FEEDBACK DYNAMICS STUDY OF AN INFREQUENTLY PURCHASED PRODUCT

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SUMMARY

The main purpose of this study is to develop a theoretical feedback model that could help understand the dynamics of a consumer product exhibiting the characteristic of being infrequently purchased.

The system analyzed includes a simplified representation of the producer sector, a distributor sector, and a consumer sector.

After formulating the dynamic hypothesis, a model is constructed and equations are developed for levels, rates, auxiliaries and general assumptions are made for the initial conditions of the system.

The simulation language used is DYNAMO III which proves suitable for feedback models.

The study tries to analyze, based on the theoretical model, what differences in the dynamic structure are casuing the differences in pattern behavior, as in the case of the sales pattern vs time.

After the running of the original model, the bahavior of it is analyzed, changing some parameters and initial conditions which are thought to be influential. These might be market size, awareness delay, purchasing delay, delay in the production decision at the producer and the delay in the ordering decision at the distributor.

Important conclusions were drawn concerning market size which resulted in a sensitive parameter. Other parameters that showed some sensitivity, although not significant, were: the production decision delay at the producer sector and the ordering delay at the distributor sector.

It is believed that although the model has many limitations it provides a good initial approach to the problem of simulating a marketing system.

CHAPTER I

INTRODUCTION

The research hereby reported addresses the need for a better understanding of the dynamic marketing environment which in the present has increased in complexity and has forced marketing managers to reexamine their methods and techniques for solving marketing problems and to develop better marketing strategies.

Methods which proved successful in the past are far too risky in today's rapidly changing economy. The effect of rapid technological and social changes, the shortening of a product's life cycle, and the complexity of dynamic systems demands methods and techniques more suitable for more effective decision making.

Feedback Dynamics is one of the best analytical tools available in the present in dealing with dynamic systems and has been successfully applied in industry.

A marketing system, like an industrial system, can be represented and analyzed through a simulation model, and this study is an attempt to achieve this goal.

A. Objectives

The present study has been organized to meet a series of objectives:

(1) Develop a theoretical approach within which a dynamic marketing system may be studied and analyzed.

(2) Develop a theoretical structure through which the interrelations of the variables of the system may be evaluated and analyzed.

(3) Develop a model that could describe as close as possible the system assumed.

(4) Develop the equations for the model proposed.

(5) Evaluate the results obtained by simulation methods.

(6) Study the effect in the overall performance of the system when changes take place.

(7) Assess the contribution of studying the model to marketing decision making.

The approach followed to analyze the system is based on the Feedback Dynamics Methodology as developed at M.I.T. (1) and extended at Georgia Institute of Technology (2).

A feedback dynamics study consists of the following steps:

(1) Problem Identification

(2) Dynamic Hypothesis Development

(3) Model Building

(4) Model Analysis

(5) Model Validation

(5) Model Synthesis

(7) Implementation

(8) Evaluation

(9) Institutionalization

This study will follow up to model analysis deriving from this the conclusions and recommendations for the problem under study. The analysis of life cycles of infrequently purchased products will be done mainly on sales peak time and accumulated average profit.

B. Perspectives of Study

Relationships and interactions within a marketing system will be considered assuming that the system is composed of three subsystems: The producer subsystem, which manufactures the product; the distributor subsystem which will be considered as selling directly to consumers; and the consumer subsystem.

The central objective is to develop a framework within which marketing behavior could be described and some general marketing management decisions could be tested and evaluated.

Consumer behavior is extremely difficult to analyze and even more difficult to predict; so some assumptions need to be made such as: in general consumers react to marketing stimuli, also that people buy based on an attached utility to the product and other assumptions that will be discussed in detail when dealing with the consumer sector.

Emphasis will be placed on some management policies and decisions concerning the introduction of the product such as price and promotion decisions.

The dynamics of a system as created by the component interrelationships and the feedback loops of a system are sometimes overlooked in the decision making process. The formulation of a model of the system facilitates the understanding of these relationships, so we believe that formulating a simple marketing system will help us understand and learn more about the decision making in marketing.

The producer subsystem will be viewed as a producing agent that transfers goods directly to the distributor.

The distributor subsystem will be assumed that sells directly to consumers.

The consumer subsystem will be based on a fixed population of potential buyers and will be analyzed in terms of purchasing behavior.

C. Producer Objectives

It will be assumed that the major objective of the producer are short term accumulated profits.

Finally, it is expected that this study will contribute to the development of market dynamics and as a broader application of the Feedback Dynamics field.

CHAPTER II

LITERATURE REVIEW

Beginning in 1950, a rich variety of models have been developed in the marketing area providing qualitative and quantitative approaches to solve marketing problems. Model building and quantitative methods of analysis are the basis of today's analytical approach. Since the types of problems faced by the marketing manager vary in complexity and in nature, different models are constructed to meet different purposes. The manager then instead of studying the actual system, studies a model of the system, thus enabling him to look at the effect in the overall performance of the system when a change takes place in it.

It would be almost impossible to ennumerate all the marketing model that have been proposed in the literature. Important contributions have been made by the following authors:

Frank B. Bass (3) proposed a growth model for the timing of initial purchase of new products making the basic assumption that the timing of a consumer's initial purchase is related to the number of previous buyers. The behavioral assumption is based on innovative and imitative behavior. The model yields good predictions of the sales peak when applied to historical data.

