Ch.8 Prescriptive Analytics: Optimization and Simulation

- What is prescriptive analytics?

  making decisions using some kind of analytical model

- What is decision analytics?

  the category of analytics that focuses on making recommendations or making decisions

- What is environmental scanning and analysis?

  a continuous process of intelligence building identification of problems and/or opportunities via acquisition and analysis of data/information

- What are influence diagrams?

  graphical models of mathematical models

- What is forecasting?

  using data from the past to foresee the future values of a variable of interest

- What is a static model?

  a model that captures a snapshot of a system, ignoring its dynamic features

- What is a dynamic model?

  a model that captures/studies systems that evolve over time

- What is the objective of this model: Optimization of problems with few alternatives

  Find the best solution from a small number of alternatives

- How do you represent this model: Optimization of problems with few alternatives

Decision tables, decision trees, analytic hierarchy process

▼ What is the objective of this model: Optimization via algorithm

Find the best solution from a large number of alternatives, using a step-by-step improvement process

▼ How do you represent this model: Optimization via algorithm

Linear and other mathematical programming models, network models

▼ What is the objective of this model: Optimization via an analytic formula

Find the best solution in one step, using a formula

▼ How do you represent this model: Optimization via an analytic formula

some inventory models

▼ What is the objective of this model: Simulation

Find a good enough solution or the best among the alternatives checked, using experimentation

▼ How do you represent this model: Simulation

several types of simulation

▼ What is the objective of this model: Heuristics

Find a good enough solution, using rules

▼ How do you represent this model: Heuristics

Heuristic programming, expert systems

▼ What is the objective of this model: Predictive models

Predict the future for a given scenario

▼ How do you represent this model: Predictive models

Forecasting models, Markov analysis

▼ Why must models be managed?

to maintain their integrity and thus their applicability

▼ What is multidimensional analysis (modeling)?

a modeling method that involves data analysis in several dimensions and data are generally shown in a spreadsheet format

▼ What 4 basic components make up quantitative models?

- result or outcome or dependent variables
- decision variables
- uncontrollable variables and or parameters
- intermediate result variables

▼ What determines the results of decisions?

- the decision made (i.e. the values of the decision variables)
- the factors that cannot be controlled by the decision maker (the environment)
- the relationships among the variables

▼ What are decision variables?

a variable of interest that describes a particular course of action

▼ What are uncontrollable variables?

mathematical modeling variables that have to be taken as given—not allowing changes/modifications

▼ What are parameters?

numeric constants are used in mathematical modeling

▼ What are intermediate result variables?

they reflect intermediate outcomes in mathematical models

e.g. employee satisfaction (intermediate outcome) and productivity level (final result)

▼ Example of a simple financial model

- P = 100,000 / (1 + 0.1)^5 = 62,092
- P = present value
- F = a future single payment in dollars
- i = interest rate (percentage)
- n = number of years
- You can determine the present value of a payment of $100,000 to be made 5 years from today, at a 10% (0.1) interest rate.

▼ What are the zones of decision making?

Certainty aka Complete Knowledge

Risk aka Increasing/Decreasing Knowledge

Uncertainty aka Total Ignorance

▼ What is risk?

a probabilistic or stochastic decision situation

▼ A decision made under risk is one in which what?

the decision maker must consider several possible outcomes for each alternative, each with a given probability of occurrence

▼ What is risk analysis (calculated risk)?

a decision-making method that analyzes the risk (based on assumed known probabilities) associated with different alternatives

▼ What model solution tasks can spreadsheets perform?

- linear programming
- regression analysis

▼ What is mathematical programming?

a family of tools designed to help solve managerial problems in which the decision maker must allocate scarce resources among competing activities to optimize a

measurable goal

▼ Example allocation problem

the distribution of machine time (the resource) among various

▼ What is linear programming?

a mathematical programming technique in which all relationships among the variables are linear

▼ What characteristics do Linear Programming allocation problems display?

