DECISION MAKING TECHNIQUES IN MANAGEMENT INFORMATION SYSTEMS (MIS)

LECTURE -1-
(Introduction)

Course schedule

Introduction to decision making
Decision Analysis (Decision making under uncertainty and under risk)
Decision Analysis (Decision Trees, Utility Theory)
Group decision making
Multiple Criteria Decision Making, Elementary Methods
Structuring the problem (Cognitive maps)
Constructing the Decision Model in MCDM (Normalization example, nonmonotonic example)
Analyzing the Problem in MCDM (SAW, WP, TOPSIS)
Outranking methods (PROMETHEE)
Analytic Hierarchy Process
Analytic Network Process
Presentations

The aim of the course

- This course aims to present the main and popular techniques applied in the decision making processes in various fields.
- Students will have knowledge about the basic terms and types of decision making problems and will learn how to structure and model them in real life cases. Moreover, students will be able to select the most suitable solving technique and learn to use the related software packages.

Problem Solving

- Management science uses a scientific approach for solving management problems
- It is used in a variety of organizations to solve many different types of problems
- It encompasses a logical mathematical approach to problem solving
- Mathematical tools have been used for thousands of years
- Quantitative analysis can be applied to a wide variety of problems
- One must understand: the specific applicability of the technique, its limitations and its assumptions

Overview of Quantitative Analysis

- Scientific Approach to Managerial Decision Making
- Consider both Quantitative and Qualitative Factors

Raw Data → Quantitative Analysis → Meaningful Information

Analyses

Problem

?

Quant.Analysis

Historic Data

Marketing Research

Scientific Analysis

Modeling

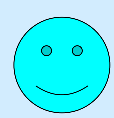
Qual. Analysis

State and federal legislation

New technological breakthroughs

Election outcome

Decision



Typical Business Decision Aspects

- Several, possibly contradictory objectives
- Many alternatives
- Decision may be made by a group
- Group member biases
- Results can occur in the future
- Attitudes towards risk
- Need information
- Gathering information takes time and expense
- Too much information
- "What-if" analysis, Scenarios
- Trial-and-error experimentation may result in a loss
- Experimentation with the real system - only once
- Changes in the environment can occur continuously
- Time pressure

Decision Making

- We spend a significant portion of our time and psychic energy making decisions.
- Our decisions shape our lives: who we are, what we are, where we are, how successful we are, how happy we are all derive in large part from our decisions
- In order to raise our odds of making a good decision, we have to learn to use a good decision making process – one that gets us to the best solution with a minimal loss of time, energy, money, etc...

Decision Making

Decision making may be defined as:

- Decision maker's (DM's) choice of one alternative or a subset of alternatives among all possible alternatives with respect to her/his goal or goals (Evren and Ülengin, 1992)
- Solving a problem by choosing, ranking, or classifying over the available alternatives that are characterized by multiple criteria (Topcu, 1999)
- …

Effective Decision Making Process

- An effective decision making process will fulfill the following six criteria (Hammond *et al.*, 1999):
  - It focuses on what's important
  - It is logical and consistent
  - It acknowledges both subjective and objective factors and blends analytical with intuitive thinking
  - It requires only as much information and analysis as is necessary to resolve a particular dilemma
  - It encourages and guides the gathering of relevant information and informed opinion
  - It is straightforward, reliable, easy to use, and flexible

Basic Concepts

- Problems
- Variables
  - Objective
  - Criteria
  - Attributes
- Alternatives
- Participants in the decision making process (Problem stakeholders)

Problem

- A felt difficulty
- A gap or obstacle to be circumvented
- An undesirable situation that is significant to and may be solvable by some agent, although probably with difficulty (Smith, 1989).

