A Study of the Contribution of Mathematical Models to Marketing Management*

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Marketing management philosoplies has been changing fron production concept, selling concept, marketing concept to societal marketing concept.[1] In order to generate customer satisfaction and long-run consumer and societal well being as the key to satisfying organizational goals and responsibilities, the top management has to be interdisplinary to get information for scientific decision marking from many interelated disciplnes.

The top management needs to study managerial economics about risk analysis, optimizing techniques and techniques of demand estimation; sociology about subcultures, demography, social class and occupation, anthropology about relations among minority groups,behaviour in extreme situations and reactions to disaster, psycology about life style, motivation, consumer behaviour and personality, international politics,inernational eonomics, even applied ethics to analyze morally difficult situations in marketing.

The management also need to know several foreign languages for effective marketing activities, nationally or internationally. The mangemant needs to know another language-mathematics which is helpful in marketing management. Mathematics can be viewed as a language that is particularly useful in formulating certain types of problems, because it focuses on only the essential factors and their logical relationships. Thus, it is a language that makes it easier for a person to see the implications of certain kinds of actions. Is mastery of calculus, matrix algebra,probability theory, and topology becoming a management prerequisite? Definiitely no. Must the top executives of tomorrow be better skilled in fundamental operations like calculating percentages and workiing out equations? Not necessarily. Will more understanding of the mathematical approach to problems be useful to the man who makes important business decisions? Unqualifiedly yes.[2]

* This paper was financed by a grant from the Korea Ministry of Education in 1984

1) Philip Kotler; *Marketing Management* Prentice-Hall, Inc, 1980. pp. 26-36

2) R.K. Gaumnitz. O.H. Brownless; "*Mathematices for Decision Makers*". HBR May-Junm 1956, p.108

As Alexander Henderson and Robert Schlaifer pointed out, mathematicians have woreked out a number of new procedures which make it possible for management to solve a wide variety of important company problems much faster,more easily, and more accurately than ever before.[3] The recent marketing environment surrounding us become more dynamic, complex and competitive, nationally and internationally. Korean companies can't survive longer with traditional intuitive marketing analysis. It is desirable for them to examine problems quatitatively. Altough techniques of quantitative analysis and the scientific method are paramount in decision making, many top management are not familiar with mathematical concepts and experience language fifficulties.

However, it is not impossible for them to overcome language difficunlties.

Thus the purposes of this paper are 1)to solve the problems of mathematical difficulties by application of its central ideas to managerial problems. 2) analyze benefits from using mathematical marketing models 3) outline typical problems involved in implementation and 4) to make a firm's final maketing plans reflect the dynamics of a going concern operating in a market system.

I . Marketing Managerment and Decision Marking

According to Kotler, marketing management is the analysis, planning, implementntion,and control of progams designed to create, build, and maintain mutually beneficial exchanges and relationship with target markets for the purpose of achieving organizational needs, wants, perceptions, and preferences of target and intermediary markets as the basis for effective product design, pricing, communication, and distribution.

Marketing management is a dynamic system which involves constantly changing environments, technologies, and philosophies. Thus the basic function of maketing management has become management of disturbance problem solving or decision making. An integral element of the managerial task is organizational decision making–choosing an overall strategy, setting specific objectives,designing structures and processes, selecting people, delegating responsibility, evaluating results, and initiating changes.[4]

All managerial activity might be considered decision making. For example, Simon states, 'What part does decision making play in managing? I shall find it conveniient to take mild liberties with the English language by using 'decison making' as though it were synonymous with 'managing'.' If all behaviour results from decision making and if managing is a particular kind of behaviour, then managing is decision making. Obviously, there are other useful ways to view management–concentration on processes or function, for example. But decision making is one of the most important tasks of managers. It pervades the performance of all managerial functions.[5] In order to improve the quality of decision making, organizations and managers constantly seek ways to be more rational, systematic and scientific in making decisions.
As Table 1 shows,

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3) Alexander Herderson and Robert Schlaifer; *Mathematical Programing, Better Information for Better Decision Making*, May–Jun 1954. p. 73

4) Fremont E. Rosenzweig; *Organization and Management*. McGraw–Hill, Inc. 1979, p. 34

5) Martin K. Starr; *Management : A Modern Approach*; Harcourt Brace Jovanovich,Inc. New York, 1971, p. viii

Lee, professor at University of Nevraska, discusses the scientific method, management decision making and the concept of economic person as a hypothesis for rational decision making.[6] But Simon has suggested a "satisficing man, "to replace economic man. "Satisficing man is at home in a bureaucracy. Such a man is more concerned with checking to see if a program is feasible and yields "enough" rather than to see if it is maximal.[7]

Table 1. Steps in the Scientific Method and their Equivalents in Management Decision Making.

The Scientific Method	Management Decision Making
1. Define the problem	1. Define the decision problem
2. Collect data	2. Search for data and information
3. Develop hypotheses	3. Generate alternative courses of action
4. Test hypotheses	4. Analyze feasible alternatives
5. Analyze results	5. Select the best course of action
6. Draw conclusion	6. Implement the decision and evaluate results

Evironmental suprasystem surrounding a firm consists of goals and values subsystem, technical subsystem, psychosocial subsystem, technical subsystem, structural subsystem, and managerial subsytem.[8]

The systems approach facilitates analysis and synthesis in a complex and dynamic markething environment. It considers interrelationships among subystem as well as interactions between the system and its suprasystem and also provides a mean of systematic aspects.

To develop optimum solutions to managerial problems, it is necessary to view the organiization in as large a context as possible, in solving a marketing problem, for example, one needs to consider organizational entities, while simultaneously weighing the relative influence of competitors, the government, suppliers, and other elements of the system.

The idea of studying as large a system as is feasible has led to a quiet revolution in problem solving. The systems approach, or way of viewing problems, has resulted in an understanding that no single individual is ever fully qualified to formuate and solve a decision problem. All of the disciplines which utilize the scientific method have developed techniques and ways of formulating problems which can prove useful in entirely different environments; e.g., the ideas of fluid mechanics or electrical flow may prove useful in analyzing the flow of products through a distribution system. As a result of the recognition that no specialist has a monopoly on problem-solving ability, the analysis of business decision problems has more and more become the province of teams composed of individuals with varied backgrounds. These individuals bring the point of view of their experience to bear on the problem, often with results which are significantly superior to those a single individual might be expected to produce. In additioin, the nature of managerial decision problems implies systems which have psychological, sociological, and physical aspects.

King pointed out that the blocks in Figure 1 which appears to represent the places of three

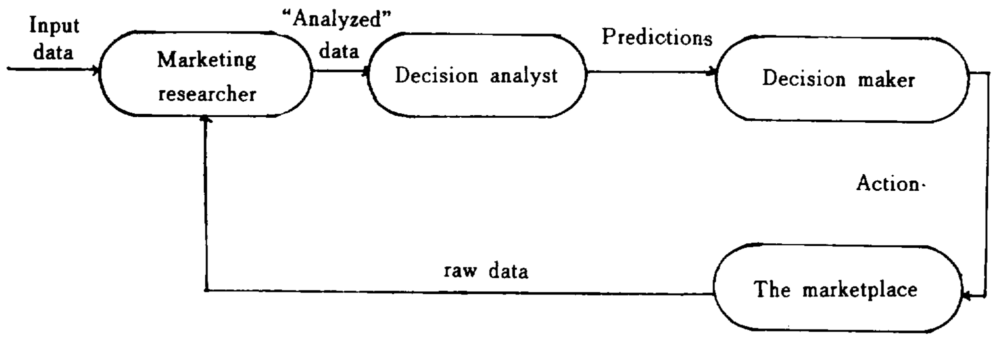
6) Sang M. Lee; *Introduction to Management Science.* CBS Cdlege Publishing, 1983.p.5

7) Hibert A. Simon; *The New Science of Management Decision.* Harper and Row, publisher,Inc. 1971,p.1

8) Same reference as footnote 4, at p.19

different people in the decision making process actually represent functions which may be performed by one or more individuals.[9]

Figure 1. Marketing Amalysis in the Decision Making Process



To apply scientific methods to the analysis of dicision problems, one must be "quantitativeyl" oriented, for one of the primary characteristics of scientific inquiry is the process of quantitative measurement. The marketing manaer has for a long time had guantitatively oriented taff specialists to call sfor aid. These "marketing researchers" have been concerned largely with the collection and analysis of marketing data rather than the analysis of problems. In analyzing data, the marketing researcher has been quantitative in the sense that he works with numbers, but the term "quantitative analysis" has come to mean something for more than a reliance on numbers. Today the term relates to a body of scientific metholodogy which draws on numerical data but is oriented toward problem solving rather than information analysis.

In this simple feedback loop the decision maker calls on the decision analyst for predictions or recommendations concerning the potential results of his alternative actions., In turn the decision analyst must use data which have been complied and evaluated by the traditional marketing researcher from the raw data supplied in the marketplace. The decision maker then takes some action and some results are observed. At this point the process begins again: the results are evaluated and compared with the prediction, better predictions and recommendations are developed, and the decision maker is given new inputs on which to base subsequent actions. As I have previously noted, the role of decision maker is still of paramount importance. The predictions or recommdations which serve as an input to the decision maker must be complemented by his judgement and intuition.

