CHAPTER 1

INTRODUCTION TO MANAGERIAL DECISION MODELING

SOLUTIONS TO DISCUSSION QUESTIONS AND PROBLEMS

1-1. Decision modeling is the scientific approach to managerial decision-making. This type of analysis is a logical and rational approach to making decisions. Emotions, guesswork, and whim are not part of the decision modeling approach. A number of academic and professional organizations support the use of the scientific approach: the Institute for Operation Research and Management Science (INFORMS), the Decision Sciences Institute (DSI), the Production and Operations Management Society (POMS), and the Academy of Management.

1-2. *Deterministic* models assume that all the relevant input data are known with certainty. That is, these models assume that all the information needed for modeling the decision-making problem environment is available, with fixed and known values. Students should be able to find several examples from the manufacturing and service sectors. For example, deciding how many sections of a course to offer during a semester can be modeled as a deterministic model since the costs and benefits of offering each section are known.

Probabilistic (also called *stochastic*) models assume that some input data are not known with certainty. That is, these models assume that the values of some important variables will not be known *before* decisions are made. Here again, students should be able to find several examples from the manufacturing and service sectors. For example, their own career based on their choice of a major for their undergraduate study can be modeled as a probabilistic model.

1-3. Quantitative factors are typically identifiable and measurable, making their inclusion in the model relatively easy. In contrast, qualitative factors measure such things as perceptions, feelings, and opinions. Although some qualitative factors do have scales of measures (for example, we can classify opinions of the President's performance as good, fair, or poor), in general, they are difficult to quantify and measure.

1-4. Unlike quantitative factor that have identifiable scales of measure (for example, length may be measured in meters), many qualitative factors are not associated with any specific scale of measure. Hence, it may be difficult to quantify these factors.

1-5. Decision modeling is a step-by-step process that allows decision makers to investigate problems using quantitative techniques. The steps of the decision modeling process include defining the problem, developing a model, acquiring input data, developing a solution, testing the solution, analyzing the results, and implementing the results. In every case, the analysis begins with defining the problem. The problem could be too many stockouts, too many bad debts, or determining the products to produce that will result in the maximum profit for the organization. After the problems have been defined, the next step is to develop one or more models. These models could be inventory control models, models that describe the debt situation in the organization, and so on. Once the models have been developed, the next step is to acquire input data. In the inventory problem, for example, such factors as the annual demand, the ordering cost, and the carrying cost would be input data that are used by the model developed in the preceding step. In determining the products to produce in order to maximize profits, the input data could be such things as the profitability for all the different products, the amount of time that is available at the various production departments that produce the products and the amount of time it takes for each product to be produced in each production department. The next step is developing the solution. This requires manipulation of the model in order to determine the best solution. Next, the results are tested, analyzed, and implemented. In the inventory control problem, this might result in determining and implementing a policy to order a certain amount of inventory at specified intervals. For the problem of determining the best products to produce, this might mean testing, analyzing, and implementing a decision to produce a certain quantity of given products.

1-6. Sometimes we may discover during a later step of the decision modeling approach that we made a mistake in setting up an earlier step. For example, during the testing of the solution, we may notice that some of the input data are being measured incorrectly. This means that the formulation and all subsequent steps have to be revised. For this reason, it is important to have an iterative process between the steps before the final solution is obtained.

1-7. Although the formal study of decision modeling and the refinement of the tools and techniques of the scientific method have occurred only in the recent past, quantitative approaches to decision making have been in existence since the beginning of time. In the early 1900s, Frederick W. Taylor developed the principles of the scientific approach. During World War II, quantitative analysis was intensified and used by the military. Because of the success of these techniques during World War II, interest continued after the war.

1-8. The types of models mentioned in this chapter are physical, scale, schematic, and mathematical. The chapter provides examples of each type of model. The purpose of this question is to have the student come up with additional examples of each type of model based on their own experience.

1-9. Input data can come from company reports and documents, interviews with employees and other personnel, direct measurement, and sampling procedures. For many problems, a number of different sources are required to obtain data, and in some cases it is necessary to obtain the same data from different sources in order to check the accuracy and consistency of the input data. If the input data are not accurate, the results can be misleading and very costly to the organization. This concept is called "garbage in, garbage out".

1-10. A decision variable is an unknown quantity whose value can be controlled by the decision maker. Examples include how many inventory items to order, how many courses to take this semester, how much money to invest in retirement plans this year, etc.

1-11. A problem parameter is a measurable (usually known) quantity that is inherent in the problem. Examples include the cost of placing an order for more inventory items, the tuition payable for taking a course, the annual fees payable for establishing a retirement plan, etc.

1-12. Some advantages of using spreadsheets for decision modeling are: (1) spreadsheets are capable of quickly calculating results for a given set of input values, (2) spreadsheets are effective tools for sorting and manipulating data, (3) spreadsheets have several built-in functions for performing complex calculations; and (4) spreadsheets have several built-in procedures (such as Goal Seek, Data Table, and Chart Wizard) and add-ins (such as Solver) that make it easy to set up and solve most of the decision modeling techniques commonly used in practical situations.

1-13. Implementation is the process of taking the solution and incorporating it into the company or organization. This is the final step in the decision modeling approach, and if a good job is not done with implementation, all of the effort expended on the previous steps can be wasted.