The model proposed by Frank Bass does not consider the effect that advertising, pricing and promotion have on sales. Rather he focuses mainly in the assumption that the probability that an initial

purchase will be made at time T, given that no purchase has yet been made, is a linear function of the number of previous buyers.

This model implies exponential growth of initial purchases to a peak and then exponential decay.

This model has been applied to data for consumer durables and has shown good agreement in the timing and magnitude of the sales peak.

Bartlett, M.S. (4) proposes the theory of adoption as related with some epidemological models.

Haines (5), Fourt and Woodlock (6), and others have suggested growth models for new brands or new products which suggests exponential growth to some asymptote.

David F. Midgley (7) develops a quantitative theory of innovative behavior based on extant behavioral knowledge as expressed by a set of differential equations. It is an approach to quantify complex areas of human behavior as mathematical theories. He developes his theory based on the concepts of potential adopters, active adopters, active rejectors and passives.

Everett, M. Rogers (8) discusses the process on innovation and develops a model based on the diffusion process.

Rogers classifies the adopters on the basis of relative time of adoption. It is very interesting that what he proposes is that the individual consumer goes through a series of stages of acceptance in the process of adopting a new product. The value of this model of the adoption process is that it requires the innovator to think carefully about new-product acceptance.

The concept of product life cycle has also been discussed thoroughly in the literature. The main concern of marketing management is to identify distinct opportunities and problems with respect to marketing strategy and profit potential.

By identifying the stage that a product is in, or may be headed toward, better marketing plans can be formulated.

Most discussions of product life cycle rely on the sales and profit history of the product. However no attention is given to how and why this time pattern is created. William E. Cox (9) goes into an analysis of product life cycles as marketing models and gives some suggestions for marketing strategies.

Theodore Levitt (10) deals also with an analysis of the product life cycle establishing better marketing plans at different stages of the product's life.

Although marketing models usually are not completely integrative, since they deal with general theories focused on few elements of the marketing system rather than following an integrative approach, in the present there has been concern to develop more complete and detailed models. These models have been developed for setting advertising budget, consumer reaction to advertising, sales response to price, as a planning and control tool, as promotional spending, and many others which are difficult to ennumerate.

Vidale-Wolfe (11) developed a model based on the assumption that the change in the sales rate at a given time t is a function of four factors: the advertising budget, the sales-response, the saturation level of sales, and the sales decay constant. This model has been

applied in long-run profit analysis and to determine alternative advertising-budgeting strategies.

Another model proposed by David B. Learner (12) called DEMON, is oriented toward a new product, and has a profit maximization approach to sales.

All the models mentioned above do not use the Feedback Dynamic Methodology.

Jay W. Forrester (13) has proposed an approach to test alternative seasonal advertising policies. He suggests that advertising has a lagged impact on consumer awareness, making this problem suitable for simulation analysis.

The model based on market-advertising interaction makes the assumption that for a total industry such as household appliances, there exists a pool of prospective customers which are at least vaguely aware of their need for the product and whose actual purchase time will vary depending presumably by the sales effort.

The system considered by Forrester's study deals only with a part of the total market, since it considers only the purchasers whose existence is independent of advertising. So the main effect that advertising has on the system is the shortening of the delay in the purchasing decision.

Forrester examines some of the implications of an advertising policy that is proportional to sales. As a result of this analysis, Forrester establishes that a system could achieve better stability when restructuring the system with a different assumption than advertising proportional to sales. A policy of reducing advertising when sales are increasing would produce greater stability on the system; but

discusses that it may not occur that way since this may create other kinds of problems in the system.

It could be concluded from Forrester's advertising model that, it is very important to consider the awareness delay in advertising in order to coordinate better inventory and production decisions. Awareness delay has an important effect on the industrial system.

Arnold E. Amstutz (26) presents an organized behavioral theory of market interactions and suggests an approach to management based on the use of microanalytic computer simulations of interactions within the marketing environment.

Amstutz focuses on the development and implementation of behavioral models and system configurations designed to provide an adequate structure of this system within which management problems involving the environment external to the firm can be defined and analyzed.

The total system includes the manufacturer, the distributor, the retailer, the consumer, the salesman, and even research and government. Amstutz presents complete models for each of the components.

It should be pointed out that Amstutz presents a complete simulation model, providing an excellent contribution in the field of simulation in management decision making.

The work previously described provided an important input in the development of this research work, especially when dealing with the consumer sector model and for the formulation of the purchasing rate equation.

In order to gain a better understanding in consumer behavior, several theories were studied (15).

It is a fact that to develop a model of a consumer behavior is not an easy task. Customers are neither simple in themselves nor in their behavior toward the purchasing activity.

Innumerable studies have been made in consumer behavior. Many theories have been developed in order to explain why consumers buy. Among the more important are the following:

1. The Marshallian Economic Model. The theory of Alfred Marshall holds that purchasing decisions are the result of largely "rational" and conscious economic calculations. The individual buyer seeks to spend his income on goods that will deliver the most utility according to his desires and relative price of the product. By utility he means satisfaction. His theoretical work was aimed at realism, but his method was to start with simplifying assumptions and to examine the effect of a change in a simple variable, such as price, while holding all other variables constant. Over the years his methods and assumptions have been refined creating the modern utility theory.

