(10)

chapter 5

QUANTITATIVE METHODS IN MANAGERIAL DECISION MAKING

Frame 1[5]

During recent years, there has been an increasing trend toward the use of quantitative methods for the purpose of managerial decision making. These methods feature: (1) a broad point of view, sometimes termed a systems-wide view; (2) identification and measurement of the objectives; (3) the quantification of all relevant variables; (4) the use of models, commonly mathematical abstractions, showing relationships quantitatively; (5) optimizing or minimizing a certain function, such as cost efficiency; and (6) orderly thinking and logical methodology.

The technique used in quantitative managerial decision making usually gives decisions applicable to the entire enterprise or a large portion of it, recognizes the impact of these decisions on the various components, and focuses managerial efforts on the vital issues. The objective itself is definite and measurable. Examples of objectives are to realize a specific rate of return on investment or to ensure that transportation costs do not exceed 5 cents a unit. Objectives should not be stated in general terms such as, "to better utilize the machines" or "to reduce transportation costs." The act of incorporating and quantifying most or all of the relevant variables characterizes the quantitative approach. Increased computer availability has helped make this possible. The use of models and the optimizing or minimizing of a particular function also are common characteristics in the quantitative decision-making approach.

Models are constructed after the goals have been set and the relevant variables have been identified and quantified. The pertinent relationships are studied and analyzed so that the proper background for constructing the model is gained. Then the model is built or created so

Answer frame 2[4]

1. False. *Marginal analysis* is also used to determine if an enterprise is overproducing, *i.e.*, marginal cost is greater than marginal revenue. It involves comparing the extra cost and extra revenue resulting from each additional unit produced. The optimum point at which to produce is at the volume where marginal cost and marginal revenue are equal.
2. False. Intuition probably is present, in most decision making, to some degree.
3. False. *Patterned decisions* arise from a manager's using his *superiors'* decisions as a guide for making his decisions. This is the follow-the-leader approach.
4. True. In a specific situation, the relatively high cost of *experimentation* may preclude its use.

Go to Frame 3[4], page 18, and continue reading.

Answer frame 3[4]

1. True. It generally is agreed that the reponsibility for a specific type of decision should be delegated to the lowest organizational level at which there is an individual possessing the ability, desire, impartiality, and access to relevant information needed for these decisions.
2. False. The responsibility for decision making can be delegated to a specific individual, and, even when a group is involved, there are those who believe that one man usually makes the final decision.
3. False. Emergency decisions typically are decided by an individual because of the need for speedy action.
4. False. The group method for decision making is quite popular and has gained tremendous acceptance.

You have completed Chapter 4. Now begin Chapter 5, page 19.

Frame 1[5] continued

that it accurately represents the relationship pattern existing among the variables and the objectives, all within the constraints or assumptions recognized in the solving of the problem. The model must fit the problem, *i.e.*, it must be appropriate. Frequently, mathematical models are used—as exemplified by equations, formulas, charts, and diagrams—but they can also be of other types, such as replicas or miniature facsimilies of the entity itself.

By using models, different alternatives can be tried out and the results noted; or, especially in the case of a mathematical model, the model itself can be manipulated to reveal certain rational outcomes in keeping with the fundamental relationships of the variables included in the model. The mathematical model is an abstract concept. It shows the interrelatedness of quantifiable data. Use of different values for the variables will bring about different results. In brief, the model serves as an effective means toward determining the answers sought to the problem.

Indicate whether each of the following statements is true or false by writing "T" or "F" in the space provided.

______ 1. The main output of any quantitative method is the identification of the relevant variables affecting a manager's decision.

______ 2. Quantitative methods are used to identify objectives.

_____ 3. There is an increasing trend toward the use of quantitative methods by management in decision making.

_____ 4. Mathematical models are characterized by the use of qualitative data.

Refer to Answer Frame 1[5], page 22 to check your answers.