1-14. Sensitivity analysis and post-optimality analysis allow the decision maker to determine how the final solution to the problem will change when the input data or the model change. This type of analysis is very important when the input data or model has not been specified properly. A sensitive solution is one in which the results of the solution to the problem will change drastically or by a large amount with small changes in the data or in the model. When the model is not sensitive, the results or solutions to the model will not change significantly with changes in the input data or in the model. Models that are very sensitive require that the input data and the model itself be thoroughly tested to make sure that both are very accurate and consistent with the problem statement.

1-15. There are a large number of quantitative terms that may not be understood by managers. Examples include PERT, CPM, simulation, the Monte Carlo method, mathematical programming, EOQ, and so on. The student should explain each of the four terms selected in his or her own words.

1-16. Many decision modelers enjoy building mathematical models and solving them to find the optimal solution to a problem. Others enjoy dealing with other technical aspects, for example, data analysis and collection, computer programming, or computations.

The implementation process can involve political aspects, convincing people to trust the new approach or solutions, or the frustrations of getting a simple answer to work in a complex environment. Some people with strong analytical skills have weak interpersonal skills; since implementation challenges these "people" skills, it will not appeal to everyone. If analysts become involved with users and with the implementation environment and can understand "where managers are coming from," they can better appreciate the difficulties of implementing what they have solved using decision modeling.

1-17. Users need not become involved in technical aspects of the decision modeling technique, *but* they should have an understanding of what the limitations of the model are, how it works (in a general sense), the jargon involved, and the ability to question the validity and sensitivity of an answer handed to them by an analyst.

1-18. Churchman meant that sophisticated mathematical solutions and proofs can be dangerous because people may be afraid to question them. Many people do not want to appear ignorant and question an elaborate mathematical model; yet the entire model, its assumptions, and its approach, may be incorrect.

<u>Note:</u> In problems 1-19 to 1-28, the BEP can be found using Excel's *Goal Seek* procedure.

1-19. See file P1-19.XLS.
(a) BEP for proposal A = 6250 units.
(b) BEP for proposal B = 7000 units.
(c) $BEP_\$$ for proposal A = $125 000.
(d) $BEP_\$$ for proposal B = $140 000.
(e) If the expected volume is 8500 units, proposal A should be selected yielding a profit of $18 000 (compared to only $15 000 for proposal B).
(f) If the expected volume is 15 000 units, proposal B should be selected yielding a profit of $80 000 (compared to only $70 000 for proposal A).

1-20. See file P1-20.XLS. BEP = 12 500 units , $BEP_\$$ = $100 000, profit at 100 000 units = $350 000.

1-21. See file P1-21.XLS. BEP = 300 000 copies, $BEP_\$$ = $15 000.

1-22. See file P1-22.XLS.
(a) BEP = 25 000 books
(b) $BEP_\$$ = $750 000.

1-23. See file P1-23.XLS.

(a) BEP = 30 000 books

(b) $BEP_{\$}$ = $900 000.

1-24. See file P1-24.XLS. Profit with the current equipment and a volume of 30 000 units is $1000. Profit with the new equipment and volume of 50 000 units is only $0. The firm should therefore not buy the new equipment.

1-25. See file P1-25.XLS. With the increased selling price, profit with the new equipment and volume of 45 000 units is $2500. The firm should therefore buy the new equipment.

1-26. See the file P1-26.XLS. Set up and solve this problem using a selling price of $4 per unit, fixed cost of $15 000, and variable cost of $1.82 per unit. The BEP is 6881 units.

1-27. See file P1-27.XLS. We can solve this problem assuming any value for the selling price since the total revenue will be the same for all options. In our analysis, we use the selling price of $2 per unit.

(a) If the volume is 3000 units or greater, the total cost is lowest (and hence, the total profit is highest) if Hoops Unlimited purchases the new equipment.

(b) If the volume is 1600, the total cost is lowest if Hoops Unlimited makes major modifications to the current equipment. However, at a volume of 2400, the total cost is lowest for the new equipment option. To calculate the production level at which the best option changes, set the total costs of these options equal. That is, if x denotes this production level, set $1100 + 0.7x = 1800 + 0.4x$. This implies $x = 2333.33$. Since making major modifications is the best choice from 1600 till 2333 units (which is most of the 1600 to 2400 interval), the recommendation should be for Hoops Unlimited to make major modifications to the current equipment.

1-28. See file P1-28.XLS.

(a) BEP for manual process = 50 000 units.

(b) BEP for mechanized process = 60 000 units.

(c) If the expected volume is 60 000 units, the manual process will yield a profit of $7500.

(d) If the expected volume is 60 000 units, the mechanized process will yield a profit of $0.

1-29. See file P1-29.XLS. Tuition will have to increase by $300 per semester.

1-30. See file P1-30.XLS. Tuition for non-member students would be $2500.

1-31. See file P1-31.XLS. The school has to recruit 300 more non-member students, for a total of 1500.

1-32. See file P1-32.XLS.

(a) BEP_A = 6500; BEP_B = 4800

(b) $BEP_{\$A}$ = $208 000; $BEP_{\$B}$ = $153 600

(c) Choose B, because with A you lose $10 000. Profit with B = $10 500

(d) Choose B, because profit is $40 500 with B as opposed to $10 000 with A.

(e) At 1400 units, total cost for both machines is the same.