Marshall's model suggests useful behavioral hypothesis; such as, there is a relationship between price and demand, and it suggests the effect of promotional efforts in higher sales. However, the major emphasis of Marshall's theory is on economic factors alone; and, these cannot explain all the variations in sales and purchasing behavior.

2. The Pavlovian Learning Model. This model suggested by Ivan Pavlov is based on four central concepts which are drive, cue, response, and reinforcement.

A drive, also called "need" or "motive", is an individual's strong internal stimuli impelling action. A drive is general and impels a particular response only in relation to a particular configuration of cues. Cues were defined by Pavlov as weaker stimuli in the environment and/or in the individual which determine when, where, and how the subject responds.

The response is the organism's reaction to the configuration of cues; and, if the experience had been rewarded, a particular response is reinforced. So there is the tendency of repeating the same response when the same configuration of cues reappears.

Although this theory does not incorporate many variables which are important to consider in purchasing behavior; it does provide guidelines in the area of advertising. Repetition reinforces the learning process and may stimulate the repurchasing activity.

3. The Freudian Model. This model suggests that buyers are motivated by symbolic as well as economic-functional product concerns. It aims basically to explain the behavioral phenomena although several philosophical divergencies have debilitated the model.

4. The Veblenian Social-Psychological Model. Thorstein Veblen established that the wants and behavior of people are largely molded by their present group memberships and the group memberships to which they aspire. He said that consumption habits were not motivated by intrinsic needs or satisfaction but mainly by the search for prestige. He divides the social influences as social levels which are: culture, subcultures, and social classes.

Veblen's input to modern theories is based on the influence of

social and psychological effects on purchasing behavior.

An important conclusion is that buyers' minds are complicated, and no one has succeeded in putting all buying motivations together into one coherent instrument for behavioral analysis. This is one goal of behavioral science. This thesis is intended to be a step in that direction.

CHAPTER III

DESCRIPTION OF THE SYSTEM

As previously stated, we will consider the system as formed by three subsystems: the producer, the distributor and the consumer.

As indicated in the total model diagram (Figure 5.1), the system has as elements of flow materials, orders, money, people and information.

The flow of goods from the producer subsystem to the distributor (Figure 5.1) is the product we are dealing with, i.e., an infrequently purchased product. It is assumed that the marketing system is for this single product, and that all the marketing effort is directed to promoting and selling only this single product.

As indicated in Figure 3.1, a simple marketing system can be generalized as:

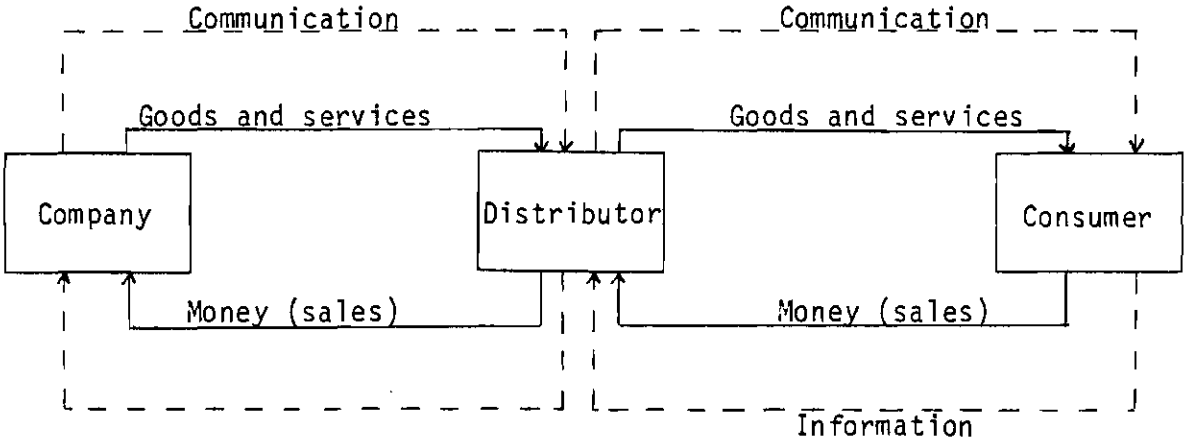

Figure 3.1. Simple Marketing System

A comprehensive marketing system map for our system may be represented as in Figure 3.2.