Ⅱ. Model and Model Classification

What is model? A model is a representation of the most important elements of a perceived real world system.[10] Models as representations of the most imjportant elements of a system are not

9) William R. King; *Quantitative Analysis for Marketing Mangement*, 1967. McGraw-Hill, p.9

10) Philippe A.Naert, Peter S.H. Leefling; *Building Implementable Marketing Models*, 1978, Martinus Nijhoff Social Sciences Division, p.9.

restricted to managment science, but are found in all sciences. Thus Tinbergen distinguished physical, psychological, sociological and economic models.[11] In marketing, a model involves translating perceived marketing relationships into constructs, symbols, and perhaps mathematical terms.

There are many defferent model classications. By Leeflang and Naert, models are classified according to their degree of explictiness;

1. Implicit Models
2. Verbal Models
3. Formatized Models
   i) a logical flow model
   ii) a formalized mathematical model
4. Numberically Specified Models[12]

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Lazer classifies dynamic models and static models, taking into consideration changes in factors through time.[14] We might classify deterministic, stochastic models, and micro, macro models as well as linear or nonlinear models.

Models are classified into descriptive and predictive model by Zoltners. Descriptive models attemjpt to provide detailed and accurate representations of the marketing phenomenon under investigantion. Models have been developed to describe consumer and industrial and industrial buyer behaviour, distributor. Predictive models, on the other hand, are concerned with forecasting outcomes of specific marketing decisions, plans, and events. They are used to estimate product class sales, brand sales, and market shares for new and establish products. Models can be both descriptive and predictive.[15].

Lee presents the classifications of models based on the degree of abstration,[16] and Turban and Meredith classified by solution technique in Figure 2 and Figure 3.

11) Tinbergen, J.; *Economic Policy: Principles and Design*, Amsterdam, North–Holland Publishing Company. p.6.

12) same reference as footnote 10, pp.11–20

13) Willim Lazer; *The Role of Models in Marketing*, Journal of Marketing April, 1962, p.10.

14) Same reference as footnote 13

15) Randall L.Schultz, Andris A. Zoltners, *Marketing Decision Models* 1981, Elsevier Science Publishing Co. Inc. p. 57.

16) same reference as footnote 6, at pp. 20–21.

17) Efraim Turban and Jack R. Meredith; *Fundamentals of Management Science*, Business Publications, Inc. Plano, Texas, 1981, pp. 34–35.

Figure 2. Model Classification

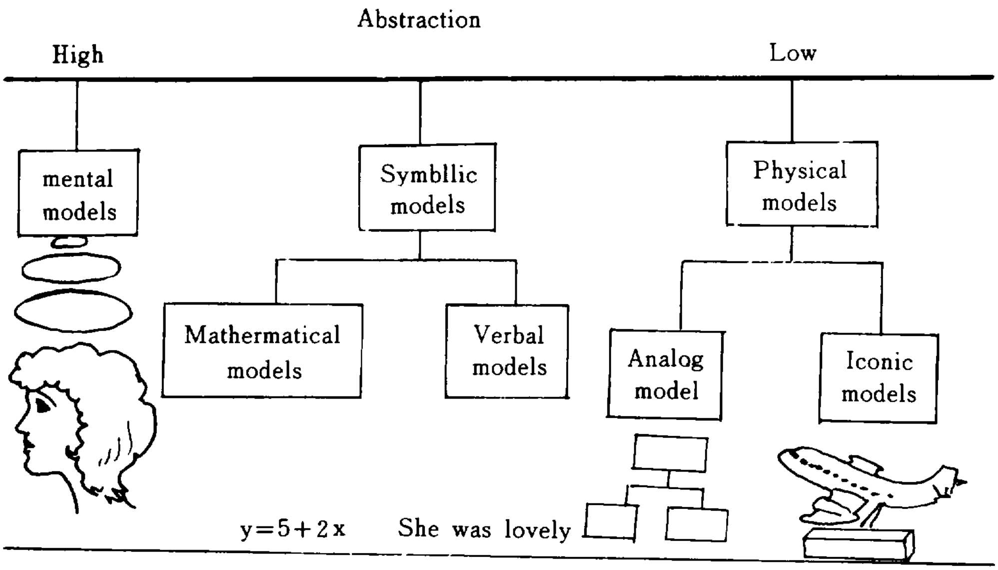
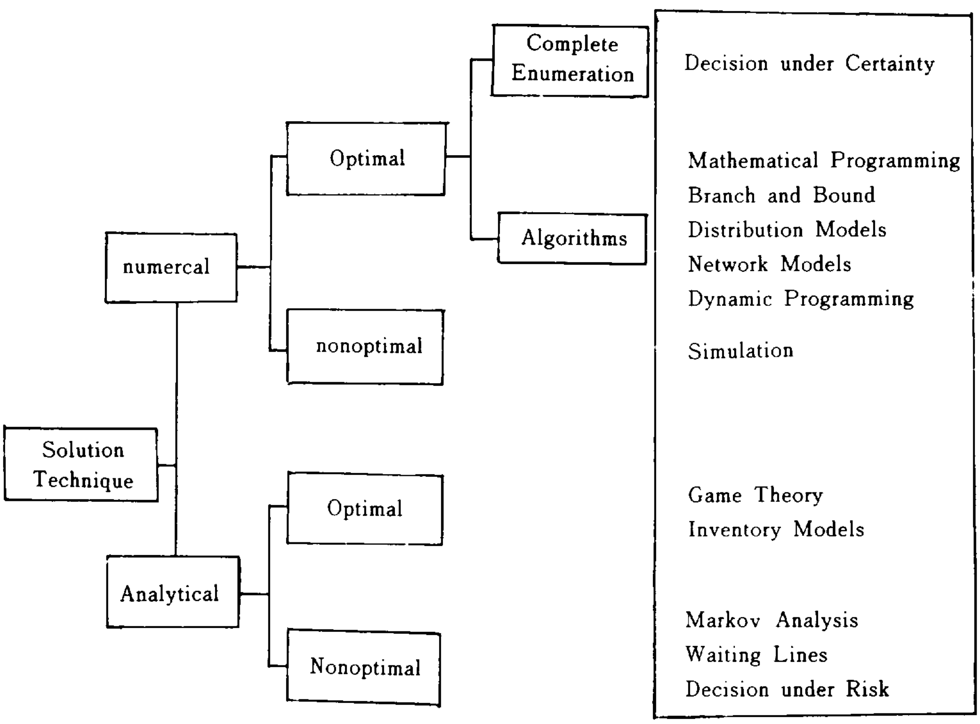


Figure 3. Model chassification by sloution technique



1. Mental Models.
   Mental models are the most abstract representation of reality such as imagination, as we discussed previously.
2. Verbal Models.
   Verbal models represent written versions of mental models such as poetry, plays, novels. theories, and a policeman's report of a traffic accident.
3. Mathematical Models.
   Mathematical models are also symbolic models but they consist of mathematical relationships rather than words. Most management science models we will be studying in this book are mathematical models.
4. Analog Models.
   Analog models are also physical models that may or may not look like the reality under study but they also perform some basic function. Maps, blueprints, and oranizational charts are good examples of anaog models.
5. Iconic Models.
   Iconic models are physical replicas of a reality, usually smaller or bigger in scale than the actual object. Many three-dimensional models such as model airplanes, buildings, and Raggedy Anns or two-dimensional paintings and photographs are good examples of iconic models.

Classifying marketing models into system models and goal models, Lazer noted that models and system have relevance to such significant marketing problems as: 1) developing marketing concepts and enriching the marketing language by introducing terms that reflect an operational viewpoint and orientation; 2) providing new methods and perspectives for problem-solving; 3) conducting marketing research and designing experiments; 4) developing marketing theories; 5) measuring the effectiveness of marketing program.[18]

Ⅲ. The Model Components and Structure[19])

The components of mathematical models

All mathematical models are comprised of three components: result variables, decision variables, and uncontrollabe variables. These components are connected by mathematical (logical) relationships, as shown in Figure. 4.

The result variables: These reflect the level of effectiveness of the system. That is, they tell how well the system performs or attains its goals. Some of the more common result variable which are used in organizations to measure effectiveness are shown in Table 2. The result variables are dependent variables. They also have other names which are often used in management science:

18) Same reference as footnote 13, at p.9.
19) Same reference footnote 17, at pp. 21–24.

Figure 4. The general structure of a model

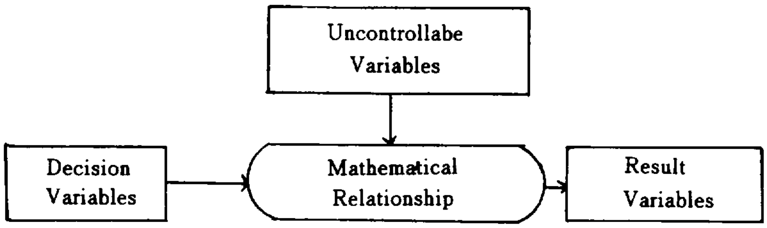


Table 2. Examples of the components of models

Area	Decision variables	Result variables	Uncontrollable variables
Financial investment	Investment amounts Period of investment Timing of investment	Total profit Rate of return Earnings/share Liquidity	Inflation rate Prime rate Competition
Markting	Advertising budget Number of models	Market share Customer satisfaction	Disposable income Competitor's acticns
Accounting	Audit schedule Use of computers Depreciation schedule	Data processing cost Error rate	Legal requirements Tax rates Computer technology
Transportation	Shipments	Total transport cost	Delivery distance regulations
Services	Number of servers	Customer satisfaction	Demand for service

- Measures of performance.
- Measures of effectiveness.
- Payoffs.
- Outcomes.

