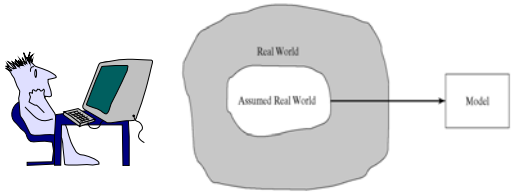
Lecture 02: OR Modeling Approach



The Usual Phases of an OR Study

1. Define the problem of interest and gather relevant data.
2. Formulate a mathematical model to represent the problem.
3. Develop a computer-based procedure for deriving solutions to the problem from the model.
4. Test the model and refine it as needed.
5. Prepare for the ongoing application of the model as prescribed by management.
6. Implement.

Defining problem and gathering data

- Most practical problems encountered by OR teams are initially described in a vague, imprecise way.
- First step is to study the relevant system and develop a well-defined statement of the problem to be considered.
  - Determine such things as the appropriate objectives, constraints, interrelationships, possible alternative courses of action, time limits for making a decision, and so on.
- The OR team normally works in an advisory capacity.
- Ascertaining the appropriate objectives is a very important aspect of problem definition.
- OR is concerned with the welfare of the entire organization.

Defining problem and gathering data

- An OR study seeks solutions that are optimal for the overall organization rather than suboptimal solutions that are best for only one component.
- For profit-making organizations, one possible approach to circumventing the problem of suboptimization is to use *long-run profit maximization* (considering the time value of money) as the sole objective.

Defining problem and gathering data

- Five parties generally affected by a business firm located in a single country are:

  (1) the owners (stockholders, etc.),

  (2) the employees,

  (3) the customers,

  (4) the suppliers, and

  (5) the government and hence the nation.

Defining problem and gathering data

- OR teams typically spend a surprisingly large amount of time *gathering relevant data* about the problem.
- It often is necessary to install a new computer-based *management information* system to collect the necessary data on an ongoing basis and in the needed form.

Example

- An OR study done for the **San Francisco Police Department** resulted in the development of a computerized system for optimally scheduling and deploying police patrol officers. The new system provided annual savings of $11 million, an annual $3 million increase in traffic citation revenues, and a 20 percent improvement in response times.
- In assessing the appropriate objectives for this study, three fundamental objectives were identified:

  1. Maintain a high level of citizen safety.

  2. Maintain a high level of officer morale.

  3. Minimize the cost of operations.

Formulating a Mathematical Model

- After the problem is defined, the next phase is to reformulate this problem in a form that is convenient for analysis.
- Models are idealized representations.
- Models abstract the essence of the subject of inquiry, showing interrelationships, and facilitating analysis.
- Mathematical models are also idealized representations, but they are expressed in terms of mathematical symbols and expressions.

Formulating a Mathematical Model

- In mathematical programming models, we have:
  - Decision variables
  - Objective functions
  - Constraint functions
  - Parameters
- Determining the appropriate values to assign to the parameters of the model (one value per parameter) is both a critical and a challenging part of the model- building process.
- Because of the uncertainty about the true value of the parameter, it is important to analyze how the solution derived from the model would change (if at all) if the value assigned to the parameter were changed to other plausible values. This process is referred to as **sensitivity analysis.**

Formulating a Mathematical Model

- Real problems normally don't have just a single "right" model.
- It is even possible that two or more completely different types of models may be developed to help analyze the same problem.
- A model is necessarily an abstract idealization of the problem, so approximations and simplifying assumptions generally are required if the model is to be tractable (capable of being solved).
- It is required that there be a high correlation between the prediction by the model and what would actually happen in the real world.

Formulating a Mathematical Model

- In developing the model, a good approach is to begin with a very simple version and then move in evolutionary fashion toward more elaborate models that more nearly reflect the complexity of the real problem.
- This process of model enrichment continues only as long as the model remains tractable.
- The basic trade-off under constant consideration is between the precision and the tractability of the model.
- If there are multiple objectives, their respective measures commonly are then transformed and combined into a composite measure, called the **overall measure of performance.**

Deriving Solutions from the Model

- After a mathematical model is formulated for the problem under consideration, the next phase in an OR study is to develop a procedure (usually a computer-based procedure) for deriving solutions to the problem from this model.
- For experienced OR practitioners, finding a solution is the fun part, whereas the real work comes in the preceding and following steps, including the *postoptimality analysis*.
- Eminent management scientist and Nobel Laureate in economics Herbert Simon points out that satisficing is much more prevalent than optimizing in actual practice.
- *Satisficing is a combination of the words satisfactory and optimizing.*
- In the words of one of England's OR leaders, Samuel Eilon, "Optimizing is the science of the ultimate; satisficing is the art of the feasible."

Testing the Model

- Developing a large mathematical model is analogous in some ways to developing a large computer program.
- This process of testing and improving a model to increase its validity is commonly referred to as **model validation.**
- The group doing this review preferably should include at least one individual who did not participate in the formulation of the model.
- It is also useful to make sure that all the mathematical expressions are *dimensionally consistent* in the units used.
- A more systematic approach to testing the model is to use a **retrospective test.**
- Documenting the process used for model validation is important.

Preparing to Apply the Model

- What happens after the testing phase has been completed and an acceptable model has been developed?
- If the model is to be used repeatedly, the next step is to install a well documented system for applying the model as *prescribed by management.*
- This system will include the model, solution procedure (including postoptimality analysis), and operating procedure for implementation.

Implementation

- After a system is developed for applying the model, the last phase of an OR study is to implement this system as prescribed by management.
- This phase is a critical one because it is here, and only here, that the benefits of the study are reaped.
- Good communications help to ensure that the study accomplishes what management wanted and so deserves implementation.