VARİABLES

- An objective is a statement of something that one desires to achieve
- A criterion is a "tool" allowing to compare alternatives according to a particular "significance axis" or a "point of view" (Bouyssou, 1990)
- An attribute measures the degree in which an objective is achieved (Keeney, 1996)

  An attribute represents the basic characteristic, quality, or efficiency parameter of an alternative (Evren and Ulengin, 1992)

ATTRİBUTES

Classification: Function type

- Benefit attributes

  Offer increasing monotonic utility. Greater the attribute value the more its preference
- Cost attributes

  Offer decreasing monotonic utility. Greater the attribute value the less its preference
- Nonmonotonic attributes

  Offer nonmonotonic utility. The maximum utility is located somewhere in the middle of an attribute range

ALTERNATİVE

- Alternatives is the set of actions, objects, candidates, decisions… To be explored during the decision process

PROBLEM STAKEHOLDERS

- The problem owner
  The person or group who has control over certain aspects of the problem situation, in particular over the choice of action to be taken. Most often, the problem owner is the decision maker.
- The problem user
  Uses the solution and/or executes the decisions approved by the problem owner or decision maker. Has no authority to change the decision
- The problem customer
  The beneficiary or victim of the consequences of using the solution
- The problem solver
  Decision Analyst who analyzes the problem and develops a solution for approval by the problem owner

Types of Decision Making

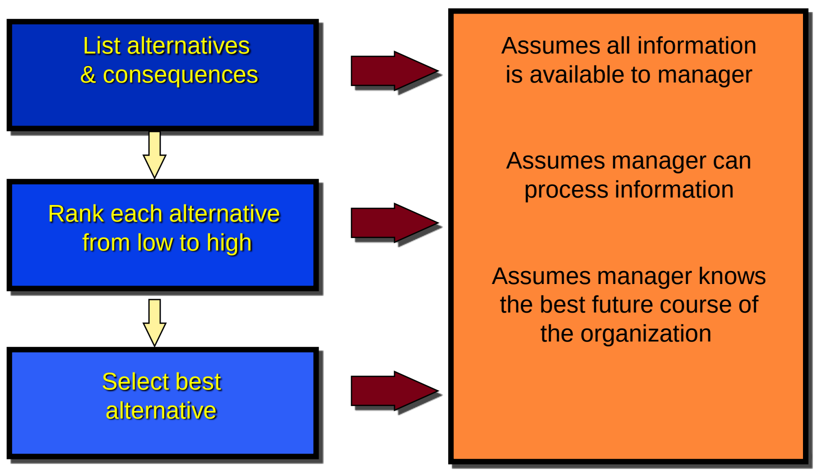
- *Programmed Decisions:* routine, almost automatic process.
  - Managers have made decision many times before.
  - There are rules or guidelines to follow.
  - *Example: Deciding to reorder office supplies.*

- *Non-programmed Decisions:* unusual situations that have not been often addressed.
  - No rules to follow since the decision is new.
  - These decisions are made based on information, and a manager's intuition, and judgment.
  - *Example: Should the firm invest in a new technology?*

The Classical Model

- *Classical model of decision making:* a prescriptive model that tells how the decision should be made.
  - Assumes managers have access to all the information needed to reach a decision.
  - Managers can then make the optimum decision by easily ranking their own preferences among alternatives.
- Unfortunately, managers often do not have all (or even most) required information.

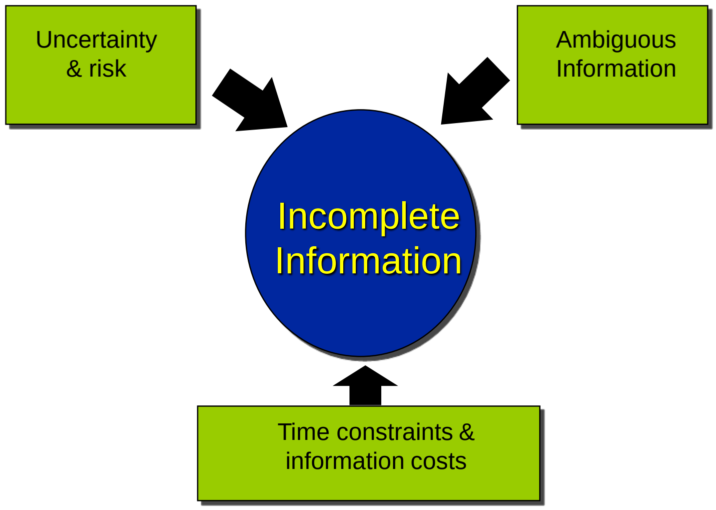
THE CLASSICAL MODEL



THE ADMINISTRATIVE MODEL

- *Administrative Model of decision making:* Challenged the classical assumptions that managers have and process all the information.
  - As a result, decision making is risky.
- *Bounded rationality:* There is a large number of alternatives and information is vast so that managers cannot consider it all.
  - Decisions are limited by people’s cognitive abilities.
- *Incomplete information:* most managers do not see all alternatives and decide based on incomplete information.