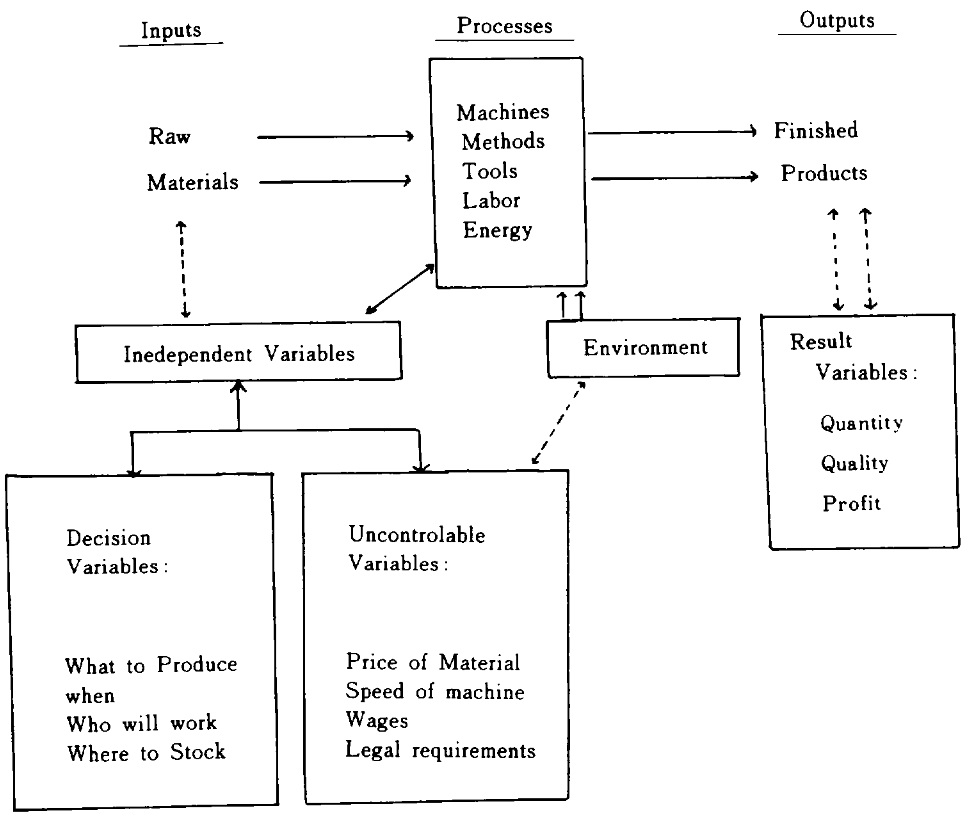
The decision variables : The decision variables are those factors where a choice must be made. These variables are manipulable and controllable by the decision maker. Examples are the quantities of products to produce, the number of units to be ordered, and the number of tellers to use in a band (others are shown in Table 2). Decision variables are classified mathematically as independent variables or unknown variables. They are denoted by the letters x_1, x_2, and so on, or by x, y, z. The aim of management science is to find the best values of these decision variables.

The uncontrollable variables:In any decision situation there are factors which affect the result variables but which are not under the control of the decision maker. Examples are the prime interest rate, building codes, tax regulations, and prices of supplies (others are shown in table 2). Most of these factors are uncontrollable because they manate from the environment surrounding the decision maker. These variable are also independent variables since they affect the dependent result variables.

The structure of mathematical models

The components of a mathemtical model are expressed as variables. These are then tied together by sets of mathematical expressions such as equations or inequalities, thereby forming a system. Figure 5 is an example of such a model of a manufacturing system. In management science, however, the arrows in the picture are replaced by mathemtical expressions.

Figure 5. A manufacturing systems model



The mathematical relationships in the model

The mathematical relationships in a management science model may include to major parts: the objective function and the constraints.

The objective function The objective function expresses the deoendent variables in the model as they relate to the independent variables. For example, an objective function may look like:

$$R = P_1X_1 + P_2X_2$$

Where R symbolizes the total revenue to a manufacturer (dependent variable); X_1 and X_2 are the quantities of the two products that are sold (uncontrollable variables): and P_1 and P_2 are the prices set by the company (decision variables).The objective, or goal, is to maximize the revenue. Such an objective is usually limited by constraints.

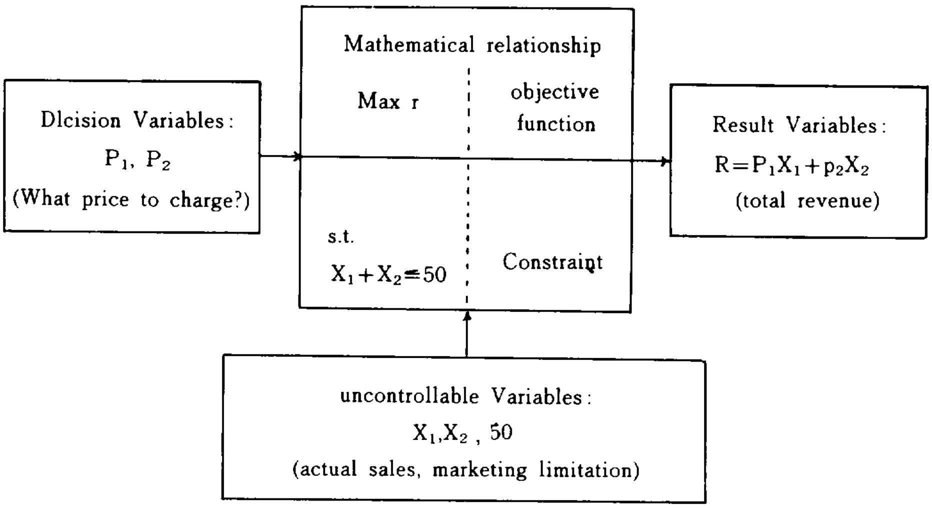
The constraints The constraints express the limitations imposed on managerial systems due to regulation, competition, scarcity of resources, technology, or other uncontrollable variables. For example, a marketing constraint might be represented by:

$$X_1 + X_2 \leqq 50$$

That is, the total quantity of the two products that can be sold is 50 or less.

Figure 6. illustrates this manufactuer's model The model can be interpreted as: Find the value

Figure 6. A model of a manufacturing situation



of the decision variables P_1 and P_2 such that the total revenue r (result variable) is maximized, subject to the marketing limitation and the level of sales, which are uncontrollable by the manufacturer.

Ⅳ. Model building and Use of Models in Marketing

Experience in model building among econometricians, management scientists and operations researchers has led to the recognition of a sequence of steps involved in the development of mathematical models. Different scholars have proposed different sequences of stages to be con sidered in the model building process.

Litlle, J.D.C. identified six model design criteria that have since been translated into a four-step procedure for the developments and implementation of marketing decision models.[20]

20) Dipankar Chakravarti, Andrew Mitchell, Staelin; *Judgement Based Marketing Decision Models: Problems and Possible Solutions.* Journal of Marketing Vol 45, (Fall 1981) p. 13–23.

First step: The manager verbalizes his implicit model of the situation to be analyzed, specity-ing the variable as well as the general relationships between these variables.

Second step: The model builder translates this verbal description into a formal mathematical model.

Third step: Estimation of the parameters of the model

Fourth step: An interactive computer program is developed to enable the manager to examine alternative decisions.

Wind presents an illustrative marketing planning model based on seven interrelated phases:[21]

1. determination of corporate mission, objectives, resources, and costraints.
2. monitoring of the current and anticipated(domestic and multinational) environment.
3. situation analysis.
4. market/product portfolio analysis and decisions.
5. gerneration of alternative marketing programs.
6. evaluation of alternative programs and selection of the best ones
7. organization for marketing action, implementation and control.

Rapoport and Drews showed how a mathematical model is actually formulated by:[22]

1. Introducing and definig the pertinent variables.
2. Reviewing the relationships employed to describe the activities and the consraints of the business system.
3. Examining how these relations are expanded to reflect the changes in operating conditions and facilities as the sytem evolves through time
4. discussing how the economic aspects or objectives of the business can be expressed in mathematical form.

One of the notable new directions of marketing management has been the utilization of mathematical models in the solution of marketing problems. Then, what kind of characteristics the model should have?

Little stated that a model should be

1. simple
2. robust
3. easy to control
4. adaptive
5. complete on important issues
6. easy to communicate with[23]

However, Little's statement has potential limitations. For example, making a model robust frequently means that information beyond the normal operating range of the firm is required to estimate some of the parameter values. Also, the completeness criterion frequently causes the models to be overparameterized (i.e., the models have a large number of parameters relative to the amount of data available). Although Simon has suggested that in order to make a complex

21) Same reference as footnote 15 at pp. 213–223.

22) Leo A. rapoport and William P. Drews; *Mathematical Approach to Long—Range Planning* in HBR, May—June 1962. pp. 75–87.

23) Little, J. D. C; Models and Managers: *The Concept of a Decision Calculus*. Management Science, Vol 16. pp. 13–485.

situation more manageable incividuals tend to construct simplified models[24], consequently, marketing model may be overly simple and, thus, incorrectly specified. The real challenge of modelling is to build as simple a model as possible by including only pertinent attributes of the system.

Lazer suggested five magor uses for models in marketing in his paper.[25]

1. Marketing models provide a frame of reference for solving maketing problems.
2. Marketing models may play an explicative role, and as such they are suggestive and flexible.
3. Marketing models are useful aids in making predictions.
4. Marketing models can be useful in theory construction.
5. Marketing models may stimulate the generation of hypothese which can then be verified and tested. Thereby, it furthers the application of the scientific method in marketing research and the extension of marketing knowledge.

Descrbing the marketing techniques and its application to marketing problems.

