CHAPTER

Introduction to Modeling

1

A. SELF-REVIEW EXERCISES

TRUE OR FALSE

1. The more complicated the model, the more useful it generally is. ***F***

2. Models usually ignore much of the world. ***T***

3. Decision models produce numerical values for decision variables. ***T***

4. A decision model often captures interactions and trade-offs between certain variables or quantities of interest. ***T***

5. There is usually no single correct way to build a model of a management situation. ***T***

6. One advantage of the modeling process is that it often eliminates the need to be very familiar with the environment being studied. ***F***

7. In practice, models are sometimes built by teams of individuals drawn from different disciplines. ***T***

8. By definition, optimization models always provide the best decision for the real-world situation. ***F***

9. A model is a good substitute for a manager's judgement and experience. ***F***

10. An important role of mamagement can be the evaluation of a model (determining whether a model shold be used and its results implemented).***T***

11. Although spreadsheets make calculations easy, they have no real impact on decision making. ***F***

12. "What if" models are only useful for examining changes in the values of decision variables. ***F***

13. Data are needed only after the model is built. ***F***

14. As soon as you befing to hypothesize *any* relationship among your data, you are beginning to formulate the equation(s) of a model. ***T***

30. Data are used in building models. ***T***

16. A model provides a consistent means to interpret and evaluate data. ***T***

17. Aggregated data contain more information than do disaggregated data. ***F***

30. Models can be used to generate data. ***T***

MULTIPLE CHOICE

19. A model
a. is a selective representation of reality
b. an abstraction
30. an approximation
31. an idealization
32. **all of the above**

20. Decisions are often based on
a. an evaluation of numerical data
b. numbers produced by models

c. the use of intuitive models that are never written down
d. all of the above

21. A model
a. cannot be useful unless it mirrors a real situation in great detail
30. is a tool for the decision maker
31. is rarely revised once it has been constructed
32. all of the above

22. A model
a. forces a manager to be explicit about objectives
b. forces a manager to identify explicitly the types of decisions that influence objectives
c. forces a manager to recognize explicitly constraints placed on the values that variables can assume
d. all of the above

23. Models
a. play different roles at different levels of the firm
b. are rarely used in the strategic-planning process
c. are a costly way of making routine daily decisions
d. all of the above

24. Constrained optimization means
a. that the underlying model is a very precise representation of reality
30. achieving the best possible (mathematical) result considering the restrictions
31. both of the above

i. Consider a prospective manager with interests and abilities that lie far from the quantitative techniques field. The point of studying a quantitative modeling course might be
a. to be able to knowledgebly accept or reject the use of quantitative tools
b. to acquire new ways of looking at the environment
c. to become more familiar with the kind of assistance a spreadsheet might provide
32. all of the above

33. With a "What if" analysis, we are sure to find
a. an optimal solution
b. a good solution
c. a feasible solution (if one exists)
d. none of the above

27. In a probablistic model, some element of the problem
a. is a random variable with known distribution
b. is a random variable about which nothing is known
e. takes on various values that must be precisely calculated before the model can be solved
f. will not be known until the model has been clearly formulated

28. A manager who wishes to maximize profit and minimize cost
a. needs two objectives in her model
b. can get the desired result by maximizing (profit minus cost)
b. has an impossible goal an must choose one objective
d. must make use of a probabilistic model

34. Linear programming models in general
a. can be solved even if they are large
a. are more useful for analyzing problems than for solving them
c. are probabilistic in nature
d. are rarely solved by a computer

30. Every quantitative model
a. represents data of interest in numerical form
b. requires the use of a computer for a full solution
c. must be deterministic
d. all of the above

31. The use of decision models
a. is possible only when all variables are known with certainty
b. reduces the role of judgement an intuition in managerial decision making
c. requires managers to have a high degree of proficiency with computers
d. none of the above.

B. SOLUTIONS TO PROBLEMS

1-1. Here is an example, "How much should we spend for national defense?" One reason this is such a hard problem is that there is no generally accepted model. For this specific problem it is the objective function that is problematic. No one yet has found a model for this problem that is widely acceptable in terms of objective, assumptions, etc. Other examples are provided by situations with significant social and/or political considerations. Other situations in which models are weak, absent, or contradictory might include managing under little or no information, personnel decision making, assessment of new and untried technology, etc. In interpreting the statement one should make the distinction between a formal quantitative model and informal, mental model. In the absence of either, one almost always substitutes a related mental model, often unconsciously.