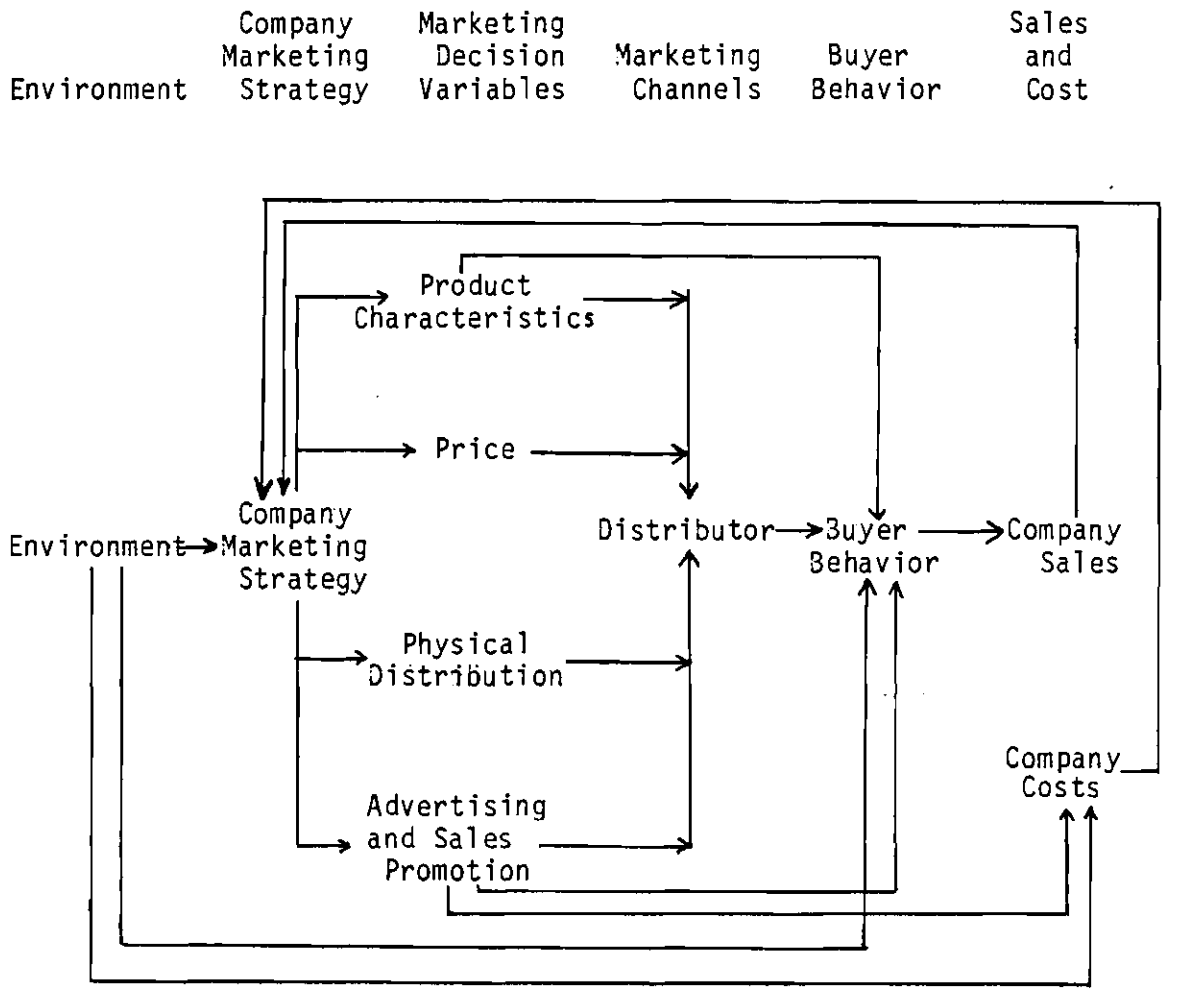

Figure 3.2. Illustration of the System Under Study

As it is observed from Figure 3.2, there are two major decisions that the company must face: trade decisions and consumer decisions.

To influence the trade, i.e., sales to the distributor, the company uses the wholesale price, trade advertising, co-op advertising allowances and service and delivery policy. To influence the consumer, the company uses product characteristics, retail price, promotion deals, and consumer advertising.

The distributor will be viewed as an active element having the function of selling the product directly to the consumer, and also as an important agent in stimulating buyer behavior, mainly through advertising and sales promotion.

Buyer behavior has an important contribution to the marketing system since it defines the sales rate and acceptance of the product. This effect on the sales rate will define the time pattern of sale during the life cycle of the product.

In this study we will try to analyze what characteristics of the feedback structure influences the time pattern of the sales response, and to hopefully achieve a better understanding of the simple marketing system previously described. Also we will try to identify and understand the cause of different patterns that a product life cycle may exhibit.

In order to construct a model that could permit us to analyze the system, it has been necessary to make several assumptions:

(1) The producer is marketing an infrequently purchased product in a single market.

(2) The producer must define the better marketing strategies during the life cycle of the product which could be more profitable.

(3) The producer controls the marketing decisions of product characteristics, price, distribution policy and advertising policy.

(4) The distributor is an active agent of the system. The major decisions that the distributor makes are: Inventory decision, and ordering decisions.

(5) The buyer behavior is influenced mainly by the product characteristics, by advertising, and considering the price of the product.

(6) External environmental factors are not considered neither the influence that uncontrollable factors may have on the system.

(7) The market may be identified as homogeneous. So buyers tend to react in the same way to marketing stimuli. (18).

(8) The infrequently purchased product falls in the category of an homogeneous product.

(9) The producer's interest in introducing the new product is first to develop the primary demand, and to achieve the best results and profits during the introductory stage of the product.

(10) No competitive sector has been considered.

These are the major important assumptions of our system.

CHAPTER IV

DYNAMIC HYPOTHESIS DEVELOPMENT

A. Introduction

A product's sales position and profitability can be expected to change over time. The product life cycle is an attempt to identify distinct stages in the sales history of the product.

This study tries to identify and understand the cause of some of the variations in the sales history of an infrequently purchased product.

Most discussions of product life cycle (15) are based on the typical S-shaped sales as indicated in Figure 4.1.