Why Information is Incomplete



Incomplete Information Factors

- Incomplete information exists due to many issues:
  - *Risk:* managers know a given outcome can fail or succeed and probabilities can be assigned.
  - *Uncertainty:* probabilities cannot be given for outcomes and the future is unknown.
    - Many decision outcomes are not known such as a new product introduction.
  - *Ambiguous information:* information whose meaning is not clear.
    - Information can be interpreted in different ways.

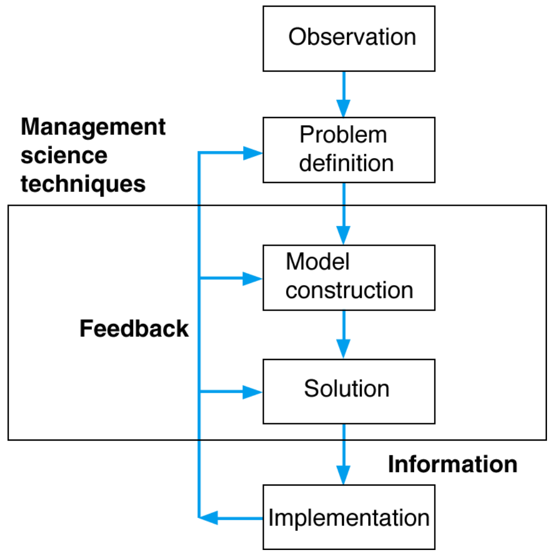
Incomplete Information Factors

- Time constraints and Information costs: Managers do not have the time or money to search for all alternatives.
  - This leads the manager to again decide based on incomplete information.
- Satisfying: Managers explore a limited number of options and choose an acceptable decision rather than the optimum decision.
  - This is the response of managers when dealing with incomplete information.
  - Managers assume that the limited options they examine represent all options.

Decision Making Process

1. Structuring the Problem
2. Constructing the Decision Model
3. Analyzing (solving) the Problem

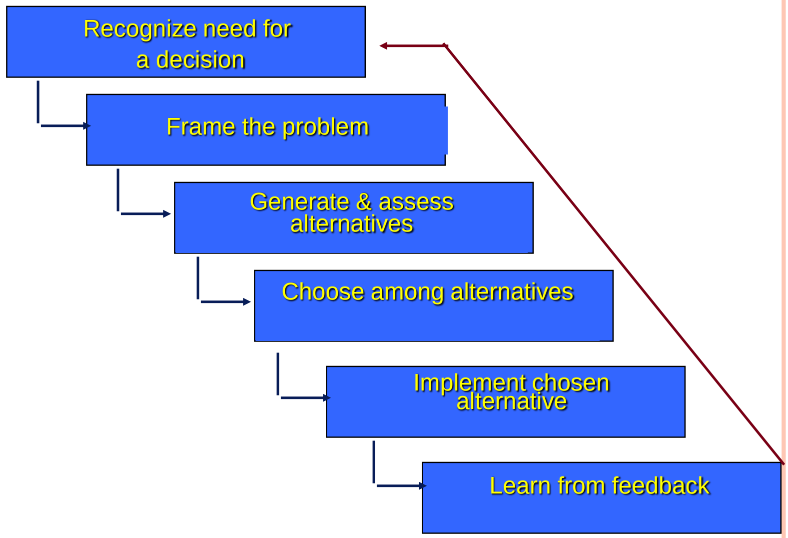
Management Science Process



Approach I

- Define the problem
- Develop a model
- Acquire data
- Develop a solution
- Test the solution
- Analyze the results and perform sensitivity analysis
- Implement the results