Dash and Berenson pointed out that two key questions management should consider in managing marketing research are:

1. Is traditional marketing research losing its relevance for the new complex processes of management decision making?
2. Have the changes in marketing research skills kept pace with the top management isolates, analyzes, and solves its problems?[26]

And they also presented marketing technignes and its application in Table 3.[27]

24) Simon, M. (1957); *Models of Man*, New York: Wiley

25) Same reference as footnote 13

26) Joseph F. Dash Concrad Berenson, *Techniques in Marketing Research* Harvard Business Review Sep–Oct, 1969. p. 1.

27) Joseph F. Dash and Conrad Berenson; *Techniques in Marketing research*, HBR, Sep–Oct 1969. pp. 1–7.

·Table3. Marketing techniques and applications

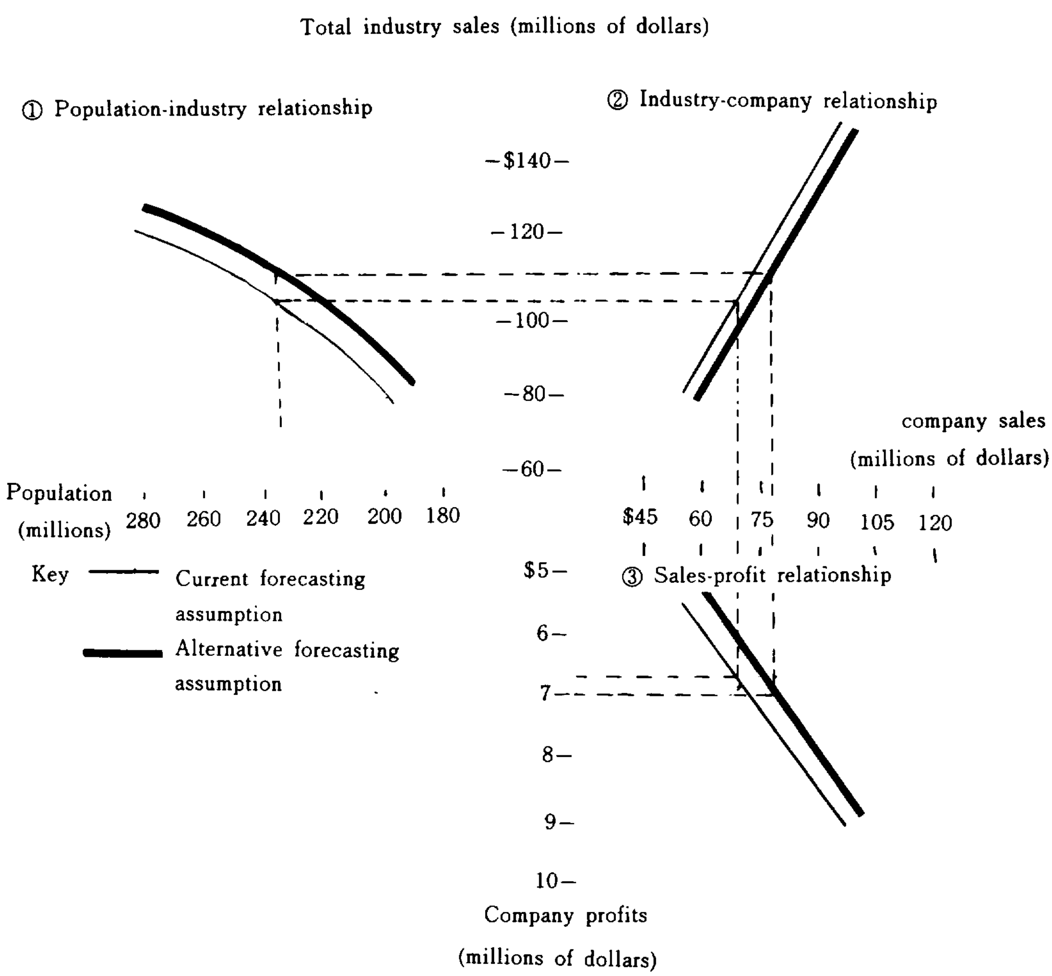
	Advertising research	Acquisition screening	Brand strategy	Customer segmentation	Customer service	Distribution planning	Market segmentation	Pricing strategy	Product life-cycle analysis	Product-line analysis	Product planning	R&D planning	ROI analysis	Sales forecasting	Test marketing	Venture planning
Mature techniques																
Regression & correlation analysis	X		X				X	X						X		
Discounted cash flow (DCF)						X				X		X	X			
Incremental analysis	X					X		X				X				
Multiple regression/ multiple correlation	X		X											X		
Random sampling																
Sampling theory	X		X											X	X	
Modern techniques																
Bayesian approach	X							X	X		X		X			
Cost-benefit analysis	X												X			
Critical path method (CPM)										X	X	X			X	X
Decision trees	X	X						X		X						
Dynamic programming	X											X	X			X
Exponential smoothing														X		
Industrial dynamics						X		X								
Input-output analysis										X	X	X		X		X
Linear programming	X					X										
Markov processes			X	X												
Monte Carlo simulation		X	X			X				X						X
Nonlinear programming	X					X										
Numerical taxonomy	X		X	X			X									
PERT										X	X	X			X	X
Queueing models					X	X										
Risk analysis	X	X						X		X						
Sensitivity analysis	X	X						X		X						
Technological forecasting							X		X	X	X	X		X		X

V. Practical Application of Mathematical Model

Kotler analyzed the various functional relationships which should be put together into a model for analzing the sales and profit consequences of a proposed marketing plan by graphical method for a candy company.[28)]

The graphical-analytical device is shown in Figure 7.

Figure 7. Profit—Forecasting and Planning Model:



28) Philip Kotler; *Corporate Models: Better Marketing Plans.* Harvard Business Review July–August 1970 pp. 93–109.

Quadrant 1 shows a relationship between population and the total sales of chocolate–covered, soft–centered candy bars. The functional relationship shows that sales tend to increase with population, but at a decreasing rate.

Quadrant 2 shows a relationship between total sales of soft–centered candy bars and company sales.

Quadrant 3 shows the relationship between company sales and company profits. The candy company assumes that the relationship is basically linear.

This kind of graphical device, which assumes that all the underlying relationships have been combined and expressed in terms of three basic relationships, allow us to visualize the effect of a particular level of an environmental factor and continued marketing program on company sales and profits. To this extent it is a forecasting device.

Its use extends beyond this however, into marketing planning as well. Suppose, for example, that the company expects the new antismoking campaign to have a big impact on candy bar sales, shifting the curve in Quadrant 1 higher. If the company is considering intersifying its marketing effort to increase its market share even further. The anticipated effect of this on company market share can be seen by shifting the function in Quadrant 2 to the right. At the same time, the company's marketing costs increase, and that shifts the sales–profit curve to the right, as shown in Quadrant 3.

What is the net effect of this complicated set of shifts? Altough sales have increased, profits have fallen. The cost to the company of attaining a still higher market share exceeds the profits on the extra sales. The company would be wise not to intensify its marketing effort, at least according to the specific plan it is considering and its estimated effects.

The four–quadrant profit–forecasting and planning model helps one to visualize the impact of a complex set to developments on final company sales and profits However, it is quite limited with respect to the number of factors that can be handled directly Kotler formulated a mathematical models for the company's marketing system.

Mathematical sales and profit model

#1 Company i's profit equation

$Z_{i,t}=(P_{i,t}-C_{i,t})\ Q_{i,t}-F_{i,t}-A_{i,t}-D_{i,t}$

#2 Company i's sales equation

${}_{i,t}=S_{i,t}Q_t$

#3 Industry sales equatin

$Qt=m_tK_tN_t$, where…

m_t=parameter

$K_t=24\ (I-.25^t)$

$N_t=200\ (I.\ 03)$

#4 market share equation

$$S_{i,t}=\frac{R_{i,t}^{eR,i}P_{i,t}^{-P,i}(a_{i,t}A_{i,t})^{eA,i}(d_{i,t}D_{i,t})^{eD,i}}{\Sigma\,[R_{i,t}^{eR}P_{i,t}^{-Pi}(a_{i,t}A_{i,t})^{eAi}(d_{i,t}D_{i,t})^{D,i}]}$$

$Z_{i,t}$=Profits in dollars of Company i in year t

$P_{i,t}$=Average Price per lb. of Company i's product in year t

$c_{i,t}$=Variable cost per lb. of Company i's product in year t

$F_{i,t}$=Fixed costs of manufacturing and selling for Company i's product in year t.

$A_{i,t}$=Advertising and promotion costs for Company i's product in year t

$D_{i,t}$=Distribution and sales force costs for Company i's product in year t

$s_{i,t}$=Company i's average maket share in year t

Q_t=Industry sales of soft-centered candy bars in year it

m_t=Soft-centerd candy bar poundage as a share of total candy poundage

k_t=Per-capita candy consumption in lbs. in year t

N_t=Millions of persons in U. S. A. in year t

$R_{i,t}$=Preference rating of company i's product in year t

$a_{i,t}$=Advertising effectiveness index

$d_{i,t}$=Distribution effectiveness index

$e_{R,i}$=Elasticities of preference, price, advertising, and distibution, respectively, of company i

$e_{P,i}$

$e_{A,i}$

$e_{D,i}$

$Q_{i,t}$=number of lbs. sold of Company i's product in year t

New product models

Assmus formulated the new product models designed to aid the marketing manager in estimating sales and/or market share for a new product before it is introduced into market.[29]

$S_t=S_{Ft}N_{Ft}+S_{Rt}N_{Rt}$,

S_t=is total sales in period t,

s_{Ft}=is the average purchase volume per period per first-time buyer.

