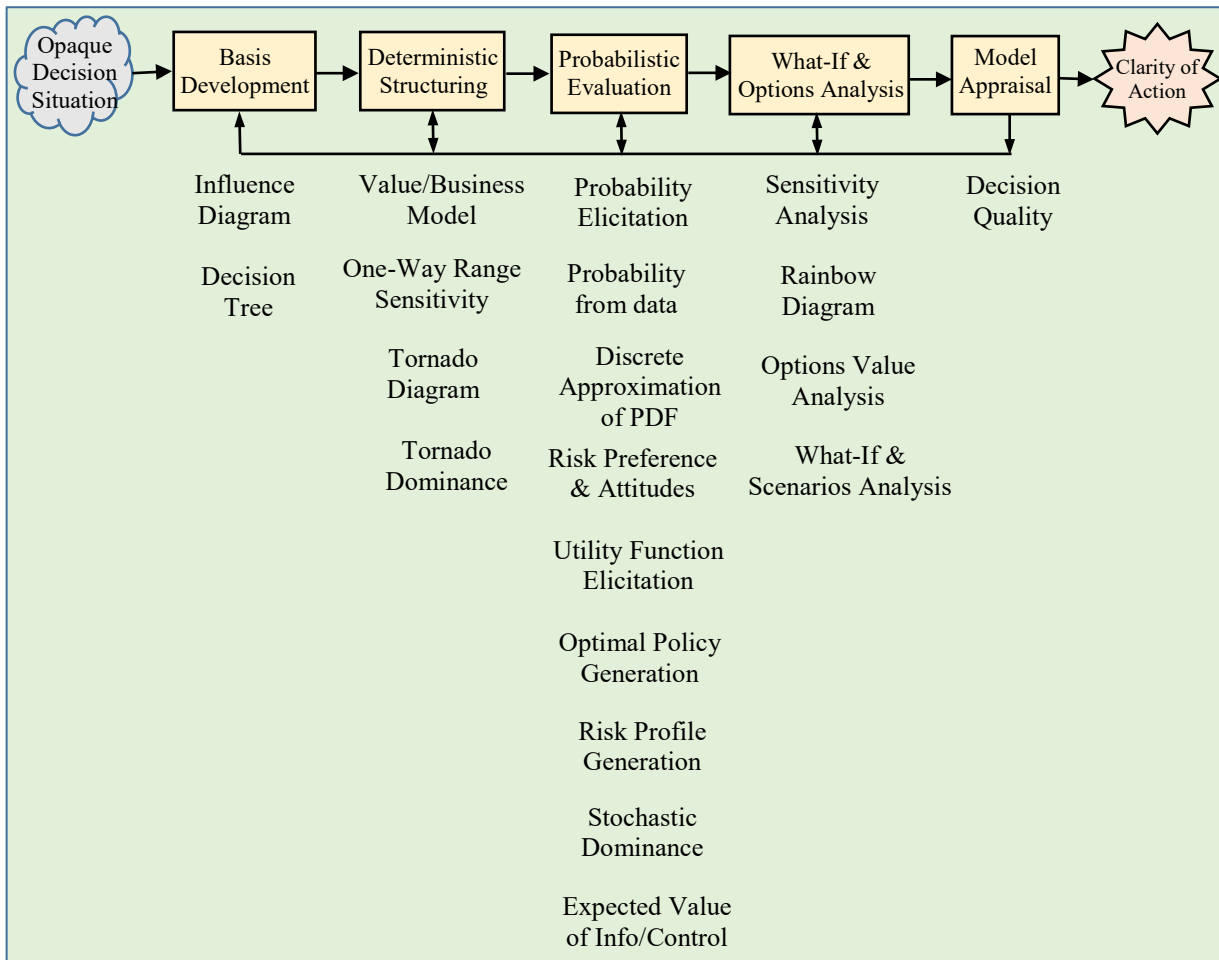
Step 5: Model Appraisal

1. Quality of decision is determined.
2. Is there a clear and defensible course of action?

- Repeat any of the above steps until a clear and defensible course of action is obtained.

1.5 The Decision Analysis Learning Roadmap

- The underlying topics relevant to each step of the Decision Analysis Process are given below:



Exercises

- P1.1** Take some time to think about an important decision situation you are currently facing or will be facing in the near future.
- Describe your decision situation.
 - What makes this decision hard? List some of the issues involved in your decision.
 - Which of these issues describes something that you can control?
 - Which of these issues describes something that you have no control over?
- P1.2** Suppose you were the highest bidder at \$45 in an open bidding (highest bidder wins) for the thumb tack tossing deal (payouts: \$100 or nothing) demonstrated in class. After winning the deal, you determined that your personal indifferent selling price for the deal is \$75. At the end of the class, the thumb tack is tossed under cover and the outcome is observed by a classmate. He offers to truthfully tell you the results before you make your call. What is your personal indifferent buying price for this information?
- P1.3** John bids \$46 for the coin-tossing deal demonstrated in class (\$100 or nothing). What must be true at the moment about John?
- His personal indifferent buying price = \$46.
 - His personal indifferent selling price = \$46.
 - His personal indifferent buying price \geq \$46.
 - His personal indifferent buying price \leq \$46.
- P1.4** Which of the following will result from making a good decision?
- Clarity of Action
 - Minimized risk of poor outcomes
 - A good outcome
 - Knowledge of what will happen
- P1.5** Alice paid \$10 for a ticket to see a movie. After watching the movie for a short time, she realizes that she does not like it and would rather leave early to revise the excellent DA Lecture Notes. On her way out, she asks the manager for a refund. Which of Alice's potential actions are most consistent with the principles of decision analysis?
- If the manager refuses to give her a refund she should stay, since she has already spent \$10 to see the movie.
 - If the manager refuses to give her a refund she should leave, since she prefers not to be there.
 - If the manager refuses to give her a refund she should insist that the manager help her with her DA homework.
 - If the manager offers to give her a refund she should accept the refund and stay, since she can see the movie for free.