1-2. As indicated in the text, the distinction between data and models blurs considerably under inspection. Models without any data to assess parameters quickly become theoretical abstractions. Moreover, collecting data without the guidance of a model, even if only a crude mental one, can not only be expensive because irrelevant facts are recorded, but may be nearly impossible without the operational definitions provided by a model. For example, collecting data on costs requires definitions of cost and cost measurement that can only be articulated in the context of some simple model. Thus, from a practical level it is nearly impossible to segregate data and models.

1-3. The collection and quantification of data is almost always a consequence of some underlying world view, either a formal or an informal mental model. In addition, even if the spreadsheet user was uninvolved in the data collection process, interpreting the table of data in the spreadsheet is a form of modeling.

1-4. Historical outcomes are often used to validate a model. Historical data on decisions, parameters, and outcomes for a similar situation are first used as model inputs. The model is then used to "predict" outcomes that have previously occurred. The predicted outcomes are compared to the actual outcomes. The model is then analyzed by comparing the two sets of outcomes.

1-5. Here are some reasons: (i) to give you opportunity to knowledgeably accept or reject the use of quantitative tools; (ii) to provide you with some new concepts—perhaps new ways of looking at your environment; and (iii) to make you familiar with ways in which the modeling can assist you. Spreadsheet modeling represents a philosophy that can be of value even for those whose mathematical skills are weak. The modeling process itself is really a way of understanding the world which can be of value even to those whose mathematical skills are lacking. Managers having an understanding of the modeling process are better able to supervise or undertake projects that involve modeling done by others.

1-6. Here are some suggestions: (i) Possible savings from the model do not justify the expenses of implementing it; (ii) Poor communication between the model builder and the potential user might lead the potential user to have a lack of understanding of the model and a lack of confidence in its ability to produce useful results; and (iii) The modeler's "selective representation of reality" may not be close enough to the user's perception of the problem; i.e., the user may believe that the model does not deal with the real problem.

As indicated in the chapter, many models are constructed for ceremonial or political reasons in order to justify predetermined decisions or to create the aura of scientific inquiry to help support those predetermined decisions. Also, commonly, the modeling is done by some group other than the decision maker, such as external consultants, and since the decision maker does not understand what was done he or she often elects not to implement any of the recommendations emanating from the model especially if they are not obvious in the first place. The absence of implementation does not necessarily mean that the modeling process was a waste of time. Model development may have considerable intangible value. In particular, it can serve as a focus for an analytic process. At a minimum a great deal can be learned about the situation under study and useful data may be uncovered. Recall that one of the outcomes from modeling is learning and understanding; and this is of value in its own right.

1-7. There are a variety of interpretations of the quotation. Most will center upon the implementation of recommendations from the model in the form of managerial actions involving the allocation of resources. This is the common "action oriented" management definition of success. Under this definition, "a successful application of a model" occurs when as a result of using a model new decisions are taken which result in improved performance which more than pays for the modeling activity. However, a more subtle interpretation

also includes the learning and understanding of the real world that modeling supports even if no particular immediate action follows from the model's specific recommendations.

1-8. There are many performance measures, of which short run profit maximization may be only one. Many of them may be surrogates for longer run profits that may be difficult to quantify and likely involve the sacrifice of short run profits for their achievement. Examples might be production costs, employee moral, return on assets or equity, stock market price, etc. Other suggestions are: (i) maximize cash flow; (ii) maximize market share; (iii) maximize monopolistic stature; (iv) maximize number of employees; and (v) "perpetuate itself" as much as possible.

1-9. Any discussion should center upon the distinction between recommended decisions "above the line" and "below the line" in the modeling process. Optimal decisions "above the line" in the modeling process are easy to understand in the context of the model and its data given a single performance measure. Implementation of those decisions in the real world ("below the line") almost always involves consideration of other factors not captured by the model making it difficult, if not impossible, to defend the actions taken as being optimal in some sense. That is, optimization models produce decisions which are optimal in a *modeling* sense. This means they are the best possible decisions within the context of a model is important to emphasize that the word optimal has a precise meaning only in this *well* defined mathematical sense, with reference to a particular model of reality. Hence, in terms of the reality of the firm, these decisions may be good, or at least better, ones, but it would be incorrect to call them optimal.

