

# Introduction to Decision Modeling

Brice Mayag

University Paris Dauphine  
LAMSADE  
FRANCE

Chapter 0

Slides available at  
<https://www.lamsade.dauphine.fr/~mayag/teaching.html>

# Outline

- 1 Models
- 2 Decision theory and Decision analysis
- 3 Main steps of developing a decision model
- 4 Our program

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## Current definitions of a model

- a standard or example for imitation or comparison.
- a representation, generally in miniature, to show the construction or appearance of something.
- an image in clay, wax, or the like, to be reproduced in more durable material.
- a person or thing that serves as a subject for an artist, sculptor, writer, etc.
- a person whose profession is posing for artists or photographers.
- a person employed to wear clothing or pose with a product for purposes of display and advertising.
- a style or design of a particular product: His car is last year's model.
- a pattern or mode of structure or formation.
- a typical form or style.
- a **simplified representation of a system or phenomenon**, as in the sciences or economics, with any hypotheses required to describe the system or explain the phenomenon, often mathematically.
- *Zoology*: an animal that is mimicked in form or color by another.

## What is a model?

- $\Rightarrow$  Representation of reality
- **More Precisely:** A model refers to some form of symbolic representation of our assumptions about reality

## Why do we use models?

- Enhance our understanding of the world to improve our decision making
- Elaborate a scientific method to solve a problem
  - Duplicable (repeatable)
  - Reduce bias

## Types of models

### ① Deterministic models

- outcomes are precisely determined through known relationships among states and events
- in such models, a given input will always produce the same output  
Ex: Resources to make a PC are the same every time
- Domains: Multi-Attribute Decision Making (MCDA); Linear programming; ...

### ② Probabilistic (stochastic) models

- Not all data is known with certainty
- Ex: College acceptance, being above average increases likelihood of acceptance but does not make it certain
- Domains: Queuing; Simulation; ...

## Models are fed by data

### ① Qualitative data

- measured by quality
- Expert opinions
- Ex: class atmosphere, ...

### ② Quantitative data

- Easily measured by numbers
- Ex: Numbers of tv programs a day; number of applications in a phone; ...

## Models are used every day

- A Scenario: Driving to school

- At what time do you need to leave home to be at school on time?
- Distance = Rate  $\times$  Time
- Time = Distance/Rate

## Formal models vs Informal models

- A formal model is a precise statement of components to be used and the relationships among them.
- Formal models are **usually stated via mathematics, often equations**.
- Formal models can be precisely communicated because they are well-defined.
- Formal models give replicable results. This is the simple meaning of “mathematical proof”.

## Formal models vs Informal models

- **Formal models are not reality:** you must choose the model.
- **Formal models may not correspond to reality:** the prediction will turn out to be false.
- **An informal model is one in which the symbols are mental, verbal, or pictorial:** e.g. we toss a coin, we ask an oracle, we visit an astrologer, we consult an expert, we think
- Informal models simply have some lack of precision. Some relationships may not be stated as equations

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## A definition of Decision

- The act or process of deciding; determination, as of a question or doubt, by making a judgment:

Ex: They must make a decision between these two contestants.

- The act of or need for making up one's mind:

This is a difficult decision.

- Something that is decided; resolution:

Ex: She made a poor decision when she dropped out of school.

- A judgment, as one formally pronounced by a court:

Ex: It is the decision of this court that the appeal is granted.

- The quality of being decided; firmness:

Ex: He spoke with decision and calm authority.