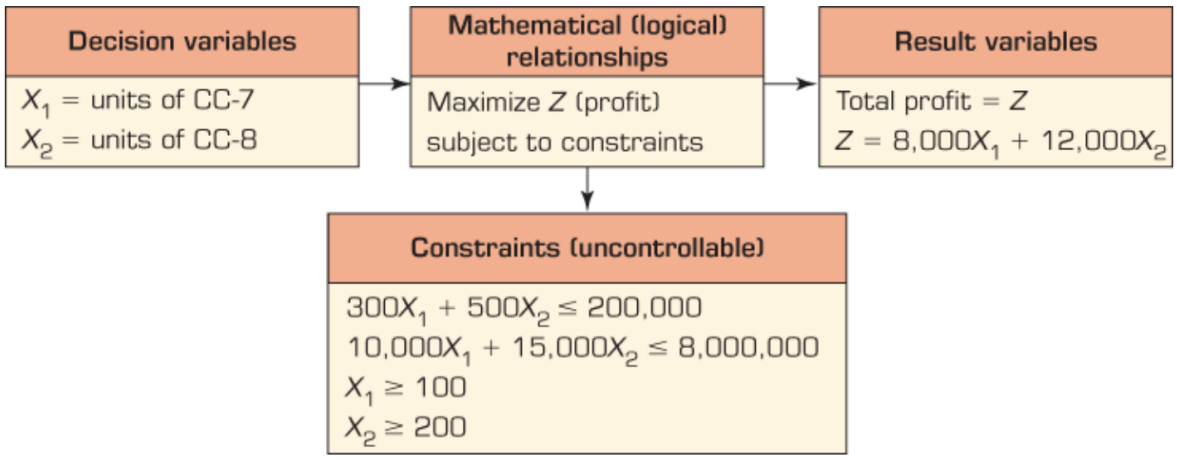
- a limited quantity of economic resources is available for allocation
- the resources are used in the production of products or services
- there are two or more ways in which the resources can be used; each is called a solution or a program
- each activity (product or service) in which the resources are used yields a return in terms of the state goal
- the allocation is usually restricted by several limitations and requirements called constraints

▼ Every Linear Programming model is composed of what?

- **decision variables** whose values are unknown and are searched for
- **an objective function**: a linear mathematical function that relates the decision variables to the goal, measures goal attainment, and is to be optimized
- **objective function coefficients**: unit profit or cost coefficients indicating the contribution to the objective of one unit of a decision variable
- **constraints aka uncontrollable variables** expressed in the form of linear inequalities or equalities that limit resources and/or requirements; these relate the variable through linear relationships
- **capacities** which describe the upper and sometimes lower limits on the constraints and variables
- **input/output (technology) coefficients** which indicate resource utilization for a decision variable

▼ Example mathematical model

- decision variables: X1 and X2 are units to be produced
- result variable: Total profit = Z
- the objective function is to maximize total profit:
  - Z = 8000 * X1 + 12000 * X2
- uncontrollable variables (constraints)
  - Labor constraint in days
  - Budget constraint in dollars
  - Marketing requirement for X1
  - Marketing requirement for X2
- internal (hidden) intermediate variables
  - the labor and budget constraints may have some slack in them when the left-hand side is strictly less than the right-hand side
  - they can be used in establishing sensitivity parameters for economic what-if analyses