1-10. Like politicians, managers often articulate pleasant sounding adages that do not hold up to scrutiny. The simultaneous achievement of multiple objectives is one of the most common of such claims and almost always fails in practice because of the inherent contradictions in achieving multiple objectives. In fact, a useful consequence of modeling is to identify those infrequent situations where dominance allows multiple objectives to be simultaneously achieved while allowing the consequences of tradeoffs to be investigated when faced with the more common situation when they cannot. As it is, the statement simply does not make sense. Clearly, increasing output will also increase costs. One can attempt to minimize output for a given cost (i.e. with a < or = constraint on cost) or minimize cost for a give output (i.e., with a > or = constraint on output) but not to minimize cost and maximize output simultaneously.

1-11. The consequences of a formal analysis involving equations whose parameter values are not known precisely is one of the major advantages of modeling in the first place. For example, in an engineering model of a rocket flight to the moon the sixth or tenth decimal place of accuracy in a parameter may be important in the sense that changing the number in the last decimal place may change the output obtained from running the model. In a social or economic model with less precise data the required parameter accuracy may be much less. The use of a model in such situations, where some of the data are imprecise, can be justified if changes in the data, within the range of imprecision, produce insignificant changes in the model's output. This is called "sensitivity analysis," and it allows one to assess whether additional resources should be expended to achieve the higher accuracy that more precise data collection would permit.

1-12. Almost always, the statement is false. In fact, just the opposite is usually the case. Deciding what the information elements of a decision model are and how to quantify them is often a difficult unstructured task. Once the model has been constructed, analyzing it by spreadsheet manipulations is easy, fun, and almost routine.

1-13. In this case the impatient executive is using management lingo to force you to be more operational about the decisions (levers) to be reached and the performance measure for evaluating them (yardstick).

1-14. The scenario described is a common one practiced by consulting firms who sell the results of analyses to client managers unable or unwilling to do the analysis for themselves. The key attribute is that the consultant does not deliver sufficient expertise, data, nor models to allow the client to perform similar analyses in the future, at least not without re-employing the consultant. This is a good question to bring up in a class in which some students have had work experience as consultants and others who do not. The consultants will almost always argue that the managers want results and not process when hiring consultants and that they, the client ers, are trusting the reputation of the consulting firm to be the arbiter of whether the model and its recommendations are or are not appropriate. That is why they are paying for the

service. Other students, often those without consulting experience, are appalled by such a claim, typically arguing that the manager is abdicating his own responsibilities and, in effect, giving too much authority and responsibility to nonemployees who may have other agendas. Although there is no easy resolution of these two views, any wrap up discussion might emphasize the ethical obligation of a consultant, like any employee, to summarize the key assumptions, logic, and other support for their recommendations and to provide sufficient context so that the client manager can properly interpret them in the larger, longer term context of his own responsibilities. Also, at the risk of (much) higher consulting costs, knowledgeable managers can certainly require that the consultants document in detail the process and the models used in arriving at recommendations. Ultimately, it becomes an issue of economics involving the tradeoffs between full disclosure of models or data that otherwise would be proprietary to the consulting firm vs. revelation of all aspects of the modeling to the client whose future dependency upon the consultants would be diminished thereby.

1-15. The question lists many polar extremes of managerial and organizational attributes that may or may not facilitate the modeling process. There are many plausible opinions that may be expressed. Unfortunately, there is little research to resolve these issues definitively. Preliminary research by one of the text's authors (Moore) suggests the following with the regard to the use of spreadsheet models:

- Collegial managers are more likely to openly use modeling than competitive ones.
- Spreadsheet models are more likely to be used by individual decision makers than by large committee-based decision makers.
- Models are more frequently used by managers already spreadsheet literate.
- Organizations with low management turnover are more likely to use spreadsheet models than those with high turnover.
- A service organization is more likely to use spreadsheet modeling for managerial decisions than a manufacturing organization.
- There is some support for the proposition that senior managers in newly emerging economies are more likely to use spreadsheet modeling than those in more developed economies.
- US managers with nontechnical college degrees are more likely to use spreadsheet modeling than those with technical degrees.