N_{Ft}=is the number of first-time buyer in period t,

s_{Rt}=is the average purchase volume per period per repeat buyer, and

N_{Rt}=is the number of repeat buyers in period t.

$N_{Ft}=f_t$, B,

where

f_t=is the proportion of all buyers in the target population who are trying the new product for the first time in period t, that is, the trial rate,

B=is the number of potential buyers in the target group.

$N_{Rt}=r_tF_tB$

where r is the repeat purchase rate in period t

29) Same reference as footnote 15, at pp. 126–143.

$F_t = \Sigma f$ is the cumulative trial rate.

S=TRIB
Where
S=is the ultimate sales level
T=is the ultimate cumulative trial rate for the new product
R=is the ultimate repeat purchase rate
I=is the average purchase quantity
B=is the member of potential buyers.

Prediction of Brand Choice

Luce showed a stochastic choice model on the basis of psychological choice axioms.[30)]

$P_{ij}=V_{ij}/ \Sigma V_{ij}, v_{ij} > k=1. \cdots\cdots j \cdots\cdots m.$

Where
P_{ij}=is the probabillity that buyer i will choose product j.
V_{ij}=is buyer i's ratio scaled preference for kproduct j,
m_i=is the number of kproducts in respondent i's relevant set of alternatives
Pessemier et al. modified theis functional form, introducting and exponent:

$P_{ij}=(V_{ij})^{\beta}/ \Sigma (V_{ik})^{\beta}$

A characteristic valueof β is expected to be associated with each product class, and it reflects how the intervening forces interact to transform prefer ences into perdicted market share.[31)]

Promotional Effects

Lilien used the linear learning model to evaluate the effect of price on the probability of buying,
His model is

$P_{t+1}=(1-C)(\alpha+\beta X_t+\lambda P_t) + C\phi(\delta_{t+1})$

Where

$X=\begin{cases} 0 & \text{not buying brand} \\ 1 & \text{buying brand,} \end{cases}$
$P_t=P_r(X_t=1),$

30) Luce, R. Duncan; *Industrial Choice Behaviour*, New York: Wiley 1959.
31) Pessemier, Edgar A, Burger, Philip, Teach, Richard and Tigert, *"Using Laboratory Preference Scales to Predict Consumer Brand Preferences"*, Management Science 20, 1027-1036 (1974).

where

C is the price consciousness of the customer, ϕ_t the measure of price and δ (ϕ_t) the value of the price response function with range (0, 1)

The larger C is, the greater the price effect.[32)]

This model implies positive feedback from a purchase event assuming that $\beta > 0$.

Sales response function

A simple example is the case of a monoplist that deals directly with its customers. Suppose that the monopolist wants to achieve maximum profits (PFT). In addition, assume that the monopolist can control the price p, can set the advertising expenditures a, and would experience the same variable cost per unit c, irrespective of the volume sold for its product. Then the problem is

with max $PFT=(p-c)\ q-a$

$$q=f\ (p,\ a)$$

The market mechanism in this case consists simply of a sales response functin. The sales response function expresses unit sales q as a function f of the marketing instruments and any other factors that might affect sales.

The monopolist might find that its market is influenced by autonomous environmental conditions such as personal income per capita y and the prime rate of interest i. The sales response function can be written.

$$q=f\ (p,\ a\ ;\ y,\ i)$$

Shape of the sales response functin.

Concave functions

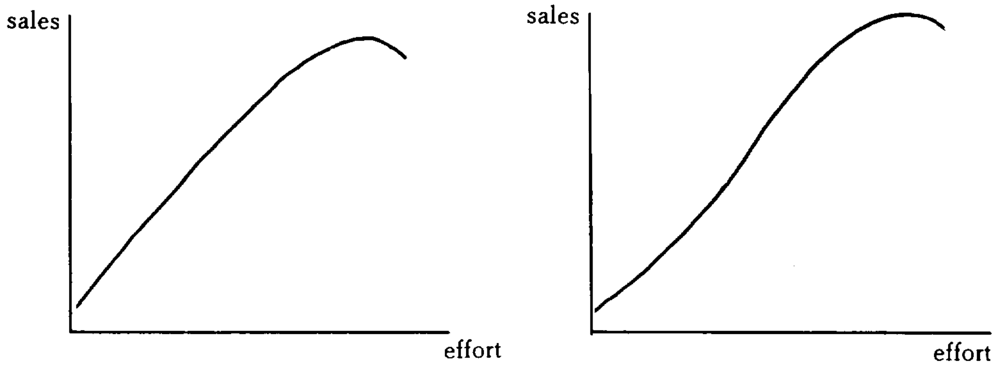
The preponderence of empirical evidence favors the strictly concave case. This is especially true for mass media advertising offrequently purchased goods. For instance Lambin, after doing an analysis of 107 individual brands from 16 product classes and 8 different countries of Western Europe, concluded "evidence that the shape of the advertising response curve is concave downward, i. e., that there is no S–curve and no increasing returns in advertising a given brand by a given firm."[33)] Simon had surveyed and found that both sales and psychological suggest that the shape of the advertising-response function is invariably concave downward, i.e., that there is no S–curve"[34)]

32) Lilien, G. L.; "*A Modified Linear Learning Model of Buyer Behaviour*" Management Science 20, 1027–1036 (1974).

33) Lambin, Jean–Jacques; *Advertising, Competition, and Market Conduct in Oligopoly over Time.* Amsterdam: North–holland, 1976, p. 95.

34) Simon, Julian L; *Issues in the Economics of Advertising.* Urbana: University of Illinoes Press, 1970, p. 8–22.

Figure 8. Concave and S—shaped functins



S- shaped functins.

An S—shaped sales response to advertising has long been conjectured.[35] The relationship between market share and share of retail outlets in a market area seems to be S—shaped. Lilien and Rao postulated on S—shaped relationship between share of market and share of outlet.[36]

Naert and Bultez did an analysis of the effect on the market share of the distribution network of a major brand of gasoline in Italy. Their results support the S—shaped hypothesis at the market share level.[37]

Other mathematical models can be defined by considering the following set of structural relations (describing the structure of a market phenomenon):[38]

$$M_{jt}=\beta_{0j}+\beta_{1j}\frac{a_{j,t-1}}{\sum_{r=1}^{n}a_{r,t-1}}+\beta_{2j}\frac{P_{jt}}{\frac{1}{n}\sum_{r=1}^{n}P_{rt}}+\beta_{3j}m_{j,t-1}+\mu_{jt}$$

$$Q_t=V_0+V_1\sum_{r=1}^{n}a_{r,t-1}+U_2V_1+V_t,$$

$$q_{jt}=M_{jt}Q_t,$$

$$R_{jt}=P_{jt}q_{jt},$$

$$TC_{jt}=C_jq_{jt}+FC_j+a_{jt},$$

$$\pi_{jt}=R_{jt}-TC_{jt},$$

$$\pi(AT)_{jt}=(1-\tau)\pi_{jt},$$

where m_{jt}=market share of brand j in period t, $j=1,\cdots,n$,

a_{jt}=advertising expenditures of brand j in period t,

P_{jt}=price per unit of brand j in period t,

$U_{jt}V_t$=random disturbance terms,

35) Zentler, A. P. and Rycle, Dorothy; *An Optimal Geographical Distribution of Publicity Expenditure in a Private Orqanization,* "Management Science 4 (july) 337–352 (1956).

36) Lilien, Gary L, and Rao, Amber G; "*A Model for Allocating Retail Outlet Building Resources Across Market Areas* "Operations research 24 (January–February) 1–14 (1976)

37) Naet, Philippe A., and Bultex, Alain; "*A Model of a Distribution Network Aggregate Performance,* "Management Science 21 (June), 1102–1112 (1975).

38) Philippe A. Naert, Peter S. H. Leeflang; *Building Implementable Marketing Models,* Martinus Nijhoff Social Sciénces Division 1978, p. 60–61.

Q_t=product class sales in period t,
y_t=disposable income in period t,
q_{jt}=sales (in units) of brand j in period t,
R_{jt}=revenue of brand j in jperiod t,
TC_{jt}=total cost of brand j in period t,
c_j=variable cost per unit of brand j,
FC_j=fixed costs of brand j,
π_{jt}=profit (before tax) from marketing brand j in period t,
$\pi(AT)_{jt}$=after tax profit, and
τ =tax rate.

Lee and Nicely applied goal programming to marketing decisions through an analysis of a case.

Unlike other quantitative techniques such as linear programming, goal programming provides a way for manager to determine the extent to which several conflicting goals may be realized simultaneously.

The basic concept of GP involves incorporating all managerial goals into the model as goal constranints. The objective of GP is to achieve a set of system (operational) constraints. Thus, GP involves a repetitive process by which the most important goal is first considered. This is followed by an attempt to achieve the second goal, to the extent possible, subject to the first goal achievement already accomplished and the system constraint relationships. This process continues until all goals have been considered in the priority ranking specified by management. A very important advantage of GP is that the GP model can be easily solved by the familiar simplex procedure.[39] Many real-world marketing problems involve multiple conflicting objectives. The GP approach on the basis of the ordinal solution appears to be the most promising technique, at least at this stage of decision science development. This approach has been applied for the optimization of specific aspects of marketing operation, such as sales effort allocation and avertising media scheduling.[40]

The optimal marketing mix

The Dorfman–Steiner theorem

One of the most comprehensive approaches to the problem of optimal marketing strategy is provided by Dorfman and Steiner. It is assumed that the marketing manager has three variables (the model can easily be extended to include a distribution variable) under his control-price, advertising and product quality-and that his objective is to find the values of those which will maximixe product profit.