▼ Using Excel's add-in Solver to help with linear programming problems

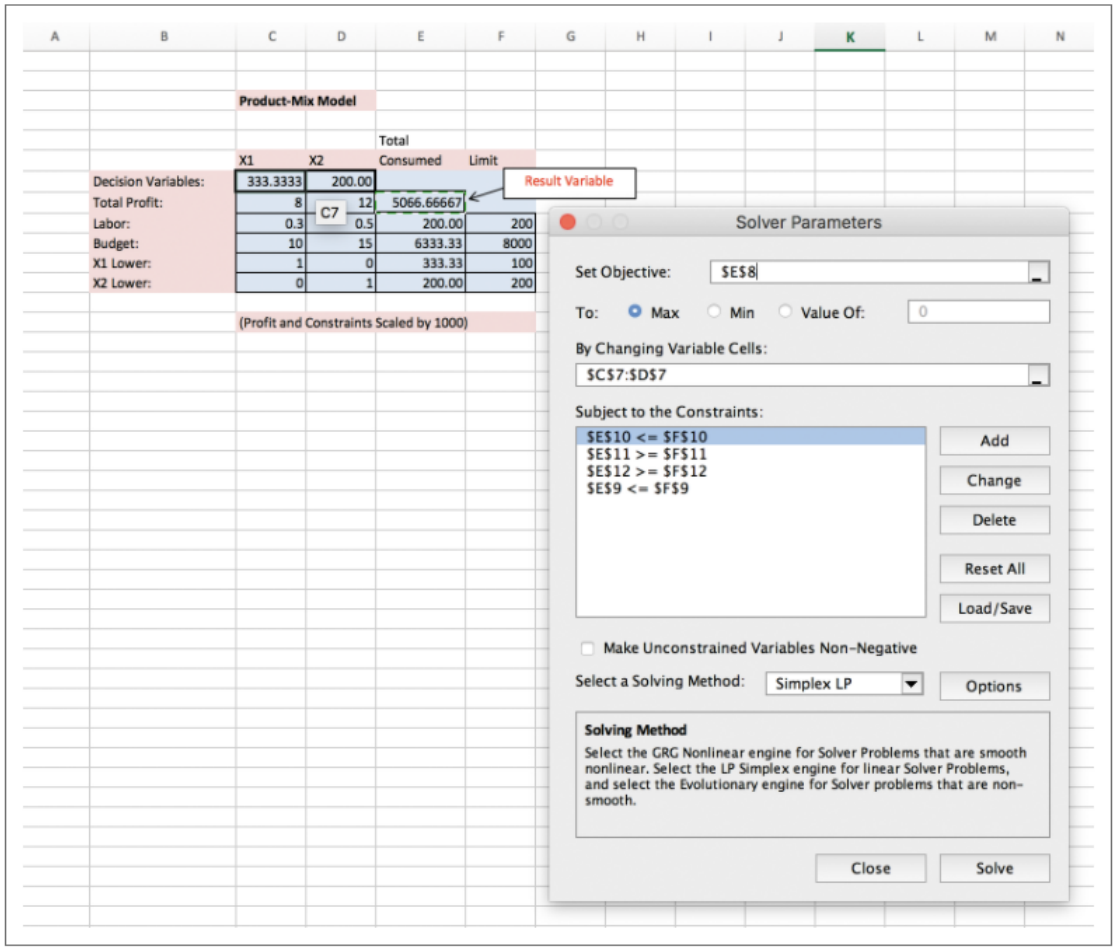
- see Data Tab > Analysis or go to Excel's Options Menu and select Add-ins

▼ Using Excel Solver for the above example (how-to)

We enter these data directly into an Excel spreadsheet, activate Solver, and identify the goal (by setting Target Cell equal to Max), decision variables (by setting By Changing Cells), and constraints (by ensuring that Total Consumed elements is less than or equal to Limit for the first two rows and is greater than or equal to Limit for the third and fourth rows). Cells C7 and D7 constitute the decision variable cells. Results in these cells will be filled after running the Solver Add-in. Target Cell is Cell E7, which is also the result variable, representing a product of decision variable cells and their per unit profit coefficients (in Cells C8 and D8). Note that all the numbers have been divided by 1,000 to make it easier to type (except the decision variables). Rows 9–12 describe the constraints of the problem: the constraints on labor capacity, budget, and the desired minimum production of the two products X_1 and X_2. Columns C and D define the coefficients of these constraints. Column E includes the formulae that multiply the decision variables (Cells C7 and D7) with their respective coefficients in each row. Column F defines the right-hand side value of these constraints. Excel's matrix multiplication capabilities (e.g., SUMPRODUCT function) can be used to develop such row and column multiplications easily.

After the model's calculations have been set up in Excel, it is time to invoke the Solver Add-in. Clicking on the Solver Add-in (again under the Analysis group under Data Tab) opens a dialog box (window) that lets you specify the cells or ranges that define the objective function cell, decision/changing variables (cells), and the constraints. Also, in Options, we select the solution method (usually Simplex LP), and then we solve the problem. Next, we select all three reports—Answer, Sensitivity, and Limits—to obtain an optimal solution of X_1 = 333.33, X_2 = 200, Profit = $5,066,667, as shown in Figure 8.6. Solver produces three useful reports about the solution. Try it. Solver now also includes the ability to solve nonlinear programming problems and integer programming problems by using other solution methods available within it.