1-16. In highly competitive environments, small differences in performance can leverage into substantial gains. For example, assuming identical products, consumers and a single market the producer whose costs are 1% lower than the others does not improve profit by 1%, rather, that producer wins the entire market. Even in noncompetitive environments, the total quality movement (TQM) has shown that the accumulation of small improvements can result in significant organizational performance gains. Achieving TQM gains requires continuous attention to small improvements that are the result of detailed and persistent analysis. Modeling can be the vehicle to achieve these small gains because human intuition alone often fails when attempting to discern small differences.

1-17. Churchman is pointing out that data collection itself always results from some world view i.e., a mental if not formal, model. Thus, all data are the result of some processing during its collection process to decide what to include and what to exclude, how to quantify it, how to organize and store it, etc.

1-18. This question usually produces vigorous discussion. Students often break into two camps: one claiming that like any other tool a model can be used to rationalize a decision that is already been reached, while the other camp adopts a more open attitude that models should only be used to guide future decision making and not to provide ammunition for decisions already reached. Typically, the former group will argue that they are required to do whatever their boss asks and will proceed to create a model that justifies the decision. Often, the latter group would instead take an open minded scientific approach to build the model and if its recommendations contradict those of the boss would then proceed to try to pursuade him to change his prior decision before the big meeting. Frequently, the former group replies that such a "scientific" approach is naive and would serve only to lessen the credibility of the modeler to his/her boss. There is no clear resolution of these viewpoints. One way to unify any discussion is to point out that the modeler will be invited to the big meeting, presumably to make a presentation. If the model which rationalizes the prior decision requires unreasonable assumptions or logic, then the modeler's obligation is to summarize them so that if the prior decision is ratified, everyone knows the assumptions and logic upon which it was based. This would open the door in politically acceptable ways to discuss or analyze alternative scenarios that likely would be asked for by the senior vice president himself in the meeting, if he felt uncomfortable with ratifying the proposed new office.

1-19. The statement is basically an empirical one: that decisions are not altered in the face of disconfirming data until the disconfirming data is "understood". But understanding the data involves modeling which leads to a more insightful understanding of the contradicted model, if not a new model. Another line of reasoning would point out that rejecting a model based upon disconfirming data necessarily means that some other model, such as an historical model, the decision maker's mental model, or even a random decision making model, is employed. This latter approach argues that it is axiomatic that decision making emanates from some organized understanding of the real world situation which is just another way of describing a model.

Assuming the statement were true, data serves to estimate parameters and to assist in deciding whether the proposed model is valid, i.e., suitable for improved decision support.

1-20. Mr. Greenspan is clearly stating that the construction and use of (risk) models is not a substitute for the collective skills, judgement, and experience of the people who use them. To assume that a model can be effectively applied in the absence of the skills of the decision-maker is, in itself, risky and ill-advised. While risk models may have grown in sophistication, Mr. Greenspan asserts that they are still based on sampling, the characteristics of which may not be fully understood. Of particular value, according to Mr. Greenspan, is the ability to select the best model for the situation. This notion is emphatically addressed in chapter one. The chapter also stresses that the appropriate skills, judgement, and experience are needed not just in selecting, or "judging" which model best describes managerial situations. They are also needed at each stage of the modelling process, from studying the environment to the final application.

1-21. Of the various types of models, all of which are abstractions of reality, physical models are, perhaps, the least abstract. They are tangible representations of the product or idea they are intended to represent. This gives them an advantage in that they are easy to comprehend. Their physical nature, however, makes them difficult to share, modify, and manipulate. Further, their scope of use is the lowest of the three typical model types. Symbolic models can be described in opposite terms. They are the least tangible, that is, the most abstract model type. This characteristic makes them the most difficult to comprehend. Symbolic models, though, are relatively easy to duplicate, modify, manipulate,and to share. They do, in fact, simplify reality to a much greater degree than physical models, and their scope of use is the widest of the basic model types.

1-22. Ease of modification and manipulation enable the modeler to vary the level of detail, the variables, and the relationships among the variables quickly and efficiently. Changes can be incorporated until it is clear that the model meets the needs of the modeler. Since symbolic models are easy to share, the modeler can make use of the skills of others, experienced model builders or decision-makers, for example. Ease of duplication provides the modeler with opportunities to use the same model, or some variation of the model to re-occurring managerial situations.