Frame 2[5]

Either optimization or minimization of the results can be calculated by utilizing a mathematical model. To illustrate, assume a model has been created and is $Y=60X-10X^2$, which shows the relationship between the values of Y, the efficiency achieved, and of X, the continuous hours worked. The equation shows that efficiency achieved, Y, is equal to 60 times the number of continuous hours worked, $60X$, less 10 times the continuous hours worked squared, $10X^2$. The efficiency, Y, is dependent upon the number of continuous hours worked, X, in the relationship represented by the equation.

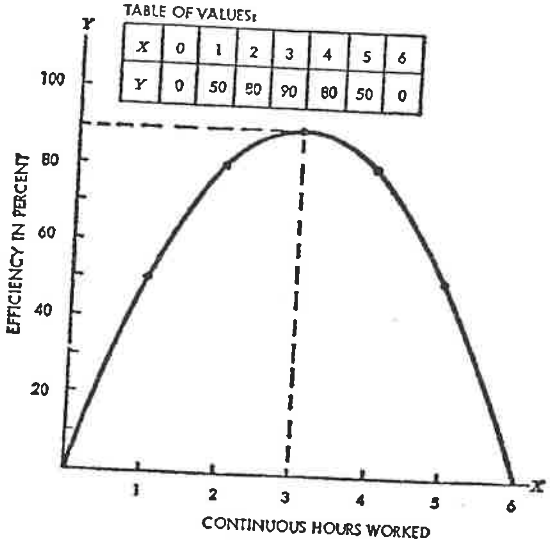
Figure 2 shows the graphic representation of this equation. The chart is constructed by substituting values for X in the equation, starting with the value of zero and calculating the corresponding value of Y. The table of values is included in Figure 2. For example, when $X=2$, $Y=80$ ($Y=60$ times 2 minus 10 times 2 squared, or $Y=120$ minus 40). Plotting the values of the table gives the chart shown. From this chart it can be observed that the greatest, or optimum, efficiency is when $X=3$, at which value the level of efficiency equals 90 percent. The same solution can be achieved quickly and directly from the equation by means of calculus.

FIGURE 2

Graphic Representation of Equation, $Y = 60X - 10X^2$

TABLE OF VALUES:

X	0	1	2	3	4	5	6
Y	0	50	80	90	80	50	0



Observe from either the chart or the table of values that the value of Y with respect to X first increases and then decreases. The optimum point is where the *rate of change* for Y is zero. This zero rate of change is determined by calculus as follows:

The equation:

$$Y = 60X - 10X^2$$

The rate of change of Y with respect to X is:

$$dY/dX = 60 - 20X$$

When rate of change is zero:

$$0 = 60 - 20X$$

Value of X at point of optimization:

$$X = 3$$

The same mathematics is employed for minimization. In this case, the curve would be U-shaped, the minimum value being at the bottom, but the ideal point would still be where the rate of change for Y is zero. Determining the minimum cost, Y, in relation to the number of markets covered, X, would be illustrative of this relationship.

Simulation makes it possible to test various alternatives and combinations of variables to determine what results they would bring about, before actually implementing any of them. "Dry runs" are made to observe the effect that changes in variables have upon the results obtained. Simulation models are commonly empirical models or quantitative representations of the attributes being analyzed. Normally, they are not

Answer frame 1[5]

1. False. The identification of the relevant variables is a key *input* for any quantitative method, whereas the output is a recommended action or decision.
2. False. Objectives are not determined by a quantitative method, but rather are prerequisites for the use of such methods.
3. True. Quantitative methods are being used increasingly in managerial decision making.
4. False. Mathematical models are characterized by the use of *quantitative* data.

Now go to Frame 2[5], page 21.

Frame 2[5] continued

used to calculate optimization or minimization, but serve as a systematic trial-and-error approach to solving complex problems. Use of a model for simulation is not imperative, but it usually makes simulation more feasible. The computer is of great assistance in processing the voluminous amount of data. Distributions, from actual data and that believed logical, are assumed; and then, at random, artificial sequences of events are generated, against which the distributions are evaluated. Many random sequence generations help to disclose the behavior of the phenonenon. Many managers view simulation as a vital decision-making tool of the future. It promises to supply insight into a multicomponent concept of an extensive area.