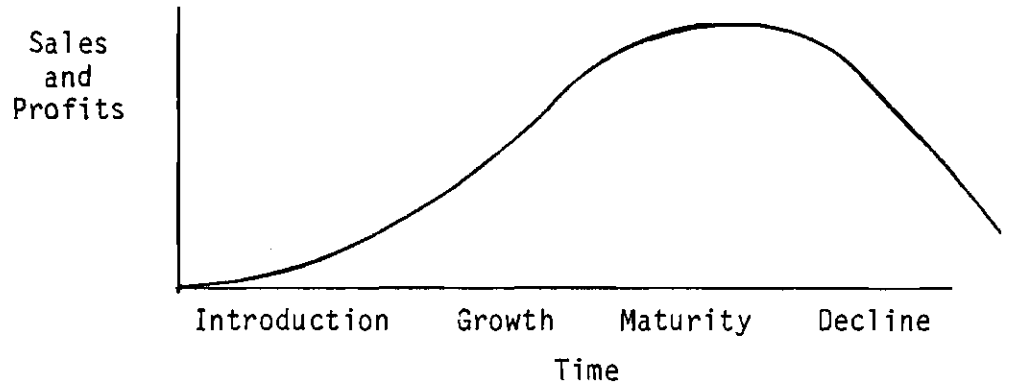

Figure 4.1. Sales and Profit Life Cycles

Hypothetically four stages are described in a typical product life cycle. Introduction, which is a period of slow growth since the product has just been introduced in the market, usually has no profits or very low ones due to the marketing expense required to introduce the product. Growth

is a period of positive market acceptance of the product and of increasing profits to the manufacturer. Maturity is characterized as a period of not so rapid sales growth, and it is a period in which profits peak and start to decline. The last period is the decline period where sales and profits decline. Often this is a period when substitutes of the product are made, new product uses are advertised, and innovations for the old product are introduced; all of which can counteract the drop on sales of the product.

However, not all products exhibit during their life cycle the idealized S-shaped product life shown in Figure 4.1. Some products may exhibit variations, such as shown in Figure 4.2; some may experience rapid growth from the very beginning; still others do not successfully grow. We are interested in analyzing possible causes for these variations.

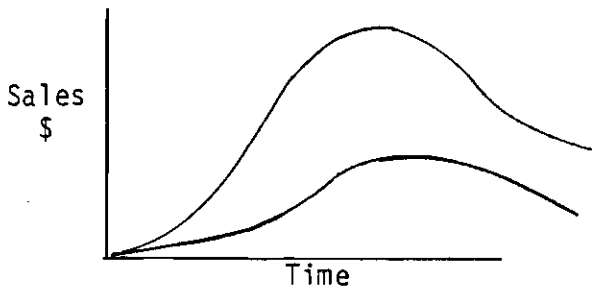

Figure 4.2. Other Life Cycle Variations

William E. Cox (19) in his studies of life cycles has found for some products, the cycle-recycle product life cycle (see Figure 4.3).

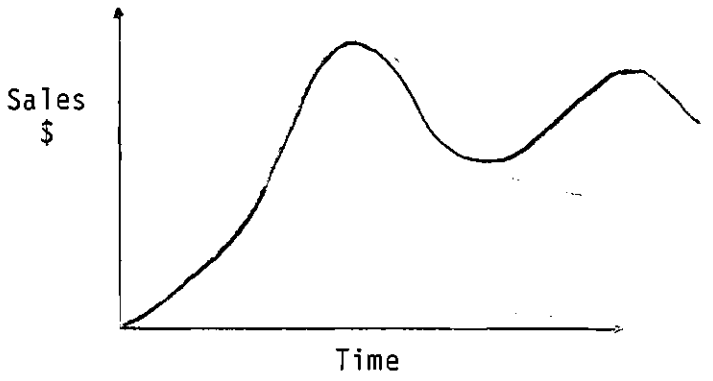

Figure 4.3. Other Possible Variations of a Product Life Cycle

Cox explained that the second cycle, which he denominated recycle, probably was caused by the traditional push of the product in the decline state, such as price reductions, product improvements and other marketing strategies which tend to stimulate sales at the declining stage.

We believe that the literature offers a good but not complete and detailed explanation of the time pattern behavior of the life cycle of a product.

The life cycle of a product may exhibit different variations depending on the conditions of the system and the interrelationships of feedback loops which create the life cycle pattern.

Factors such as product characteristics, inventory policies, pricing policies, advertising strategies, consumer behavior, environment, and many others effect the pattern behavior of sales for a given product.

The basic structure of a system is the totality of relationships between the variables that form the feedback loops. Forrester points out that the basic structure of alternating levels and flow rates seems to

represent the nature of industrial management system.

Levels are the accumulations within the system and determine the decisions that control flow rates (see Figure 4.4).

Flow rates define the present, instantaneous flows between the levels in the system (see Figure 4.4).

The control of the rates of flow between levels is exerted by the decision functions (see Figure 4.4).

A general structure of a model is therefore represented as levels interconnected by rates of flow and the fundamental time sequence of computation can be described in terms of levels and rates. Time delays arise in every stage of system activity and are important to consider in the model formulation.

It is important that in order to do a proper formulation of a dynamic simulation model there should exist a close correspondence between the real world situation or real system and the model to be constructed. Model variables have to be represented in the same units as the real variables.

It must also be distinguished between the actual conditions of the system and the desired conditions of the system. An information feedback loop usually includes accumulations, flows and auxiliaries. The difference between an actual accumulation and a desired accumulation leads to a decision that will correct the discrepancy. This is represented in Figure 4.4.