Approach II



Decision Making Steps

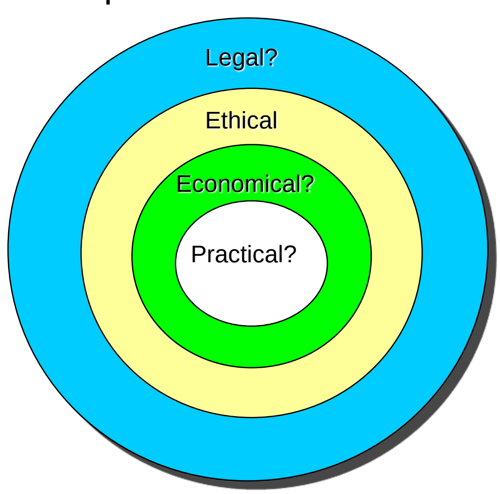
1. Recognize need for a decision: Managers must first realize that a decision must be made.
   - Sparked by an event such as environment changes.
2. Generate alternatives: managers must develop feasible alternative courses of action.
   - If good alternatives are missed, the resulting decision is poor.
   - It is hard to develop creative alternatives, so managers need to look for new ideas.
3. Evaluate alternatives: what are the advantages and disadvantages of each alternative?
   - Managers should specify criteria, then evaluate.

Decision Making Steps

4. *Choose among alternatives:* managers rank alternatives and decide.
   - When ranking, all information needs to be considered.
5. *Implement chosen alternative:* managers must now carry out the alternative.
   - Often a decision is made and not implemented.
6. *Learn from feedback:* managers should consider what went right and wrong with the decision and learn for the future.
   - Without feedback, managers never learn from experience and make the same mistake over.

Evaluating Alternatives

Is the possible course of action:



Evaluating Alternatives

- *Is it legal?* Managers must first be sure that an alternative is legal both in this country and abroad for exports.
- *Is it ethical?* The alternative must be ethical and not hurt stakeholders unnecessarily.
- *Is it economically feasible?* Can our organization's performance goals sustain this alternative?
- *Is it practical?* Does the management have the capabilities and resources to do it?

Modeling in the Real World

- Models are complex
- Models can be expensive
- Models can be difficult to sell
- Models are used in the *real world* by *real organizations* to solve *real problems*

1. Example of Model Construction Problem Definition (1)

Information and Data:

- Business firm makes and sells a steel product
- Product costs $5 to produce
- Product sells for $20
- Product requires 4 tons of steel to make
- Firm has 100 tons of steel

Business problem:

Determine the number of units to produce to make the most profit given the limited amount of steel available.

1. Example of Model Construction Mathematical Model

Variables: x = number of units (decision variable)

Z = total profit

Model: Z = $20x - $5x (objective function)

4x = 100 tons of steel (resource constraint)

Parameters: $20, $5, 4 tons, 100 tons (known values)

Formal specification of model:

maximize Z = $20x - $5x

subject to 4x = 100

1. EXAMPLE Solution

X (Number of units) = 25

Z = TOTAL PROFIT = $ 375

2. Example of Model Construction Problem Definition

Dakota Furniture makes desks, tables, and chairs. Each product needs the limited resources of lumber, carpentry and finishing; as described in the table. At most 5 tables can be sold per week. **Maximize weekly revenue**.

Resource	Desk	Table	Chair	Max Avail.
Lumber (m2)	8	6	1	48
Finishing hours	4	2	1,5	20
Carpentry hours	2	1,5	0,5	8
Max Demand	-	5	-	
Price ($)	60	30	20	

2. Example of Model Construction Mathematical Model

Variables: x1 = Number of desks to be produced (decision variable)

x2 = Number of tables to be produced (decision variable)

x3 = Number of chairs to be produced (decision variable)

Z = total profit

Model: Z = \$60x1 + \$30x2 + \$20x3 (objective function)

8x1 + 6x2 + x3 <= 48 m2 of lumber (resource constraint)

4x1 + 2x2 + 1.5x3 <= 20 hours of finishing (resource constraint)