Figure 8.6 **Excel Solver Solution to the Product-Mix Example.**



▼ Alternative to Excel is lindo.com

Lindo is a modeling system

▼ What should a multiple-goal problem be transformed into *before* comparing the effects of the solutions?

a single-measure-of-effectiveness problem

▼ What are some methods of handling multiple goals?

- utility theory
- goal programming

- expression of goals as constraints, using LP
- a points system

▼ What does sensitivity analysis assess?

the impact of a change in the input data or parameters on the proposed solution (i.e. the result variable)

▼ What relationships does sensitivity analysis test?

- the impact of changes in external (uncontrollable) variables and parameters on the outcome variable(s)
- the impact of changes in decision variables on the outcome variable(s)
- the effect of uncertainty in estimating external variables
- the effects of different dependent interactions among variables
- the robustness of decisions under changing conditions

▼ What is a What-if analysis?

- What will happen to the solution if an input variable, an assumption, or a parameter value is changed?
- example: What will happen to the total inventory cost if the cost of carrying inventories increases by 10%?

▼ What is goal seeking?

it calculates the value of the inputs necessary to achieve a desired level of an output (goal)

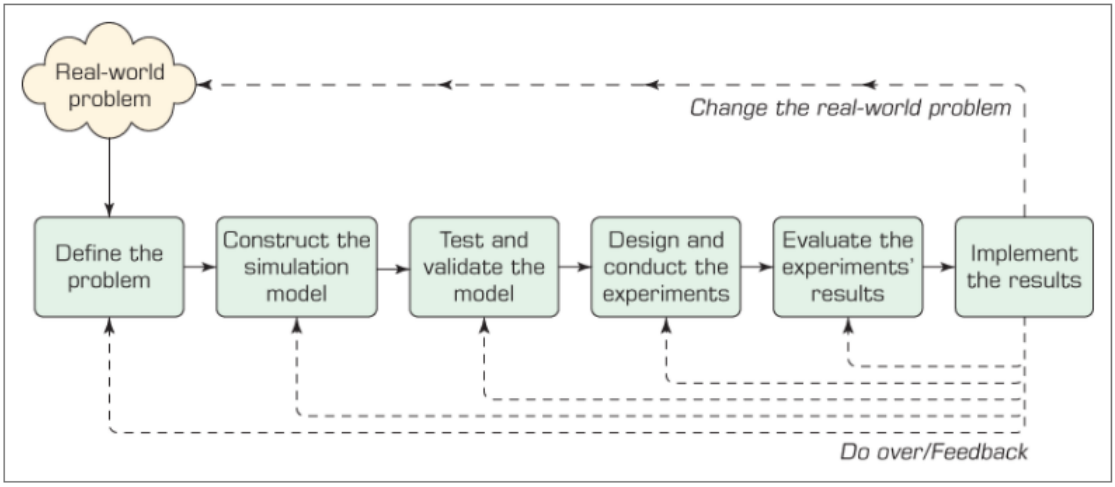
▼ Decision analysis?

an approach that involves a finite and usually not too large number of alternatives

▼ What can decision tables or decision trees model?

single-goal situations

▼ What is the methodology for simulation?



▼ What is probabilistic simulation?

one or more of the independent variables are probabilistic and follow certain probability distributions:

- discrete: a limited number of events or variables that can take on only a finite number of values
- continuous: unlimited numbers of possible events that follow density functions such as the normal distribution

▼ What is a time-independent simulation?

a situation in which it is not important to know exactly when the event occurred

▼ What is the Monte Carlo simulation technique?

it relies on change/probability distribution to represent the uncertainty in the modeling of the decision problem

- the method begins with building a model of the decision problem without considering the uncertainty of any variables
- then we recognize that certain variables are uncertain or follow an assumed or estimated probability distribution
  - the estimation is based on past data
- then sampling experiments are run:

    - they consist of generating random values of uncertain variables and then computing values of the variables
    - these experiments solve the model thousands of times
  - then we can analyze the behavior of the dependent variables by looking at their statistical distributions

▼ What is discrete event simulation?

it builds a model of a system where the interaction between different entities is studied

- example: restaurant with a server and customers
- can model the arrival of customers (varying amounts) and the average waiting time, etc.

▼ What is visual interactive problem solving?

a simulation method that lets decision makers see what the model is doing and how it interacts with the decisions made, as they are made