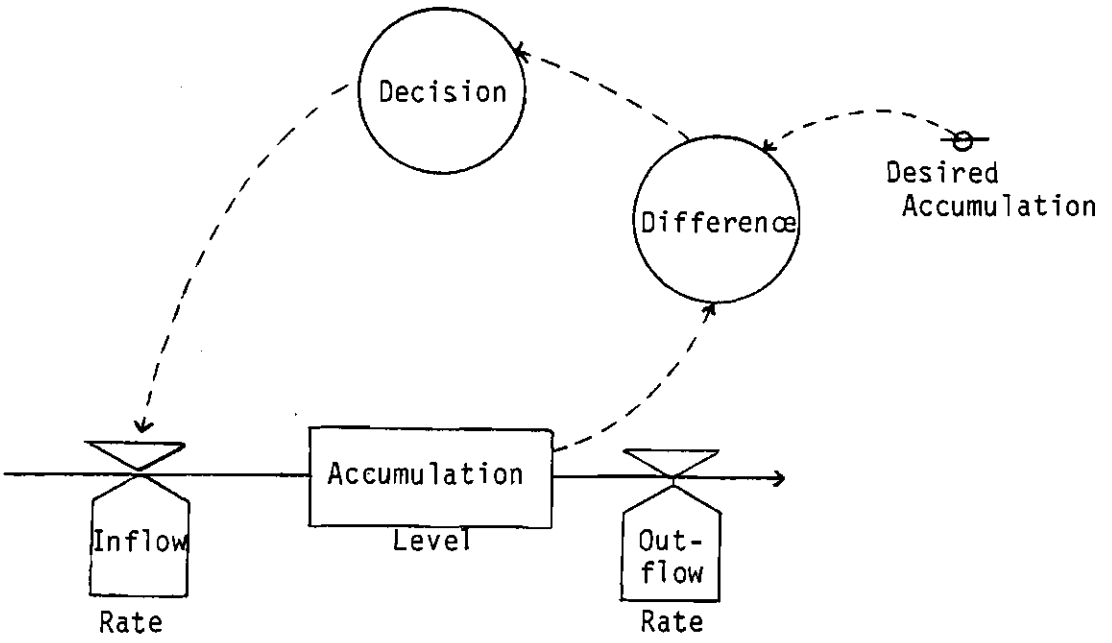

Figure 4.4. Negative Feedback Loop

Feedback loops may either be positive or negative. A positive feedback loop is characterized by a positive change in the accumulation value coming around the loop after an initial positive change in the accumulation was made. Positive loops have zero or an even number of sign alternations (negative link gains) around the loop, and negative feedback loops have an odd number of sign alternations.

For example, the sign of the link between an inflow and an accumulation is plus and between an outflow and an accumulation is minus. A general loop structure representation is illustrated in Figure 4.5.

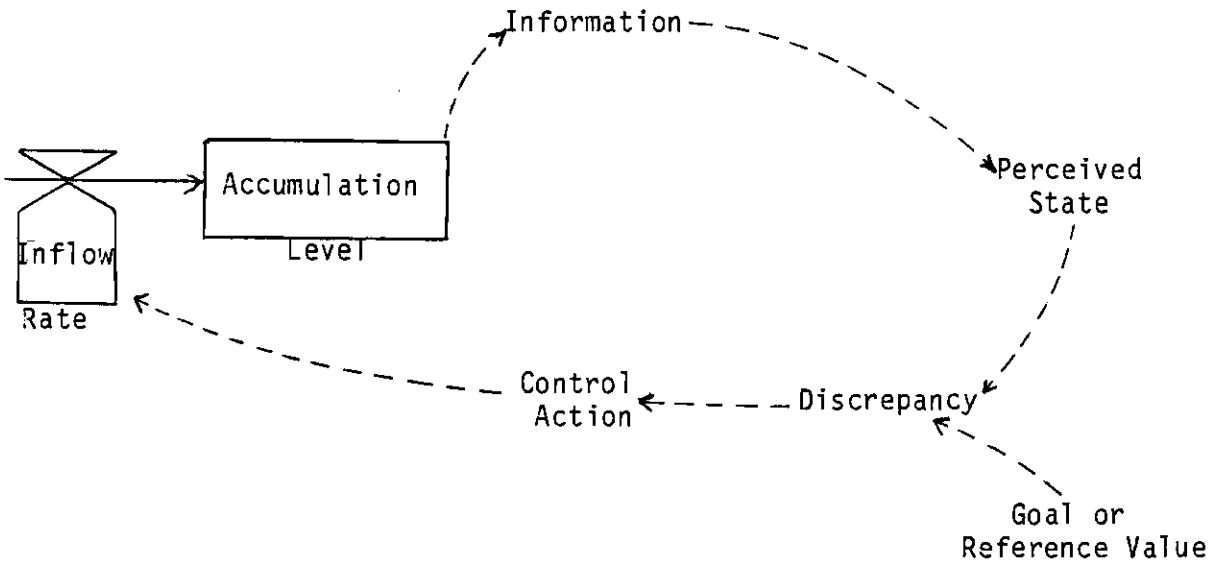

Figure 4.5. Feedback Loop Representation

Positive feedback loops are associated with trends, usually growth, and negative feedback loops are usually associated with oscillatory behavior.

The coupling of several feedback loops creates the time pattern behavior of a system and in a real situation a variable's time history is the result of how the feedback loops are combined. It becomes important to analyze which loop influences more the variable behavior and how this loop is interrelated with other loops in the system.

