FIT3158 Note - W1 Introduction to Optimisation and Linear Programming

⊙ type	Post
◷ Created date	@August 5, 2022 11:07 AM
⊙ category	Business
☰ tags	Decision Making
⊙ status	Published
⊙ Language	
⊙ From	School
☰ summary	
☰ slug	
☰ password	
☰ Author	
⊙ Priority	
⫰ Cover	
☑ Featured	☐
⧉ Origin	
⫰ Type	
⧉ URL	
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▼ TOC

What is Business Analytics and why it is useful for businesses
today?

A field of study that uses computers, statistics, and mathematics
to solve business problems.

- Considerable overlap with:

- Operations Research

- Management Science

- Decision Science

A few real-world cases can illustrate its usefulness.

- **Alliance for Paired Donations (APD)**
  - Transplant patients needing a kidney often have potential donors who are incompatible
  - APD finds exchanges with other patient-donor pairs to optimize paired matches
  - Benefits:
    - 220 lives saved since 2006
    - Value of savings: *priceless*

- **Kroger**
  - Analytics team created models to determine reorder point & order up to quantities for items in 1,950 in-store pharmacies
  - Benefits:
    - Reduced prescription stock outs by 1.6 million
    - Lowered inventory by over $120 million
    - Increased revenue by $80 million

- **National Broadcast Network Company**
  - Gov't owned broadband provider in Australia
  - Developed tool to optimize design of network servicing 8 million locations
  - Benefits:
    - Reduction in network design time
    - Savings of ~$1.7 billion

- **Chevron**
  - Developed optimization tool for
    - Operational & strategic planning
    - Mixing crude oils
    - Planning capital expenditures
  - Benefits:
    - Annual savings of $1.0 billion

- **Dell**
  - Built analytics models to
    - Optimize hardware configurations
    - Optimize its website's design
    - Optimize promotion design and timing
  - Benefits:
    - Increased profit by $142 million

Characteristics and benefits of modelling

What is model?

A structure which has been built purposely to exhibit features and characteristics of some other objects. Everyone uses models to make decisions.

A more formal definition is a device which behaves approximately like part of the real world:

- Train-sets, dolls, toy prams...

- Small aircraft replicas in wind tunnels...

- Sponge-rubber men used in car crash...

- The solar system as a number of small balls moving in ellipses round a larger ball...

What are the types of models:

- Mental (arranging furniture)

- Visual (blueprints, road maps)

- Physical/Scale (aerodynamics, buildings)

- Mathematical (what we'll be studying)

What is the characteristics of a model?

- A simplified versions of things they represent
- A valid model accurately represents the relevant characteristics of the object or decision problem being studied.

What is the benefits / advantage of modelling?

- Economy — Less expensive and disruptive than experimenting with real world system
- Feasibility — Used to do things that would be impossible in reality.
- Timeliness — Models can reduce the time taken to make decisions
- Insight & understanding —
  - Models enable us to ask 'what if' questions and test the sensitivity of particular values
- Models force a consistent, systematic approach to a problem
- Models require managers to be specific about constraints and goals.

What is the disadvantage of modelling?

- May be expensive to develop and test
- May be misused and misunderstood because of their complexity
- Models may down play the value of non-quantifiable information
- May oversimplify the variables of the real world

Discuss the modelling approach to decision making

Profit = Revenue - Expenses

or

Profit = f(Revenue, Expenses)

or

$Y = f(X_1, X_2)$

Dependent variable

Independent variables
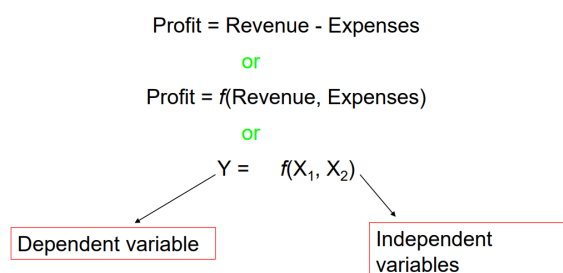
Where:

Y = dependent variable
    (aka bottom-line performance measure)
X_i = independent variables
    (inputs having an impact on Y)
$f(\cdot)$ = function defining the relationship between Y & X_i

Most spreadsheet models are very similar to our generic mathematical model:

$$input\ cells = X_i$$
$$bottom\ line\ performance\ measure = Y$$

$$Y = f(X_1, X_2, X_3, X_4, X_5)$$
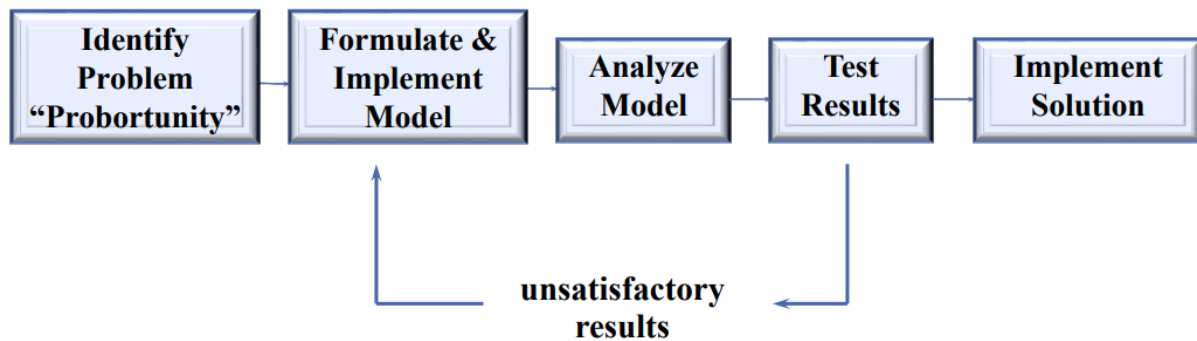

Categories of Mathematical Models

Model Category	Form of $f(\cdot)$	Independent Variables	OR/MS Techniques
Prescriptive	known, well-defined	known or under decision maker's control	LP, Networks, IP, CPM, EOQ, NLP, GP, MOLP
Predictive	unknown, ill-defined	known or under decision maker's control	Regression Analysis, Time Series Analysis, Discriminant Analysis
Descriptive	known, well-defined	unknown or uncertain	Simulation, PERT, Queueing, Inventory Models

How do you use a model?

- Don't accept an answer without further analysis and questioning.

- A mathematical model is only one of a number of tools for decision making.

- If the answer is unacceptable, the reasons for unacceptability should be spelled out and incorporated in a modified model. - An acceptable answer is only an option.

- By successive questioning of the answers and altering the model, it is possible to clarify the options available and obtain a greater understanding of what is possible in a real situation.

Discuss the problem solving framework for leveraging business opportunities

What is the problem solving framework?

Identify Problem "Probortunity" → Formulate & Implement Model → Analyze Model → Test Results → Implement Solution

unsatisfactory results

What is Psychology of Decision Making?

- Models can be used for structural aspects of decision problems.

- Other aspects cannot be structured easily, requiring intuition and judgment.

- Caution: Human judgment and intuition are not always rational!

- Errors in human judgment often arise because of anchoring and framing effects associated with decision problems.