Indicate whether each of the following statements is true or false by writing "T" or "F" in the space provided.

______ 1. In the example depicted in Figure 2, X (continuous hours worked) is dependent on Y (efficiency percent) for its value.

______ 2. The example in Figure 2 is one in which we are trying to maximize efficiency (Y).

______ 3. Simulation models are used only when the objective is minimization.

______ 4. Simulation models allow one to test the possible outcomes of various alternatives without actually implementing them.

Now refer to Answer Frame 2[5], page 24.

Frame 3[5]

The *Monte Carlo* technique is used in predicting the timing or frequency of events occurring within a specific future period. Monte Carlo is actually a form of simulation using probability factors. It assumes that the particular spacing of events will occur in random fashion. It utilizes random samples of past events to predict future events. Its applications are many. For example, it can be used in determining the optimum manpower level to maintain over a given future period.

Queueing deals with waiting-line situations, such as those involved when several sales representatives must see one buyer of a company. A cost is involved in tolerating waiting lines. The problem is to balance the costs of bottlenecks against the costs of idle capacity. If the number of buyers is insufficient, the cost of waiting is high, whereas having too many buyers results in excessive idle-time cost. In other words, the decision making involves a balancing of expenditures for existing queues with the cost of supplying additional buyers. Monte Carlo technique can be utilized to determine the timing or frequency of arrivals, especially when the queue is not constant. Complex equations and a computer are commonly employed.

Gaming includes the study of situations in which two or more players or competitors seek to maximize gain and minimize loss. Each player is given similar motivation and considers not only his own strategy but also that of his opponents. It is assumed that each player acts rationally. Frequently, to begin the game, each competitor is assumed to possess similar facilities as shown on identical balance sheets which are distributed. The decisions made by each affect his future balance sheets. Utilizing these results, decisions again are made and new results calculated. Typically, each player is given certain selected data concerning the results of his opponent's decisions. Several sequential "rounds of decisions" are made to make up the total game. A winning player or team often is determined at the conclusion of the game.

Linear programming is perhaps the best known of the quantitative decision-making techniques. Linear programming is useful when: (*a*) several variables related to attaining an objective exist; (*b*) the relationship between each variable and the objective is linear (or constant); (*c*) constraints on the overall relationships are present—the objective cannot be attained unencumbered; and (*d*) the problem is to find the best (*e.g.*, least cost) combination of variables that will satisfy the objective. Linear programming often involves arranging the data in a matrix or row-column form, but graphic and algebraic methods also can be used in solving the problems. Intensive application of linear programming is found in problems of production, inventory, and transportation. Figure 3 shows, in matrix form, the data of a problem in which

FIGURE 3
Linear Programming Data in Matrix Format

WAREHOUSES → / FACTORIES ↓	A	B	C	
1	8	(100) 4	7	100 UNITS
2	(100) 5	(300) 6	7	400 UNITS
3	(100) 3	5	(100) 4	200 UNITS
	200 UNITS	400 UNITS	100 UNITS	700 UNITS

three factories, 1, 2, and 3, ship to three warehouses, *A*, *B*, and *C*, the unit cost of transportation indicated by the figure in the lower right of the appropriate square. Cost from factory 1 to warehouse *A* is $8, from factory 3 to warehouse *B* is $5, and so on. Total respective capacities of factories are indicated in the last column to the right, 100–400–200, capacities of warehouses on the bottom line or row, 200–400–100. The problem is to determine the amount each factory should ship to each warehouse to obtain *total* minimum transportation costs. The answer is shown by the circled numbers, the total costs for which are $3,400. The answer is obtained by any one of several methods. One is to start at the "northwest corner" and fill in the cells, working across and down. This distribution is then improved by evaluating each blank cell to determine if cost reduction would result by assigning an entry in any one of them. Another method is VAM (Vogel Approximation Method), which is less time consuming and simple to apply. You should consult a text for fuller explanations of these methods.