The feedback structure of the system is the result of the totality of relationships between the variables that form the feedback loops.

Feedback Dynamics focuses its analysis on the interrelated loops of a system. It analyzes the performance patterns of the variables from the past through the present and to the future; and after evaluating performance, it focuses on a continuing improvement of the system.

The analysis of the feedback loops of our system are discussed in the next section of this chapter.

B. Feedback Loops Analysis

The life cycle of a product may exhibit different variations depending on the marketing system and basically on the interrelationship of feedback loops which create the life cycle pattern.

The life cycle of a product is created by a feedback system that should be analyzed considering all or at least the most important feedback loops in its marketing system.

The most important feedback loops in the marketing system assumed are exhibited in Figure 4.6.

Another important feedback loop in the system involving product availability is illustrated in Figure 4.7.

Inventory decisions for both producer and distributor is also an important feedback loop. The inventory decision is made considering actual inventory, average sales during a certain period of time and considering an estimate time of desired inventory. This important decision is illustrated in Figure 4.8.

The effect of price reduction is exhibited in Figure 4.9, and Figure 4.10 exhibits some of the simple life cycle variations to be studied, which are mainly based on sales peak time and accumulated average profits during the project's life.

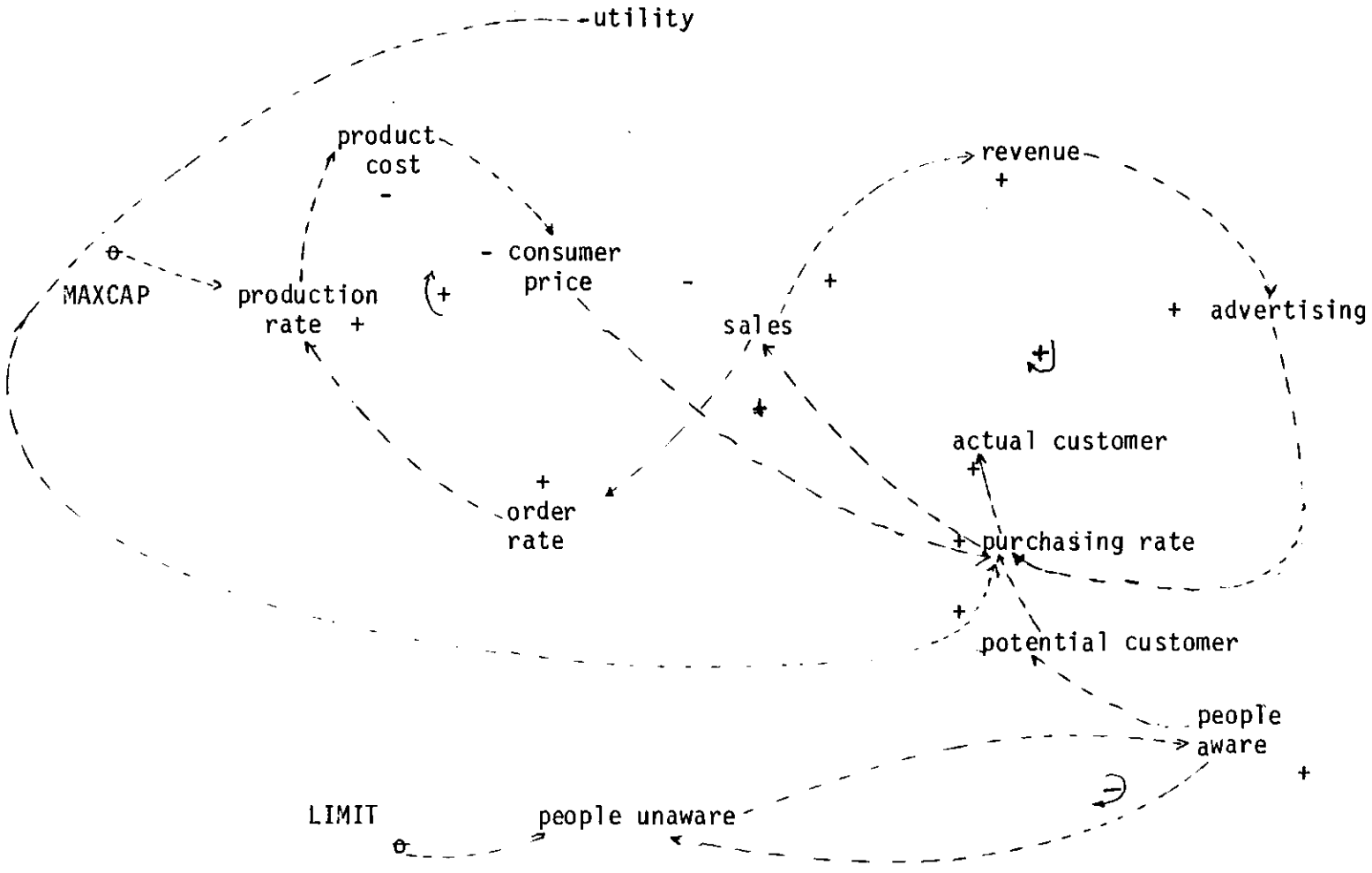

Figure 4.6. Most Important Feedback Loops of the Marketing System Under Consideration

We can identify two important positive loops and one negative loop. One positive loop is present as an increase of sales and leads to more revenue, increasing thus the advertising. Advertising as a means of communication will influence the awareness rate.