2x1 + 1.5x2 + 0.5x3 <= 8 hours of carpentry (resource constraint)

x2 <= 5 units (resource constraint)

Parameters: \$60, \$30, \$20, 48m2, 20 hours, 8 hours, 5 units (known values)

Formal specification of model:

max z = 60x1+30x2+20x3

s.t. 8x1+ 6x2+ x3 < = 48

4x1+ 2x2+1.5x3 < = 20

2x1+1.5x2+. 5x3 < =8

x2 < = 5

x1,x2,x3 > 0

2. EXAMPLE Solution

X1 (Number of desks) = 2

X2 (Number of tables) = 0

X3 (Number of chairs) = 8

Z = TOTAL PROFIT = \$ 280

3. Model Building Break-Even Analysis (1 of 7)

- Used to determine the number of units of a product to sell or produce (i.e. volume) that will equate total revenue with total cost.
- The volume at which total revenue equals total cost is called the break-even point.
- Profit at break-even point is zero.

3. Model Building Break-Even Analysis (2 of 7) Model Components

Fixed costs (c_f) - costs that remain constant regardless of number of units produced

Variable cost (c_v) - unit cost of product

Total variable cost (vc_v) - function of volume (v) and variable per-unit cost

Total cost (TC) - total fixed cost plus total variable cost

Profit(Z) - difference between total revenue vp (p=price) and total cost:

$$Z = vp - c_f - vc_v$$

3. Model Building
Break-Even Analysis (3 of 7)

Computing the Break-Even Point

The break-even point is that volume at which total revenue equals total cost and profit is zero:

$V = c_f/(p-c_v)$

Example: Western Clothing Company

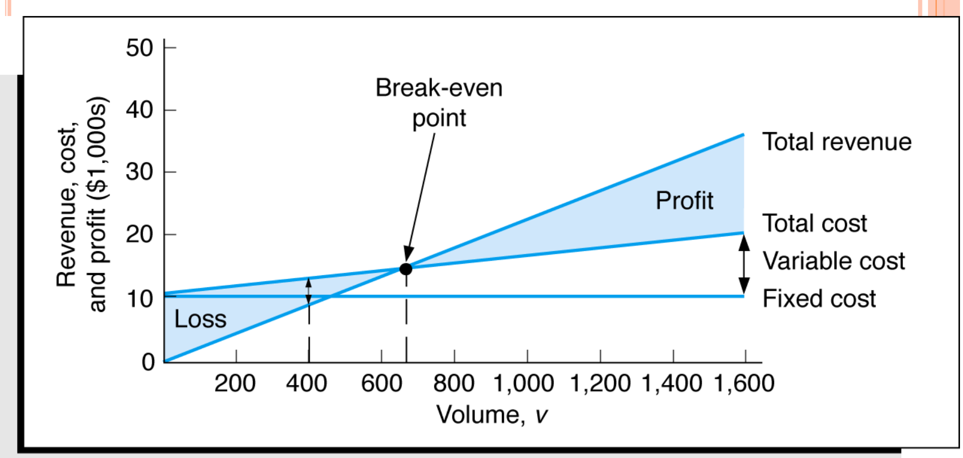
c_f = \$10000

c_v = \$8 per pair

p = \$23 per pair

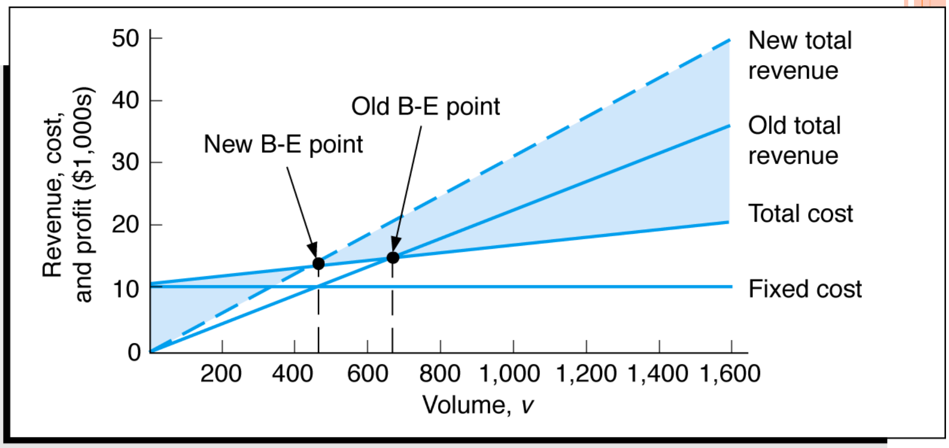
v = 666.7 pairs, break-even point

3. Model Building
Break-Even Analysis (4 of 7)



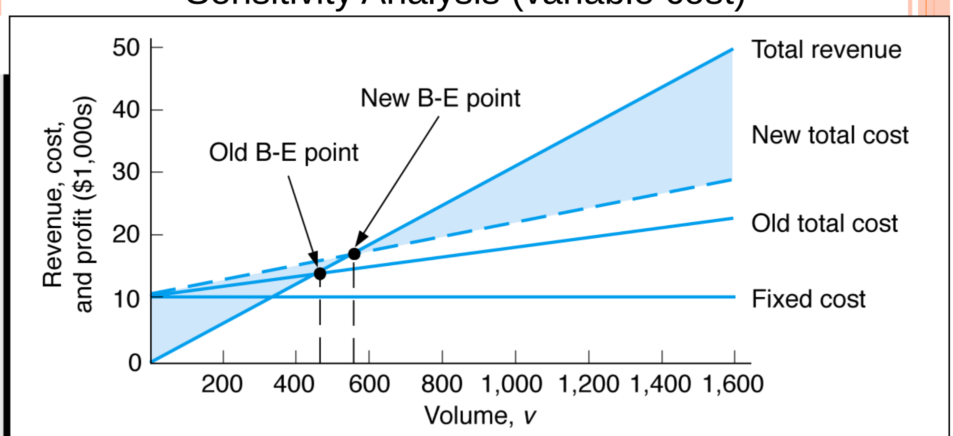
Break-even model

3. Model Building
Break-Even Analysis (5 of 7)
Sensitivity Analysis (price)



Break-even model with a change in price

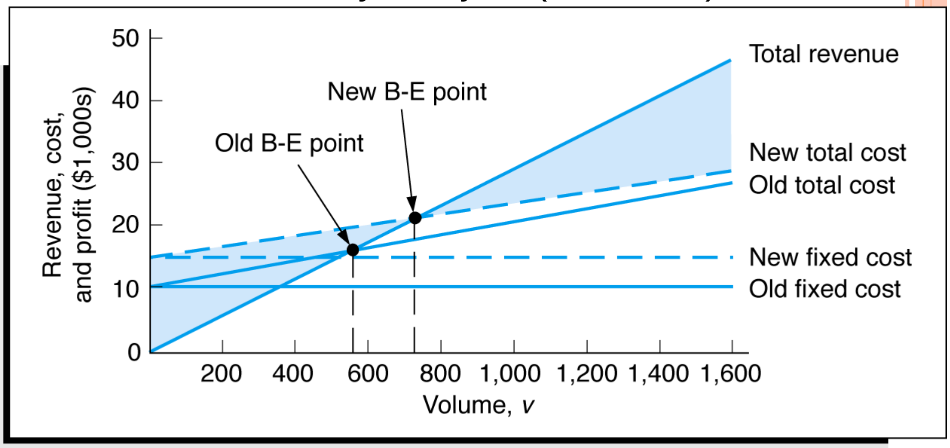
3. Model Building
Break-Even Analysis (6 of 7)
Sensitivity Analysis (variable cost)



Break-even model with a change in variable cost

3. Model Building
Break-Even Analysis (7 of 7)

Sensitivity Analysis (fixed cost)



Break-even model with a change in fixed cost

Models Can Help Managers to

- Gain deeper insight into the nature of business relationships
- Find better ways to assess values in such relationships; and
- See a way of reducing, or at least understanding, uncertainty that surrounds business plans and actions

Models

- are less expensive and disruptive than experimenting with real world systems
- allow "*What if*" questions to be asked
- are built for management problems and encourage management input
- enforce consistency in approach
- require specific constraints and goals