Anchoring effect

- **Arise when trivial factors influence initial thinking about a problem.**

- **Decision-makers usually under-adjust from their initial "anchor."**

- **Example:**

  - What is 1x2x3x4x5x6x7x8?   Median estimate = 512

  - What is 8x7x6x5x4x3x2x1?   Median estimate = 2,250

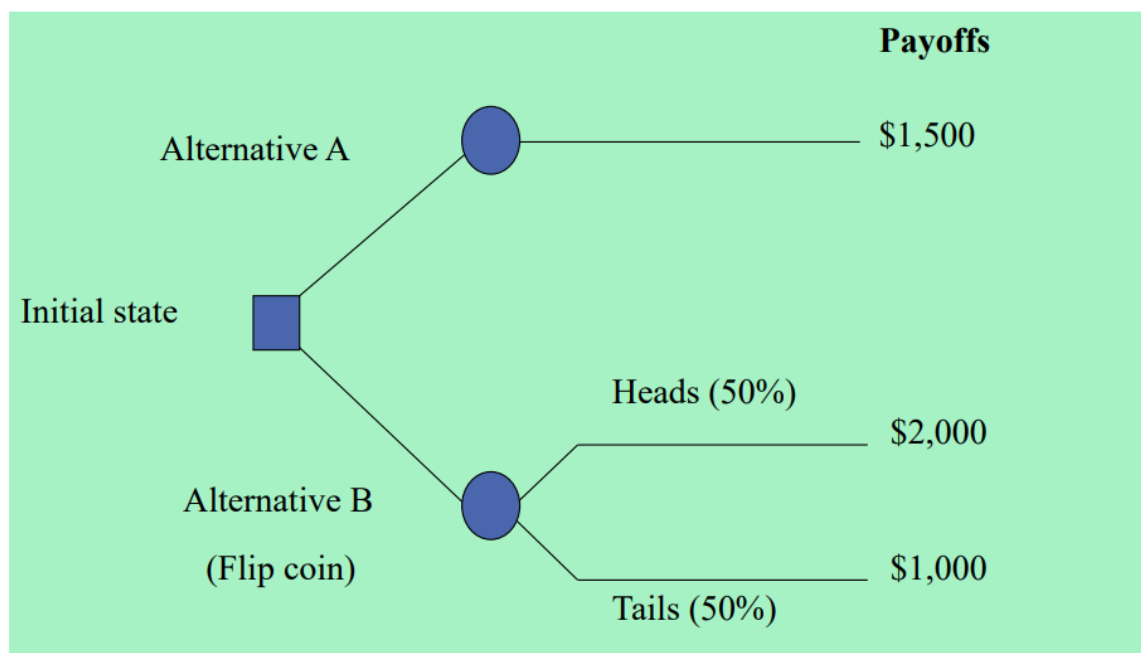 The product is the same in both cases: 40,320

Framing Effects

- Refers to how decision-makers view a problem from a win-loss perspective.

- The way a problem is framed often influences choices in irrational ways...

▼ Example 1:

- Suppose you've been given $1000 and must choose between:
  - A1. Receive $500 more immediately   => Most popular
  - B1. Flip a coin and receive $1000 more if heads occurs or $0 more if tails occurs.

- Now suppose you've been given $2000 and must choose between:
  - A2. Give back $500 immediately
  - B2. Flip a coin and give back $0 if heads occurs or give back $1000 if tails occurs.   => Most popular

Payoffs

Alternative A	$1,500
Initial state	
Alternative B (Flip coin)	Heads (50%) $2,000
	Tails (50%) $1,000

▼ Example 2:

Which option would you select?

This food is 95% fat free

vs

This food consists of 5% fat

You generally obtain different answers from the same person.

A structured, modelling approach to decision making helps us make good decisions, but can't guarantee good outcomes

		Outcome Quality	
		Good	Bad
Decision Quality	Good	Deserved Success	Bad Luck
	Bad	Dumb Luck	Poetic Justice

A good decision is one that harmonizes

- What we can do

- What we know

- What we want

And to which we are committed

1. Understand the problem.

2. Identify the decision variables.

   `X_1 =number of Aqua-Spas to produce`

   `X_2 =number of Hydro-Luxes to produce`

3. State the objective function as a linear combination of the decision variables

   `MAX: 350X 1 + 300X 2`

4. State the constraints as linear combinations of the decision variables

$$1X_1 + 1X_2 <= 200 \qquad \} \text{ pumps}$$
$$9X_1 + 6X_2 <= 1566 \qquad \} \text{ labor}$$
$$12X_1 + 16X_2 <= 2880 \} \text{ tubing}$$

5. Identify any upper or lower bounds on the decision variables.

   `X1 >= 0 && X2 >= 0`

MAX: $350X_1 + 300X_2$

S.T.: $1X_1 + 1X_2 <= 200$

$9X_1 + 6X_2 <= 1566$

$12X_1 + 16X_2 <= 2880$

$X_1 >= 0$

$X_2 >= 0$

Solving LP problems using graphical approach