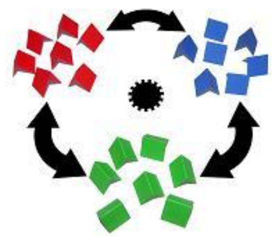
Optimization Programming



In this section we introduce several methods for optimizing an objective function (e.g., maximizing profit, minimizing cost, etc.). These optimization methods can significantly improve a company's bottom line. Here we will focus on operations optimization, where such techniques are most often applied; note, however, that they can also be of great value to marketers (e.g., media optimization, product line and pricing optimization, etc.).

Throughout the following sections we will have links to specific, concrete examples of various types of optimization problem, along with their solutions. We will use very simple examples containing few decision variables and constraints, just for educational purposes. However, in reality some optimization problems can get very complicated, with hundreds, thousands or even tens of thousands of decision variables and constraints.

But it is also possible to solve important problems profitably even when they have relatively few decision variables and constraints.This means that even small companies, or companies with small budgets, can profit from optimization modeling.

Linear Programming

Linear Programming (LP) can take several forms, depending on the nature of the data being programmed. But in each case we are always defining decision variables (e.g., resources), constraints (limits on the range of possible values for the decision variables), and an objective function (our optimization goal, such as profit maximization or cost minimization). LP assumes that the constraints and the objective function are linear functions of the decision variables.

When the variables are all considered to be continuous variables (non-integers), then the problem can be formulated as a straight LP problem. But when some of the variables are continuous but others are integers, then it is a mixed-integer LP problem. And when all the variables are integers, then it is an integer LP problem. Depending on the situation, a straight LP problem is typically easier to solve, since the variables can take on fractional/decimal values; a mixed-integer problem is somewhat more difficult, because some of the variables are restricted to integer values only; and a fully integer LP problem is usually the most difficult to solve because the variables are restricted to being only integers.

This link takes you to an LP example that sets up and then solves a Make-vs.-Buy problem.

And this link leads to a Personnel Staffing Optimization example that employs ***integer*** programming.

Nonlinear Programming

When the constraints and objective function are not linear functions of the decision variables, then the model involves Nonlinear Programming (NLP). NLP can get rather complicated, and it is sometimes difficult to find a "global" best solution. Running a NLP model several times using several different starting points can help to identify a true global solution; but sometimes such a solution is difficult or impossible to identify with certainty.

This link leads to an example of nonlinear programming in which a consulting firm assigns consultants to projects in a way that maximizes profit.

Evolutionary Optimization

Recently the field of optimization has begun to apply concepts borrowed from Darwinian evolutionary theory. The resulting evolutionary algorithm, or genetic algorithm (GA), is sometimes able to provide a solution that is superior to that of NLP for difficult nonlinear problems, especially ones that contain discontinuities and other troublesome features. The following brief description is a bit of an oversimplification, but it gives the reader a sense of how evolutionary optimization works.

We begin with a set of "chromosomes" representing various possible solutions to an optimization problem. Each chromosome contains "genes" representing the various possible component values of the chromosome. After the analysis begins, new chromosomes are developed via processes of crossover and mutation, where crossover represents the probabilistic exchange of values between different possible solutions, and mutation represents random substitutions of values within a given solution.

At each step in the evolutionary process, chromosomes are evaluated according to a fitness criterion (objective function). The fittest of these chromosomes survive into the next generation, gradually evolving to produce a gene pool that tends to contain better and better solutions to the optimization problem.

This link takes you to examples of Evolutionary Optimization that is used to solve transportation logistics problems.

Goal Programming

So far we have discussed optimization techniques that have "hard" constraints. That is, the constraints we put on the ranges of decision variables are absolute and cannot be violated. But sometimes we have a goal in mind for which we need to set a more flexible or "soft" constraint, such as when buying a large piece of equipment. We may have a maximum price in mind, but if we find equipment that we really want, we may be able to come up with additional money beyond our original budget to make the purchase. This more flexible approach to constraints is called Goal Programming (GP), and it may involve both hard and soft constraints.

This link takes you to an example of Goal Programming.

Multiple Objective Optimization

Sometimes business situations arise where it may be necessary or useful to have more than one objective function. These situations can be modeled using Multiple Objective Linear Programming (MOLP), which is a special case of Goal Programming. These situations typically involve some sort of tradeoff decision between two or more desirable but competing outcomes, such as maximizing profit and minimizing damage to the environment. In such cases, MOLP can help us arrive at a reasonable compromise solution.

This link takes you to an example of MOLP.

Queueing Optimization

Many operations involve the efficient management of queueing systems. Whether managing customer traffic, inventory or production flow, or machine maintenance or many other processes, there are powerful modeling and simulation techniques that can increase efficiency and improve the bottom line.

This link takes you to the main Queueing Optimization page, where there are also links to specific examples of queueing problems and solutions.