Models: The Up Side

Models

- Accurately represent reality
- Help a decision maker understand the problem
- Save time and money in problem solving and decision making
- Help communicate problems and solutions to others
- Provide the only way to solve large or complex problems in a timely fashion

Models: The Down Side

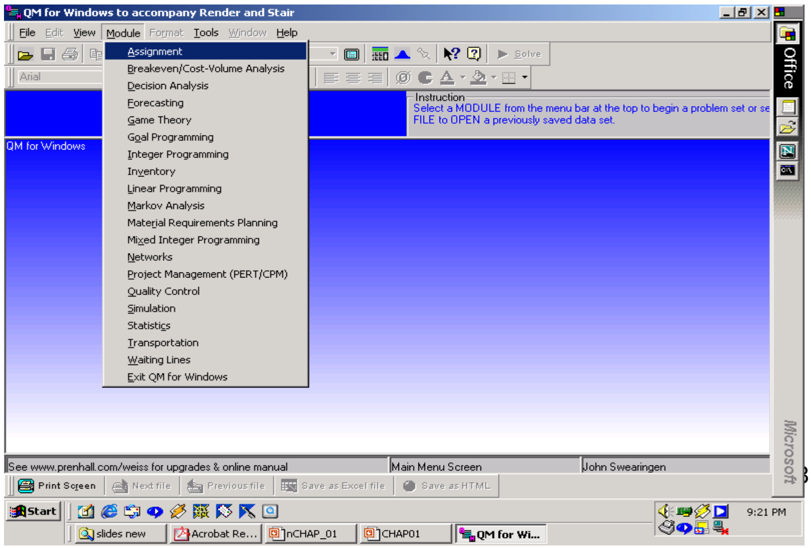
Models

- May be expensive and time-consuming to develop and test
- Are often misused and misunderstood (and feared) because of their mathematical complexity
- Tend to downplay the role and value of nonquantifiable information
- Often have assumptions that oversimplify the variables of the real world

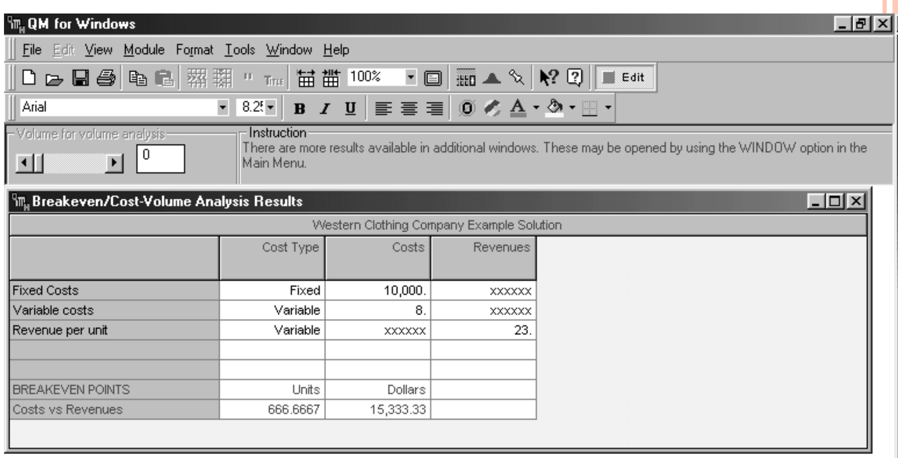
Mathematical Models Characterized by Risk

- *Deterministic models* - we know all values used in the model with certainty
- *Probabilistic models* - we know the probability that parameters in the model will take on a specific value