Indicate whether each of the following statements is true or false by writing "T" or "F" in the space provided.

______ 1. *Monte Carlo* analysis utilizes the results of a random sample of historical data to predict future events.

______ 2. *Queueing* is the most elementary of all analytical techniques.

______ 3. *Gaming* involves decision making under certainty.

______ 4. *Linear programming* can only be applied to situations that are free from constraints.

Turn to Answer Frame 3[5], page 24, to check your answers.

Answer frame 2[5]

1. False. In Figure 2, Y (efficiency percent) is the dependent variable and X (continuous hours worked) is the independent variable.
2. True. The example in Figure 2 *is* one in which we are trying to maximize efficiency (Y). The maximization point (of 90 percent efficiency) occurs when the value for continuous hours worked is three hours.
3. False. Simulation models normally are not used for optimization or minimization problems, but rather serve as a systematic trial-and-error approach to solving complex problems.
4. True. Simulation models *are* used to predict the results of choosing various alternatives before implementation of any of them.

Now continue with Frame 3[5], page 22.

Answer frame 3[5]

1. True. *Monte Carlo* analysis *does* utilize random samples of past occurrences to predict future events.
2. False. *Queueing* typically involves complex equations, and a computer usually is needed for the solution of these problems.
3. False. *Gaming* involves decision making under *uncertainty*. Each player is unaware of his competitors' decisions in the current round of decisions.
4. False. *Linear programming* is useful when there *are* constraints on the overall relationship, *i.e.*, the objective cannot be attained unencumbered.

You have completed Chapter 5. Now proceed to Chapter 6, page 25.

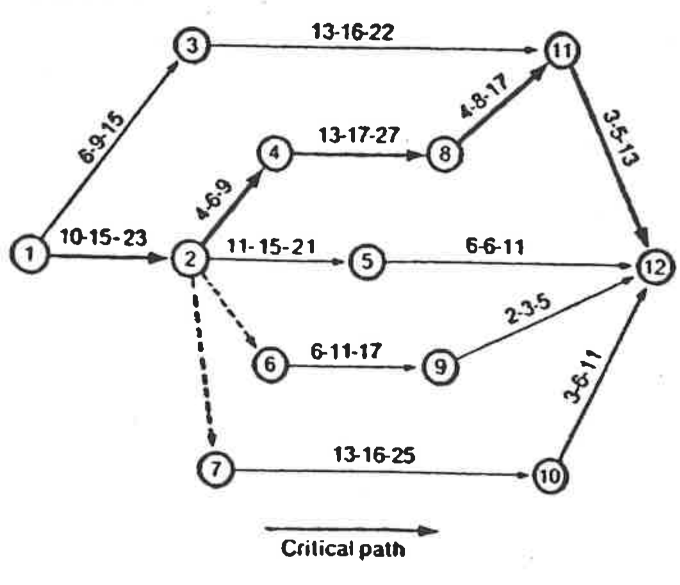
PERT

Program evaluation and review technique, PERT, is performed on a set of time-related activities and events which must be accomplished to reach an objective. The evaluation gives the expected completed time and the probability of completing the total work within that time. By means of PERT, it is possible not only to know the exact schedule but also to control the various activities on a daily basis. PERT is more practical for jobs involving a one-time project than for repeat jobs. It is a planning-controlling medium designed to (*a*) focus attention on key components, (*b*) reveal potential problem areas, (*c*) provide prompt reporting on accomplishments, and (*d*) facilitate decision making.

The time-related activities and events are set forth by means of a PERT network (see Figure B–1).

In this illustration, the circles represent events that are sequential accomplishment points; the arrows represent activities or the time-consuming elements of the program. The dashed lines represent "dummy" activities which are used to represent activity dependencies. Dummy activities do not consume any time or resources. In this type of network, an arrow always connects two activities. All of the activities and events must be accomplished before the end objective can be attained.

FIGURE B–1



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