Assume that demand for the product is given by:

$$q=f(P, A, R) \quad \cdots\cdots (1)$$

39) Sang M. Lee and Roy E. Nicely; "*Goal Programming for marketing decisions*: A case study" Journal of Marketing Vol. 38 (January 1974) pp. 24–32.

40) Sang M. Lee and M. Bird: "*A Goal Programming Model for sales effort allocation*" Business Perspectives, Vol 6 (Summer 1970) p. 17–21.

Where q is the sales in units per period, P is the price of the product, A is the advertising expenditure per period and R is the level of product quality, Note that in the formulation of demand, eq. (1) environmental and competitive factors are ignored and the model is static.

It is also assumed that the average unit cost for the product is a function of both and the level of product quality, and is given by:

$$C=g(q, R) \quad \cdots\cdots (2)$$

Where C is the unit average cost. Product profit is consequently given oy;

$$\Pi = Pg-Cg-A \quad \cdots\cdots (3)$$

Given this profit equation, a necessary condition for optimizatin of the marketing mix is

$$\frac{\partial \pi}{\partial P}=\frac{\partial \pi}{\partial A}=\frac{\partial \pi}{\partial R}=0 \quad \cdots\cdots (4)$$

Substituting the partial derivatives from eq. (3) into eq. (4) it can be shown that the following equilibrium condition holds:

$$e_p=\mu_u=e_R\frac{P}{C} \quad \cdots\cdots (5)$$

Equation (5) is called the Dorfman-steiner theorem. This theorem does not enable us to set the optimal levels of price, advertising and quality. Instead, it states that if the firm adopts a cirterion of short term profit eq. (3) and it is operating at optimum levels of the three variables of the marketing mix, the relationships in eq. (5) will hold. If the firm has manipulated price, advertising and quality in such a fashion that the price elasticity is equal to the marginal revenue product of advertising is equal to the product quality elasticity, then the firm is operating optimally.

When the firm is operating optimally marginal cost is equal to marginal revenue. Consequently,

$$c=P\ (1-\frac{1}{e_p})$$

where c is the marginal cost, using the Dorfman–Steiner theorem it follows that

$$\mu_A=\frac{1}{W} \quad \cdots\cdots (6)$$

where

$W=\frac{P-c}{P}$=gross margin proportion.

Equation (6) provides the basis for a test of the short-term profitability of advertising. The equation states that if the firm is acting optimally, the marginal revenue product of advertising is equal to the reciprocal of the gross margin as a proportion of price.[41]

Retailing

Of all retailing decisions, none is more strategic than the selection of a store site.
The selection of store sites is usually accoplished through the use of common sense, accumulated experience, benchmark figures rough judegement,and extensive computation. A few efforts have been made to provide the merchant with more penetrating tools for selecting sites. Huff has developed a computer–programmed solution for approximating an optimum location for a proposed retail development but to date its assumptions are untested, and its performance is untried. Fareley and Ring have developed a analytical approach for making layout decisions. Cross aided

41) Peter T. Fitz Roy; *Analytical methods for Marketing management* McGraw–Mill, 1976, pp. 311–312.

an oil company by OR in deciding the assortment of gasolines its service station station should sell. Baumol and Ide also treated the breadth of assortment. By incorporating ('ecision theory into classic economec analysis,Buzzell and Slater analyzed wholesale bakery's pricing situation in a systematic and rationaway. As for promotional decisions, Lee developed a comprehensive model to determine the most profitable allocation of a fixed shelf space to each of a number of products. OR has largely unimproved personal selling activities in retailing as in marketing as a whole. Nevertheless, Stokes and Mintz developed a Monte Carlo queuing model to determine the optimum number of clerks to assign to a floor in a department store. Service is a very difficult product to manage. Hespos reported one company's use of a simulation to determine the number of serviceman it should place in each of its branches. Retailing management generally considers credit to be part of its total marketing mix. Smith analyzed credit scores by using Bayesian statistics.[42]

Ⅵ. Benifits from using mathematical decision model

In this section, I examine the direct benifits and the side benifits from mathematical models for decision making in marketing.

Direct beifits are:

1. Suppose a model indicates that a firm is overspending on advertising, i.e. marginal cost from advertising exceeds marginal revenus. Adjusting the spending level will result in higher profitability.

2. An a dvertising budget can be split into two major component:media costs and creative costs. A model could be helpful in these two. Gross (1967,1972) indicated that, in general, not enough is spent on the creative effort. He also showed how to calculate the differential profit resulting fron a re-allocation of the available funds.

3. In sealed competitive bidding, candidates submit a price and the lowest bidder wins. Systematizing information on past bidding behaviour into a model, may result in a pricing strategy leading to an increase in expected profit.

Side benefits are:

1. Model building will often lead(perhaps in time) to an improved understanding of his prolems.

2. Model may even work as problem findinginstruments which means that problems may emerge after a model has been developed.

3. Models will be instrumental in improving the process by which decision makers deal with existing information.

4. Models help in deciding what information should be collected.

5. Models can also guide reseaerch by identifying areas in which information is needed, as well as by pointing out the kinds of experiments which would provide useful information.

6. A model will often enable management to pinpoint changes in the environment faster than would be possible without models.

7. Models provide a framework for discussion at evaluation time.

8. Finally, a model might result in a beneficial reallocation of management time, which means

42) M. S. Moyer; *Management Science in retailing*, Journal of Marketing Vol. 36 (Jan. 1972). pp. 3–9.

less time spent on programmable or structured activities, and more time on less structured ones.[43)]

Lazer also pointed out some benifits of mathematical models.

1. The translation of a model from a verbal to a mathematical form makes for greater clarification of existing relationships and interactions.
2. Mathematical models promote greater ease of communication.
3. Mathematical models tend to be more objective, while verbas constructs lean heavily on intuition and rationalizations.
4. Analyses that are not feasible through verbal models[43)]

Zoltner enumerated a wide range of benefits from using models, paricularly computer–based ones, can be realized by the manager. A computer–based marketing mlodel may

1. help to better utilize a manager's judgment and available data.
2. limit a manager's tendency to overact.
3. provide quick and convenient evaluation of alternatives,
4. search for better solutions,
5. allow emergence of "unmentionable" solutions,
6. improve prediction,
7. help with the formal statement of (a) through sensitivity analysis and (b) the logic of analysis,
8. provide vocabulary with which to discuss problems,
9. organize data, and
10. provide a guide to research (a) through sensitivity analysis and (b) by exposing gaps in knowledge.[45)]

Hiller and Lieberman, professors at Stanford university, discussed the contribution from the operation research approach:

1. The structuring of the real life situation into a mathematical model, abstracting the essential elements so that a solution relevant to the decision maker's objectives can be sought. This involves looking at the problem in the context of the entire system.
2. Exploring the structure of such solutions and developing systematic procedures for obtaining them.
3. Developing a solution,including the mathematical theory, if nesessary, that yields an optimal value of the system measure of desirability (or possibly comparing alternative courses of action by evaluating their measure of desirability.)[46)]

43) Same Reference as footnote 10, at pp. 21–28.
44) Same Reference as footnote 13, at p. 14.
45) Same Reference as footnote 15, at o. 254.
46) Frederick S. Hiller and Gerald J. Lieberman ; *Introduction to Operations Research*, Third Edition 1980, Holden–Day, Inc. p. 5.

Ⅶ. Implementation

Implementation refers to the actual use of OR/MS output (projects, models, or solutions) by managers that influences their decision processes. Influence is thus the key to understanding the notion of implementation, for if management science, designed to influence decision making, does not in fact influence the decision process, then a model (or management science) can hardly be thought of as being implemented. It is possible, of course, that organizational decision–making processes could be influenced without the particular OR/MS output being actually used, although in this case the benefits of operations research are more correctly attributable to organizational intervention or consulting in general.

Marketing decision making, but not all changes in decision making,but that does not mean that all of them do just that. Improved decision making implies changed decision making, but not all changes in decision processes are improvements, a point worth noting since it suggests that not all decision models should be implemented. In fact, implementation can be thought of as changed decision making and successful implementation as improved decision making. Thus, any OR/MS intervention in decision making that changes decision making(or decisions) is "implemented." If decision making is improved, then implementation is "successful." A successful model is one that adequately represents the phenomena being modeled and is used for the purpose for which it was designed. So model success is a more narrow concept than implementation success,since the former is defined in terms of the model's goals and the latter in terms of the organization's goals. A marketing decision model designed to optimize advertising expenditures, for example,is successful only to the extent that it is used for this purpose and accomplishes its goal. But since models need not be "used" to have a change in decision making, a kind of fringe benefit of the attempt to adopt the model may accrue to the organization. It is even possibl that, in an indirect way, the advertising decision process is improved. So successful OR work may not imply the success of a model.

A behavioral perspective of implementation would include the development and the use of a decision model that results in a positive change in organizational effectiveness. In the scenario above, this would mean that the sales forecasting model was successfully developed and was adopted by sales managers (model success), and that it in fact improved the process of sales forecasting(implementation success). In this scheme, user and manager satisfaction are appropriately tied to user performance and hence to organizational effectiveness.

Mamangement science activity involves(1) intervention, (2) implementation, and (3) improvement. Intervention occurs when OR/MS activity takes place (a model is built, a project is done, consulting takes place, etc.). Improvement obtains when there is a positive change in decision making or organizational effectiveness.[47)]

Managers spend much of their time in implementation activities rather than in classical decision making, and much of this implementation may have substantial impact on the basic structure of the organization in which the manager works.