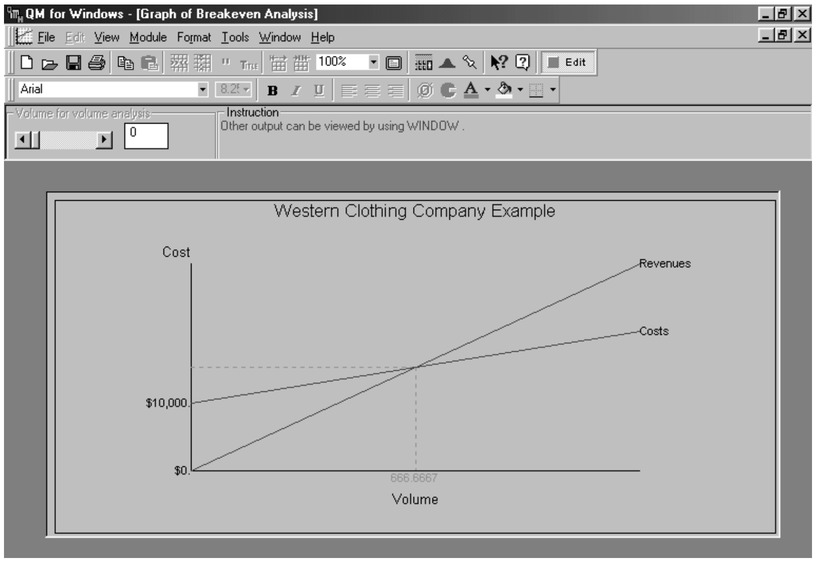
QM For Windows



QM For Windows



QM For Windows



QA Techniques

- Mathematical Programming
  - Linear Programming
  - Integer Programming
  - Graphical analysis
  - Sensitivity analysis
  - Transportation
  - Assignment
  - Goal Programming
- Probabilistic Techniques
  - Probability and statistics
  - Decision analysis
  - Queuing
- Network Techniques
  - Project Management (CPM/PERT)
  - Network flows
- **MCDM**
  - **Value/Utility based**
  - **Interactive**
  - **Outranking**
  - **Simple**
- Other
  - Simulation
  - Forecasting
  - Inventory
  - Non linear programming

Characteristics of Techniques

- Linear mathematical programming: clear objective; restrictions on resources and requirements; parameters known with certainty.
- Probabilistic techniques: results contain uncertainty.
- Network techniques: model often formulated as diagram; deterministic or probabilistic.
- Forecasting and inventory analysis techniques: probabilistic and deterministic methods in demand forecasting and inventory control.
- Other techniques: variety of deterministic and probabilistic methods for specific types of problems.

MATHEMATICAL MODEL APPLICATION 1

- ABC company makes two types of products; product A and B. Each product needs the limited resources of material A, B, C and D as described in the table. Moreover, the capacities for the resources for one month and the other related parameters are given in the table. **Maximize monthly revenue**.

Resource	Product A	Product B	Max Avail.
Material A	6	4	40
Material B	4	3	20
Material C	2	3	24
Material D	8	8	50
Price ($)	100	90	

MATHEMATICAL MODEL APPLICATION 1

Variables: x1 = Number of product A (decision variable)

x2 = Number of product B (decision variable)

Z = total profit

Model: Z = $100x1 + $90x2 (objective function)

6x1 + 4x2 <= 40 units of material A (resource constraint)

4x1 + 3x2 <= 20 units of material B (resource constraint)

2x1 + 3x2 <= 24 units of material C (resource constraint)

8x1 + 8x2 <= 50 units of material D (resource constraint)

Parameters: $40, $30, $20, 40 units, 20 units, 24 units, 50 units (known values)

Formal specification of model:

max z = 100x1+90x2

s.t. 6x1 + 4x2 <= 40

4x1 + 3x2 <= 20

2x1 + 3x2 <= 24

8x1 + 8x2 <= 50

x1,x2 >= 0

1. APPLICATION Solutİon

X1 (Number of product A) = 1.25

X2 (Number of product B) = 5

Z = TOTAL PROFIT = $ 575

BREAKEVEN/COST-VOLUME ANALYSIS APPLICATION 2

- If the related cost parameters for producing a special product are as follows, what is the break-even point?

  Fixed cost: $25 000

  Variable cost: $20

  Selling price: $30

2. APPLICATION SOLUTİON

The break-even point value:

V= 2500 units ($75 000)

REFERENCES

- Lecture notes of "Prof. Dr. Y. İlker Topçu", http://web.itu.edu.tr/topcuil/

- Winston, W. L., Operations Research : Applications and Algorithms.