Source: <http://www.dictionary.com/browse/decision>

## Provisional definition of Decision [RONALD HOWARD]

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



## A definition of Decision in our context

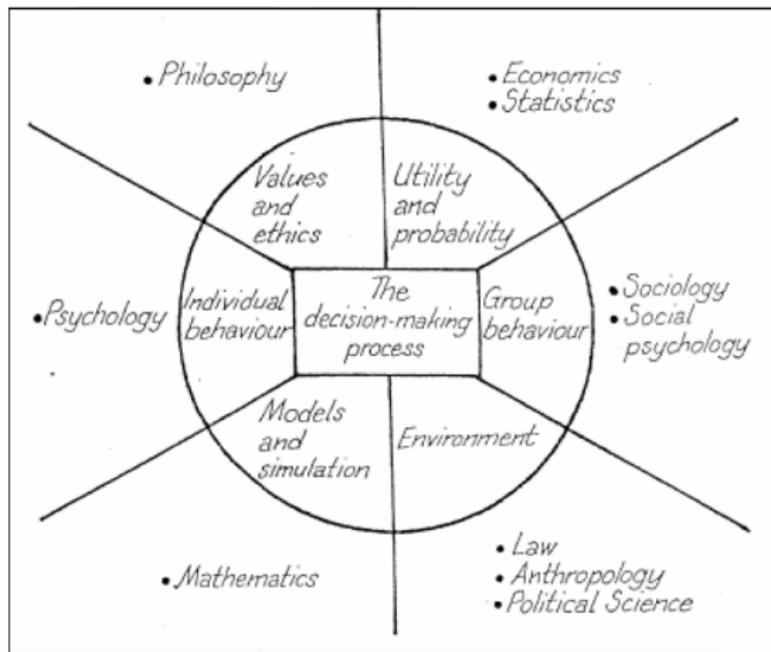
- A choice that you make about something after thinking about several possibilities
  - Ex: We need to take a lot of factors into account in our decision-making.
  - Ex: She has had to make some very difficult decisions.
  - Ex: The company will reach/come to/make a decision shortly.

Source:

<https://dictionary.cambridge.org/dictionary/english/decision>

## Decision in many domains

Philosophy, Economics, Mathematics, Operational Research, Psychology, Computer sciences, Political sciences, Biology? Theology?



## What Decision Analysis is not !

- A general method for taking “good decisions”
  - Example 1: Choice of new job
  - Example 2: medical decision
  - Etc.
- What is a “good decision”?
  - Good for whom, according to what criteria, at which moment in time?
- Good decision processes vs. good decisions?
- A description on how “wise people” decide
  - Expert systems
  - Doctors / Politicians: Nuclear Industry vs Road safety; Prevention vs First Aid

## Decision Analysis

- **Definition (B. Roy):** “consists in trying to provide *answers* to questions raised by actors involved in a *decision process* using a *model*”
- **Decision process:** strategy of intervention: aid, communication, justification, etc.
  - Many different ways to provide decision-aid
  - Difficulty to compare methods
  - What is a “good” Decision Analysis model ?
  - Different models may lead to different recommendations

## Decision Analysis

- **Definition (B. Roy):** “consists in trying to provide *answers* to questions raised by actors involved in a *decision process* using a *model*”
- **Answers:** “Optimal solution” or “Good decision” is absent
- **Models:** formalized or not

## Decision Making

- **Intervention in a decision process:**
  - imagine compromises
  - communicate
  - coordinate
  - control
  - motivate
  - conduct change
  
- **Importance of “final choice” ?**

## Formal decision models

- A set of explicit and well-defined rules to collect, assess and process information in order to be able to make recommendations in decision and/or evaluation processes
- A perfect or not even a best formal decision model do not exist.
  - It is important to describe the decision model used (transparency?).
- Actually, defining a “perfect model” would be a difficult, if not impossible, task.

Decision analysis makes use of explicit and formalized models

## Formalized decision models

- **Drawbacks:** complex, opaque
- **Advantages:**
  - Provide a clear language: communication tool
  - Capture the essence of a situation: structuration tool
  - Answers “what-if” questions (sensitivity, robustness): Exploration tool
- **Example:** choosing a bottle of wine

## Possible objections

- I do not need such tools because I know how to decide
- Let's organize a high-level meeting to discuss it
- Intuition is often enough

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## *Developing a decision model (Step 1)*

Formulation: Translate the problem scenario into a mathematical model

- Define the problem
- Develop a decision model
  - **Variables**: Measurable quantity that can be variable
  - **Parameters**: measurable quantity inherent to problem

## *Developing a decision model (Step 2)*

Solution: Mathematical expressions from formulation are solved

- **Develop a Solution:** Manipulate model to arrive at the best solution. Ex:  
 $\text{Time} = \text{Distance} / \text{Rate}$
- **Test Solution:** Does the solution make sense?

## *Developing a decision model (Step 3)*

### Interpretation: Implication of results

- **Conduct sensitivity analysis:**
  - what happens if parameters vary?
  - Testing outcomes under a variety of states
- **Implement results:** Enact solution & monitor it performs as expected

## *Possible problems*

### Possible problems

- **Defining the problem:** Conflicting viewpoints, impact on other stakeholders
- **Model development:** Fitting problem scenario to textbook model, understanding of others
- **Acquering data:** Existence, validity
- **Developing a solution:** Limitations of one answer
- **Implementation:** Management and user support

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## Our Program

- Chapter 1: Preferences as binary relations
- Chapter 2: Introduction to MCDA
- Chapter 3: MAUT Approach
- Chapter 4: Outranking approach