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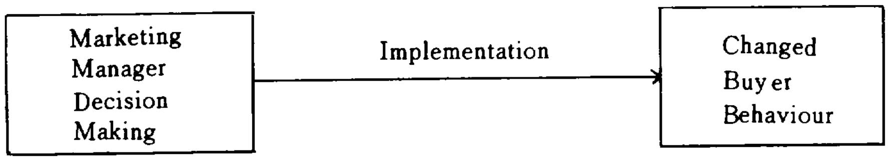
47) Randall C. Schultz and Michael D. Henry; "*Implementing Decision Models*". in randall L. Schultz and Andris A. Zoltners (eds), Marketing Decision Models, new York: North Holland, 1981, pp. 275–293.

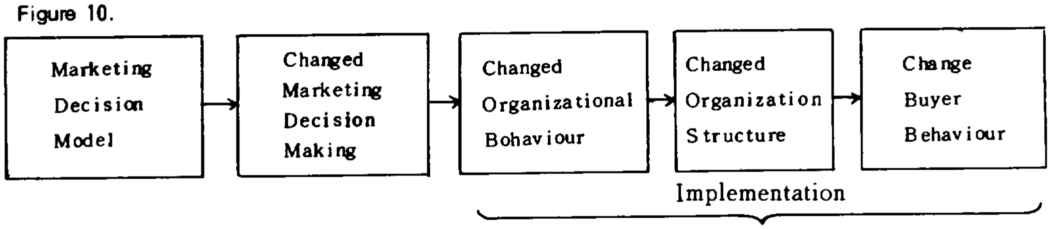
Figurg 9 shows the imputs of marketing models and the implementation effects on organizational behaviour and organizatioal structure.

Figure 9.



As can be seen from Figure 10,and can also be concluded from a basic knowledge of organizational behaviour, there are many step between development of a marketing decision model and the final goal of changed buyer behaviour. These implementation steps can have a tremendous impact on the behavior of the organization and the actual strucrural design of the organization.[48]

Figure 10.



There are differing views about successful implementation. The practicing manager tends to declare output helps the manager to achieve his or her intended objectives. On the other hand, the management scientist tends to think that a successful implementation has occurred if the porject provided valuable new imformation, experience, or insights about the problem.

A successful implementation is often associated with following characteristics:

1. An improved organizational perfomance through the use of the model results or information generated by the process.

2. An improved communication or work relationship among the interdisciplinary parties involved (the manager, management scientist, operations personnel, staff specialists, and others.)

3. Carefully planned and monitored activities in each phase of the entire process.

4. A continuous and dynamic process of updating, feedback, review, control, and communication.[49]

Many other recent studies have identified a number of factors that are important for successful implementation of management science. Some of these factors are:

The degree of management participation and support.

Technical competence and organizational influence of the management scientist.

Relevance of management science to organizational problems.

Effectiveness of the model–simplicity, robustness, adaptability,and ease of communication.

48) Dennis P. Slevin, "*Marketing Models nad Organizational Design*" in Randall L. Schutz and Andris A. Zolthers, (eds), Marketing Decision Models, New York: North Molland, 1981, pp. 1–18.

49) Same Reference as footnote 6, at p. 168.

Resources allocated to management science projects.
Organizational climate for innovation and change.
Organizational commitment to long-range strategic planning.
Commitment of all personnel to organizational values and purpose.
Communication among all levels of the ofganization.
Unique aspects of the organization, problem, decision environment,or personnel.[50]

An interesting summary of approaches which are likely to improve the long-run success of quantitative applications was advanced by Harvey Wagner, a long-time academic leader in quantitative methods. He looked at the future of operations research from three points of view: those of(1)the practitioner,opportunities available to pracititioners are to:

1. Improve the mechanics of applying operations research so as to reduce the resource costs for developing,and implementing OR models.
2. Devise diagnostic techiques to predict accurately the economic benifits that will accure from a proposed OR into application.
3. Expand the purview of OR into new ares of managament, including formulating a corpōration's growth strategy, structuring organizational responsibilities, birdging cultural gaps within a comoany, improving a company's profit performance, designing management information systems, and delineating the enterprise's public responsibilities.

The challenges open to a management science theoreticians are to :

1. Develop insightful models that sidestop the axim of managerial rationality
2. Propose analytic concepts that enable managers to deal with the future as reality.
3. Build practical models for treating day-to-day operating problems.
4. Find new ways to exploit the full power of computers.
5. Explore approaches to model building that enocompass principles of behavioral science.

The recommendations made to educators are that they:

1. Assess the appropriate mix between professional and technical training to best prepare students for having practical influence on managerial decision
2. Examine the relative merits of the various approaches to OR higher education that have been in vogue for over a decade.

Wagner is not confident that OR professionals will pursue these tasks with vigor and complete them with dispatch, but he remains hopeful that the OR professional's fundamental commitment to seek improvements in society continually will direct its energies to solving problems of vital significance.

AN ASSESSMENT OF 25 YEARS OF QUANTITATIVE METHODS IN DECISION MAKING

50) Same Reference as footnote 6, at p. 621.
51) Harvey M. Wagner, "*The ABC's of OR*" Operation Research, vol. 19, no. 5, Sep-Oct. 1971.

Probaly the most comprehensive of the views I present in this section are those of W.T.Morris,based on interviews with 320 middle managers and his own very comprehensive experience in the quantitative area. Morris has condensed his findings into seven propositions, which have been modified somewhat and restated here:

1. Use of term "quantitative" is probably not correct; we will get futher if go beyond surface manifestations (numbers, equations, etc.) and consider a broad range of approaches that are (1)exolicit, (2)involve data,and (3) are analytical.

2. The more willing mangers are to view managing as a scientific experiment, the greater their tendency will be to build quantitative methods into their management style. Ideally, in Morris's view, managing should be more like a research laboratory.

3. Quantitative methods tend to have a life cycle with the these phasses;(1) renaming of basic ideas, (2)application to a specific managerial situation, (3)enthusiasm deriving from speicfic scess, (4)institutionalization, (5)emergnece (decline and possible failure). Morris claims that management's awareness of these phases and the process in which they are contained is crucial to the success of quantitative methods.

4. Success in applying quantitative methods in organizations rises with the client's involvement in both the creation and development of the method used. When quantitative methods are thought to have been introduced by outsiders, the chances for failure rise. Morris suggests that ideas must be sold, that politics must be recognized and dealt with, and that paricipation is the key to success in implementation.

5. Whether the quantitative approach enjoys sustained successful use depends, Morris says, on whether the technique "maps on" the client's (or organization's) style or characteristics. If the organization is not sophisticated, complicated computer-basecd models have little chance of success. If an individual client has a management style which involves tolerance for uncertainty, self-confidence, and a willingness to go,beyond policy, then he or she is a prime candidate for the use of quantitative approaches.

6. Management still remains very much an art, and the use of scientific quantitative methods is not always better than intuitive hunch or gut feel. Quantitative methods are not the answer, but noly a help. Regardless of how extensive the quantitative methods, managers need to have the final say, a managerial overrids as it were.

7. Quantative methods that are simple, straightforward, and basic have higher benefit/cost ratios than those that are sophisticated and complex. The more complex the quantitative technique, the more willing managers are to consider it as unproven, and therefore to resist its use.[52)]

52) Richard I. Levin. Charles A Kirkpatrik. David S. Rubin. "*Quantitative Approaches to Management*, 5th Edition. MaGraw-Mill, 1982, pp. 702-803.

Table 4. Results of the Thomas and DaCosta Survey, 1978

Techniques	Firms Using the Technique
Statistical analysis	935
Simulation	84
Linear programming	79
RERT/CPM	70
Inventory theory	57
Queuing theory	45
Nonlinear programming	36
Heuristic programming	34
Bayesian decisin analysis	32
Dynamic programming	27
Risk analysis	3
Integer and mixed proramming	2
Delphi	1
Financial methods	1

Table 5. Results of the Lee Survey, 1981.

Techique	Use		
	Frequently	Sometimes	Not at All
Statistical analysis	60.6%	37.9%	1.5%
Simuation	45.1	45.1	9.8
Linear programming	29.8	50.4	19.8
Other mathematical programming	23.4	46.1	30.5
PERT/CPM	16.5	45.7	37.8
Inventory models	15.0	42.5	42.5
Multiriteria methods	9.5	34.1	56.4
Search techniques	7.2	35.2	57.6
Queuing models	5.6	45.2	49.2
Game theory	2.4	20.8	76.8

G. Thomas and J.A. DaCosta surveyed 260 of Fortune's top 500 corporations and 160 of the largest California–based firms in 1978. Table 4 presents the results of this survey concerning the corporate use of management science techniques.

Another survey was conducted by Lee in early 1981. A queationnaire was mailed to 950 nonacademic (practing) members of the Operations Research Society of America. Table 5 presents the overall results.[53]

53) Same Reference as footnote 6, at p. 15–16.

C. Jacson Grayon lists the reasons for not applying management science:

1. Shortage of time
2. Lack of data
3. Resistance to change
4. Long responce time
5. Simplificationd and assumtions[54)]

Management by ideology

The process of management science is based on the approach by information. Its characteristics are:a high of organizational instrumentation, emphasis on measurable short–term objectives, top–down communication of objectives, a technology based functional structure, a general lack of organozational commitment on the part of its members, and problem solving approach of management. A new concept of management is a broad approach of management by idology. Its characteristics are: superordinate organizational values and philosophies, long–term strategic objectives, a two–way (top–down– and bottom–up) communication system, cooperation and harmony–oriented functional structures, a strong commitment to the organizational values on the part of the members, and consultative decision making.

