

OR 540: Management Science

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Purpose of the Course

- **Provide a broad exposure to important *Management Science* and *Operations Research* problems**
- **Introduce solution techniques for a variety of applications**
- **Introduce computational aspects of modeling using MS Excel**

Note: This course is broad but not deep. There is a complete course on each of the topics covered. This is just a start!

Definition of Operations Research

Operations Research (from Hillier and Lieberman)

- “ 1. The structuring of real life situation in a mathematical model, abstracting the essential elements so that a solution relevant to the decision maker can be sought
2. Exploring the structure of such solutions and developing systematic procedures for obtaining them
3. Developing a solution, including the mathematical theory, if necessary, that yield an optimal value of the system measure of desirability (or possibly comparing alternative courses of action by evaluating their measure of desirability). ”

Applying OR/MS

- **Observation of system to be studied**
- **Problem definition**
 - Identify objectives, goals, alternatives, measurement criteria
- **Model construction**
 - Identify relevant components and their interrelationships
- **Problem solution**
 - use various quantitative solution techniques
- **Solution implementation**
 - Feasibility, quality

Problem Identification

Fundamental Problem Types

- (1) Problems of *Association*
 - (2) Problems of *Construction*
 - (3) *Combinations* of the above two types
 - (4) Problems beyond our understanding
 - Tasks involving creativity
 - Tasks needing leaps of faith - intuition
 - Reasoning by (obscure) analogy
 - Learning how to talk (language)
- ★ These problems are hard to define, characterize, model and solve



To be discussed later

Problems of Association

- Association of attributes of given object(s) to specific outcome (class or response)
- These include:
 - *Prediction*
 - *Pattern classification or pattern recognition*
- Typically solved by Substitution:
 - Facts or data substituted into model
 - Outcome or outcomes are observed
- Examples
 - Curve fitting
 - Forecasting
 - Medical diagnosis
 - Trouble-shooting

Problems of Construction

- Involve need to create plan or configuration from among a set of alternatives
- These include:
 - Development of combinations
 - Blending problems
- Typically solved by Feedback and Comparison
 - Trial solution is found
 - Solution is compared to some criteria
 - Better solution is sought
- Examples
 - System configuration
 - Facility location
 - Product mix
 - Capital budgeting

Fundamental Operations

- Substitution and Inference
 - Insertion of information into model for evaluation
 - Interpret the output of the model
- Feedback
 - Return of information regarding status of solution
 - Done periodically through solution process
- Comparison
 - Comparing attributes of problem objects
 - Perhaps using the results to order the objects
- ★ Problems of Association need only *Substitution and Inference*
- ★ Problems of construction may need all

Message

- **Know the enemy!**
- **Use the right model for the problem**
 - Don't use what you have because you have it
 - Avoid hammer and nail syndrome
- **Problem identification is the first step**
- **All problems can be categorized as association or construction or combination of the two**
 - Break problem into its components
 - Categorize each piece
 - Right model for each

Modeling

Definition: Model - the representation of one system by another

- Can represent some theory or law
- Can account for empirical observations
- Combination of the two

Essence of MS - gain insight into real system by studying model

Model Building

- Involves abstraction and simplification
- Contains essential elements of the system
- Artistic

Properties of Models

- **Organizes theoretical beliefs and empirical observations about the system**
- **Helps identify important aspects of system**
- **Allows testing of system**
 - **Response to different stimuli**
 - **Desirability of changes in the system**
- **Usually easier to manipulate than whole system**
- **Allows control over sources of variation**
- **Low cost (relatively)**

Elements of Mathematical Models

- **Variables (unknowns)**
 - **Decision (changing) variables**
 - **Independent and dependent variables**
- **Parameters (knowns)**
 - **Coefficients, etc.**
- **Equations/Functions**
 - **Relationships between parameters and variables**
 - **Relationships between independent and dependent variables**

Types of Models

- (1) **Verbal Models - experts sit and discuss the system**
 - Fast and low cost
 - Often ambiguous or biased - totally subjective
- (2) **Physical Model or Iconic Model**
 - Mock-up
 - Used frequently in engineering and physical sciences
- (3) **Schematic or Analog Model**
 - Property of real object is substituted by another object and used in similar manner
 - Map is an example

Types of Models

- (4) **Symbolic Model - usually mathematical**
 - Probability models
 - Statistical models
 - Optimization models
 - Simulation models (can include aspects of the others)

Aspects to be Considered

- (1) **Families of Laws**
 - Indexed by parameters
 - Not under human control
 - ex. Arrival rate of customers to a bank
- (2) **Families of Policies**
 - Indexed by factors
 - Under human control
 - ex. Number of tellers in the bank

Model Formulation

- **What are the choices to be made?**
 - **Decision Variables (Independent)**
- **What are we trying to accomplish?**
 - **Objective Function (Dependent)**
- **What are the "givens"?**
 - **Parameters**
- **What are the relationships between model elements?**
 - **Equations/Functions**

Classification of Models

- **Prescriptive/Descriptive**
 - **Prescriptive used to formulate and optimize a system**
 - **Descriptive used to help understand the behavior of a system**
- **Discrete/Continuous**
 - **Continuous models have real valued variables**
 - **Discrete models don't**
- **Stochastic/Deterministic**
 - **Stochastic (probabilistic) includes random events**
 - **Deterministic models don't (usually expected value)**

Classification of Models

(continued)

- **Static/Dynamic**
 - **Static models have variables that don't change over time (snapshot of the system in steady state)**
 - ex. Evaluation of physical layout of a factory**
 - Try several configurations
 - Evaluate performance of each
 - **Dynamic include time dependent variables**
 - ex. Queuing analysis of a bank during a whole day**
 - Arrival rates change
 - Number of tellers changes

Implementation

- **Optimal solutions may not be good management**
- **Solutions should be examined for reasonableness, intuition, etc.**
- **Results in more than a single value -- often a "policy" described in solution**
- **Communication of results is key**
 - **Charts and graphs make understanding easy and helpful**
- **Bottom line: Management science should support good business decision making**
 - **Good management AND good mathematics**