Unit 34: Operations Management

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Learning Outcome 2

- LO3 **Understand how to organise a typical production process**
  - Ac 3.1 assess how linear programming adds value to a given production process
  - AC 3.2 evaluate critical path analysis and network planning
  - AC 3.3 justify the need for operational planning and control in a selected production process

In this Session

- LO3 **Understand how to organise a typical production process:**
- Ac 3.1 assess how linear programming adds value to a given production process
    - Linear Programming
    - Describe the type of problem that would lend itself to solution using linear programming.
    - Formulate a linear programming model from a description of a problem
    - Solve simple linear programming problems using the graphical method.
- Further readings
- References

Introduction

- According to prenhall.com (2016) many operations management decisions involve trying to make the most effective use of an organization’s resources. Resources typically include machinery (such as planes, in the case of an airline), labor (such as pilots), money, time, and raw materials (such as jet fuel). These resources may be used to produce products (such as machines, furniture, food, or clothing) or services (such as airline schedules, advertising policies, or investment decisions).
- **Linear programming (LP)** is a widely used mathematical technique designed to help operations managers plan and make the decisions necessary to allocate resources.

What is Linear Programming

- According to Stevenson (2015) Linear programming consist of a sequence of steps that will lead to an optimal solution to problems, in cases where an optimum exists.
  - Two types of general-purpose solution techniques are graphical linear programming and computer solutions.
  - Graphical Linear Programming provides a visual portrayal of many of the important concepts of linear programming. However, it is limited to problems with only two variables.

Eg. Of Problems LP has solved

- Scheduling school buses to *minimize* the total distance traveled when carrying students.
- Allocating police patrol units to high crime areas to *minimize* response time to 911 calls.
- Scheduling tellers at banks so that needs are met during each hour of the day while *minimizing* the total cost of labor.
- Selecting the product mix in a factory to make best use of machine- and labor-hours available while *maximizing* the firm's profit.
- Picking blends of raw materials in feed mills to produce finished feed combinations at *minimum* cost.
- Determining the distribution system that will *minimize* total shipping cost from several warehouses to various market locations.
- Developing a production schedule that will satisfy future demands for a firm's product and at the same time *minimize* total production and inventory costs.
- Allocating space for a tenant mix in a new shopping mall so as to *maximize* revenues to the leasing company.
- (Prenhall.com, 2016)

General Process for Solving LP Exercises.

- According to purplemath.com (2016)The general process for solving linear-programming exercises is
    - to graph the inequalities (called the "constraints")
    - to form a walled-off area on the x, y-plane (called the "feasibility region").
- Then you figure out the coordinates of the corners of this feasibility region (that is, you find the intersection points of the various pairs of lines), and test these corner points in the formula (called the "optimization equation") for which you're trying to find the highest or lowest value.
- For LP examples go to http://people.brunel.ac.uk/~mastjjb/jeb/or/lpmore.html

Constraint Optimisation

- Linear programming is a powerful quantitative tool used by operations managers and other managers to obtain optimal solutions to problems that involve restrictions or limitations, such as budgets and available materials, labor, and machine time. These problems are referred to as constrained optimization problems. It includes:
  - Establishing locations for emergency equipment and personnel that will minimize response time
  - Determining optimal schedules for airlines for planes, pilots, and ground personnel.
  - Developing financial plans
  - Determining optimal blends of animal

Requirements of a LP Problem

- According to prenhall.com (2016) all LP problems have four properties in common:
  1. LP problems seek to *maximize* or *minimize* some quantity (usually profit or cost). We refer to this property as the **objective function** of an LP problem. The major objective of a typical firm is to maximize dollar profits in the long run. In the case of a trucking or airline distribution system, the objective might be to minimize shipping costs.
  2. The presence of restrictions, or **constraints**, limits the degree to which we can pursue our objective. For example, deciding how many units of each product in a firm's product line to manufacture is restricted by available labor and machinery.We want, therefore, to maximize or minimize a quantity (the objective function) subject to limited resources (the constraints).

Requirements of a LP Problem cont

3. There must be alternative courses of action to choose from. For example, if a company produces three different products, management may use LP to decide how to allocate among them its limited production resources (of labor, machinery, and so on). If there were no alternatives to select from, we would not need LP.

4. The objective and constraints in linear programming problems must be expressed in terms of linear equations or inequalities.

LP Model

- The objective function is a mathematical expression that can be used to determine the total profit (or cost, etc., depending on the objective) for a given solution.
- Decision variables represent choices available to the decision maker in terms of amounts of either inputs or outputs.
- For example, some problems require choosing a combination of inputs to minimize total costs, while others require selecting a combination of outputs to maximize profits or revenues.

Constraint

- Constraints are limitations that restrict the alternatives available to decision makers. Three (3) types of constraints are:
    1. Less than or equal to (<),
    2. Greater than or equal to (>), and
    3. Simply equal to (=).
- A < constraint implies an upper limit on the amount of some scarce resource (machine hours, labour hours, materials) available for use.
- A > constraint specifies a minimum that must be achieved in the final solution (e.g., must contain at least 10 percent real fruit juice, must get at least 30 km/L on the highway).
- The = constraint is more restrictive in the sense that it specifies exactly what a decision variable should equal (e.g., make 200 units of product A).

LP Model Mathematical Statement

- An LP model consists of a mathematical statement of the objective and a mathematical statement of each constraint.

- These statements consist of symbols (e.g., x1, x2) that represent the decision variables and numerical values, call parameters.

- The parameters are fixed values; the model is solved given those values.

LP Assumptions

- Bennett (2015) states that in order for linear-programming models to be used effectively, certain assumptions must be satisfied. These are:
    1. Linearity: the impact of decision variables is linear in constraints and the objective function.
    2. Divisibility: noninteger values of decision variable are acceptable.
    3. Certainty: values of parameters are known and constant.
    4. Nonnegativity: negative values of decision variables are unacceptable.

Five Essential Conditions in a Problem Situation

1. There must be limited resources (such as a limited number of workers, equipment, finances, and material); otherwise there would be no problem.
2. There must be an explicit objective (such as maximize profit or minimize cost)
3. There must be linearity (two is twice as much as one; if it takes three hours to make a part, then two parts would take six hours and three parts would take nine hours).

Five Essential Conditions in a Problem Situation cont

4. There must be homogeneity (the products produced on a machine are identical, or all the hours available from a worker are equally productive.

5. There must be divisibility: Normal linear programming assumes products and resources can be subdivided into fractions. If this subdivision is not possible (such as flying half an airplane or hiring one-fourth of a person), a modification of linear programming, called integer programming, can be used.

Further Reading

- *http://wps.prenhall.com/wps/media/objects/2234/2288589/ModB.pdf*

- http://www.purplemath.com/modules/linprog.htm

- http://people.brunel.ac.uk/~mastjjb/jeb/or/lpmore.html

References

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- Prenhall.com (2016) Linear Programming retrieved from http://wps.prenhall.com/wps/media/objects/2234/2288589/ModB.pdf
- Purplemath.com (2016) retrieved from http://www.purplemath.com/modules/linprog.htm
- Stevenson, William (2005) Operations Management 8th Ed. McGraw-Hill/Irwin