Lee proposed that management by ideology, supported by management science, should replace the management by information approach blindly pursued by so many organizations. Figurell presents a broad overview of the role and position of management science in the management by ideology framework.[55)]

Gupta, on the basis of his real–world experience in the U.S. Postal Service, suggests the following srategies for successful implementation:

Analyse the decision situation and construct its descriptive model

Establish the cause and effect relationship of decision factors influencing the manager's thinking.

Explore or develop appropriate information systems to secure the neede data.

Construct a mathematical model with explicit recognition of data requiremants and availability.

Identify the managerial and organizational changes required by the modeel.

Obtain multiple and competitive solutions to the model

Analyze each solution in terms of the consequences on decision factors.

Prepare a realistic cost/benefit analysis of each competitive solution.

Provide the manager with multiple solutions with consequences and cost/benefit analysis.

Aid the manager and his/her staff in implementing the manager's decision, if he/she requests it.[56)]

54) C. Jackson Grayson, Jr, "*Management Science and Business Practice*", HBR. 51:4 1973, pp. 41–45.

55) Same Reference as footnote 6, at p. 623–625.

56) J. N. D. Gupta, "*Management Science Implementation: Experiences of a Practicing O. R Manager*", Interfaces, 7:3, 1977, pp. 54–90.

Table 6. Barriers to Successful Application of Quantitative Techniques (Watson and Marett Study of Management Scientists' Perspective)

Rand	Percentage	Barrier description
1	35	Selling management science techniques to management meets with resistance
2	34	Neither top nor middle management has the educational background to appreciate management science techniques
3	32	Lack of good clean data
4	23	There is never time to analyze a real problem using a sophisticated approach
5	22	Lack of understanding by those who need to use the results
6	19	Hard to define problems for applications
7	16	The payoff from using unsophisticated methods is sufficient
8	12	Shortage of personnel
9	11	Poor reputation of management scientist as problem solvers
10	10	Individuals feel threatened by management scientists and their techniques

Source: H. J. Wtson and P. g. Marett, "A Survery of Management Science Implementation Problems," Interfaces, 9:4 (1979), 124-128.

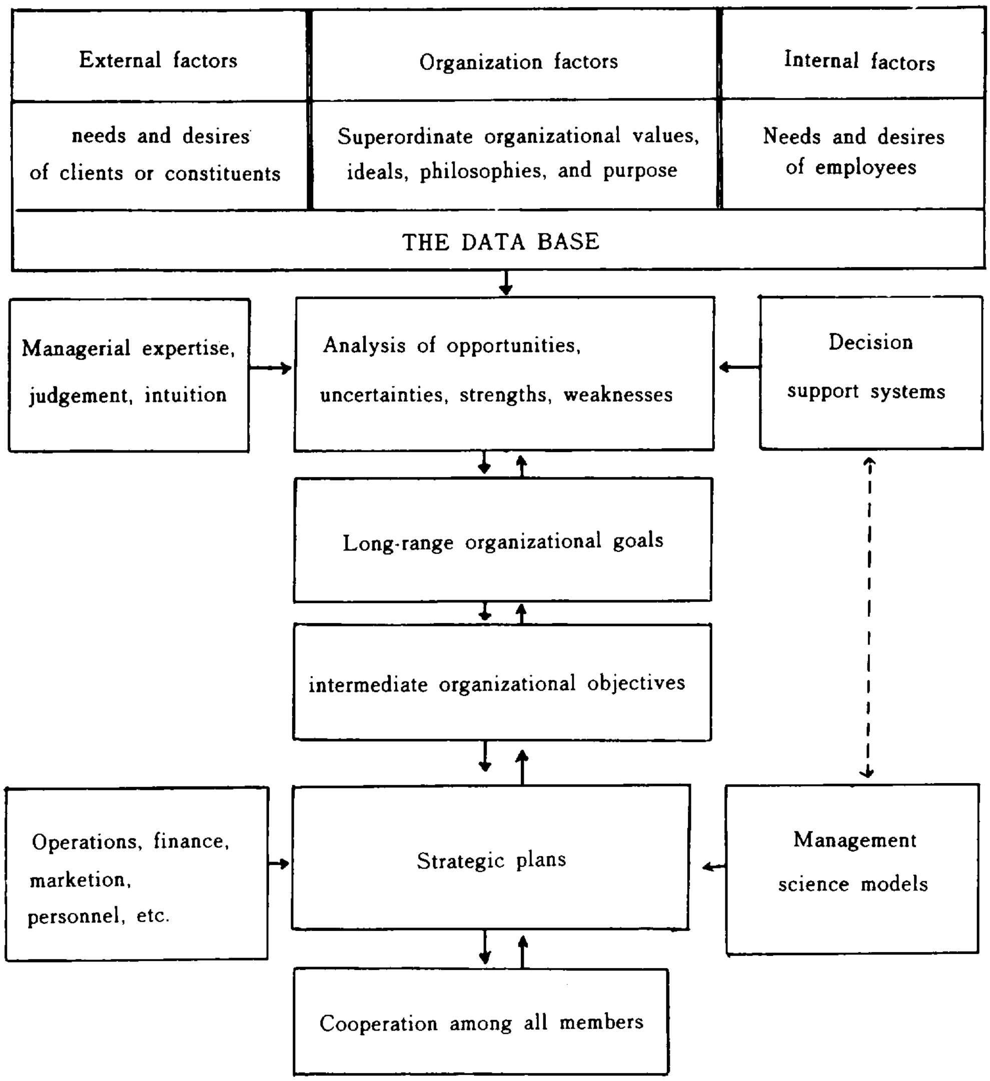
Several survey studies shows as the meaningful causes of implementation difficulties. Green, Newsom, and Jones provides managers' perceptions on barriers to the use of management science. Table 7. presents the survey results. Watson and Marett in 1979 conducted another survey presented practicing management scientists' perceptions about the barriers to management science Implementation, Table 6. presents the survey results.

Table 7. Rank-ordered Barriers to Successful Application of Quantitative Techniques (Green, Newsom, and Jones study of production Manaers perception)

Rank	Mean, 1-10	Barrier description
1	6.51	Benfits of using techniques are not clearly understood by managers
2	6.04	Managers lack of knowledge of quantitaitive techniques
3	5.80	Managrs are not exposed to quantitative techniques early in their training
4	5.79	Required data are difficult to quantify
5	5.47	Only a small portion of management is trained in the use of quantitative techniques
6	5.43	Management is successful without using techniques
7	5.39	Managers in key positions lack knowledge of quantitative techniques
8	5.33	The cost of developing models and using techniques is too high
9	4.85	The data required in using the thchniques are not available
10	4.56	Managers are not quantitatively oriented
11	4.32	Recent college graduates with quantitative training have not yet attained positions of influence
12	4.17	Managrs are unwilling to use the computer for decision making, and/or computers are not available
13	4.16	The expense of employing quantitative specialists is too great
14	3.93	Senior management personnel do not encourage use of thechiques by younger management personnel
15	3.92	Management distrusts of fears the use of techniques

Souree: T. B. Green, W. B. newsom, and s. r. jones, "A Survey of the Application of Quantitative Techniques to Production/Operations Management in large Organizations," Academy of Management Journal, 4 (Dec. 1977), pp. 669-676.

Figure 11. Management Science in the Management by Ideology Framework



國文抄錄

마케팅관리에의 수리모형의 기여에 관한 연구

강 덕 수

오늘날 기업이 당면한 마케팅환경은 과거와 달라서 국내적으로나 국제적으로 매우 복잡하고 빠른 속도로 변하고 있다. 기업이 이러한 환경에서 성공적으로 기업활동을 수행하기 위해서는 관리경제학, 사회학, 인류학, 심리학, 정치학, 국제정치학, 철학, 윤리학등의 경영학의 인접학문을 알아야 될 뿐만 아니라 수학에 대해서도 연구할 필요가 있다.

오늘날의 기업은 과거와 같이 경영자의 경험이나 직관에 전적으로 의존하여 정책결정을 하기에는 그 규모나 환경이 너무 커졌고 복잡해졌다. 기업의 정책결정이 과학적으로 분석되어 수립되지 않으면 타기업과의 경쟁에서 생존하기 어려울 것이다.

이 논문의 목적은 ① 기업활동중에서 가장 중요한 마케팅관리의 여러문제들, 이를테면 신제품개발, 판매촉진, 판매비용, 시장점유, 광고비용, 제품믹스, 소비활동등에 수리모형을 적용시켜 봄으로써 경영자로 하여금 수리적 내지는 계량적인 접근방법에 대한 신뢰감을 높이고,

② 수리모형을 적용하여 정책결정을 할때 기업이 얻을 수 있는 이점들과

③ 또 수리 모형을 개발하여 현실문제에 적용시킬 때 기업이 당면하는 여러 문제점들을 분석하므로써, 기업이 그들의 마켙시스템 속에서 다이나믹하게 기업활동과 정책결정을 하는데 있어서 이 논문이 조금이나마 도움이 되고저 하는데 있다.

아울러 터빈(Turban)이 조사한바에 의하면 「포천」(Fortune)에서 선정한 미국의 500개의 대기업의 50%가 그들의 기업에 경영과학부서를 설치하고 있으며 한국의 대기업체들도 앞으로 이러한 국제적인 추세를 고려하여 기업내에 수리적으로 경영문제를 분석하는 부서를 설치하는 것이 바람직할 것이다.