Another important positive loop is that increasing sales increases order rate from the distributor, this will tend to increase production rate and if the pricing of the product is based on cost; and if price is dependent of production output, an increase in production will tend to reduce the cost of producing the product. This price reduction favors consumer response and can be assumed that has a positive influence on the sales variable.

An important negative feedback loop is the assumption of a limited population of prospective purchasers, with the decrease of potential customers, sales will gradually drop to unprofitable levels.

It is expected that the sales pattern history may change depending on many factors such as: product characteristics, product availability, reordering policies, inventory policies, manufacturing decisions, pricing and advertising strategies and consumer response.

Two important feedback loops coupled together that involve product availability are indicated in the next Figure: 4.7.

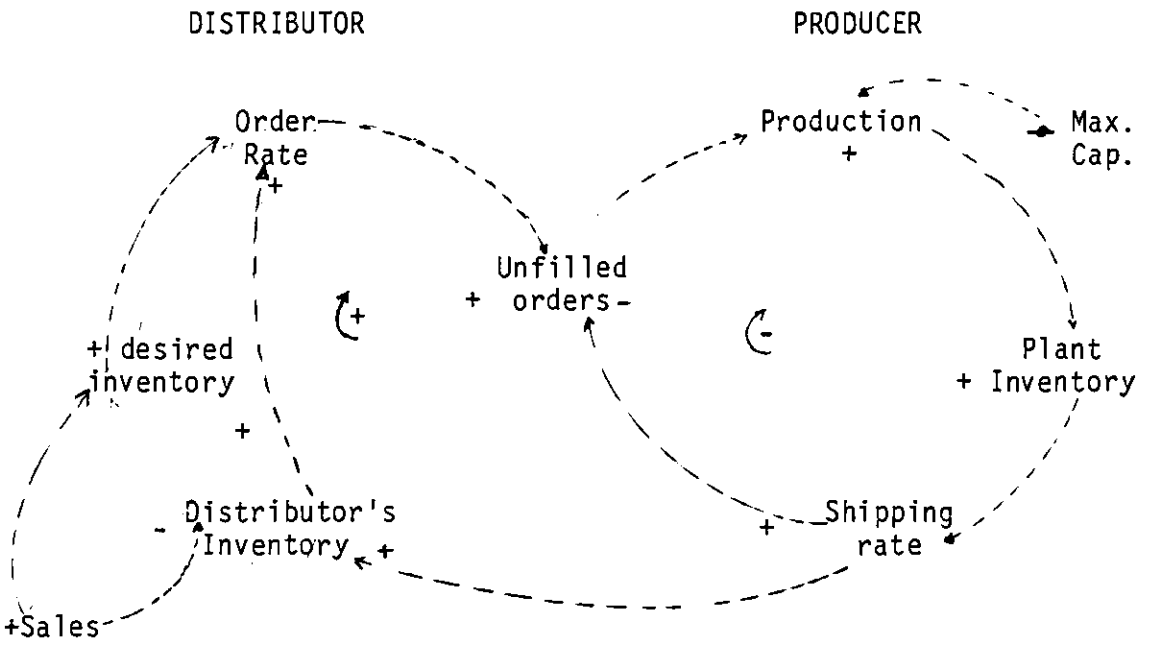

Figure 4.7. Coupled Feedback Loops Involving Product Availability

Product availability is an important marketing variable that has effect in the sales response pattern of a product.

Inventory decisions for both producer and distributor are based on actual inventory data, desired inventory evaluation and corrective action needed to eliminate discrepancy (see Figure 4.8). As, for example, in the case of the producer the corrective action is directed toward an increase or decrease of production, while in the case of the distributor the action leads to an increase or decrease of the order rate.

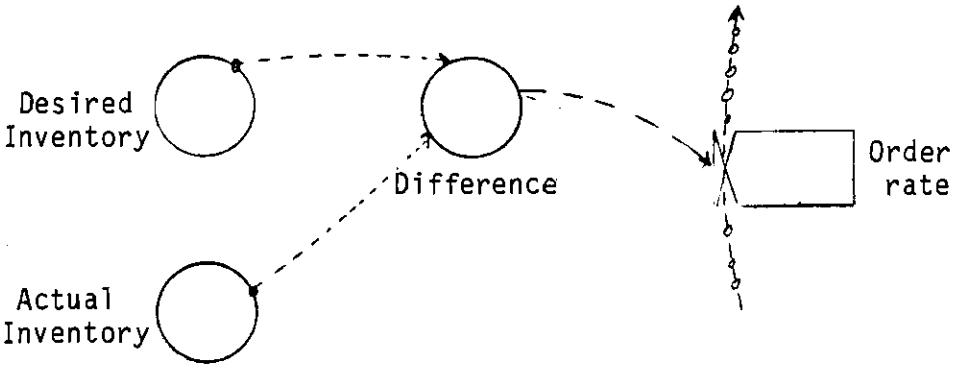

Figure 4.8. Inventory Control

Once product availability is established by adequate reordering policies and inventory policies, it is important to focus our attention in the advertising variable.

Advertising is an importatn variable in the promotional effort. People unaware of the product may become aware of it through advertising.

Advertising is an important tool by which the producer directs persuasive communications to target buyers. Advertising has the important task of enhancing potential buyers by providing them valuable information about the product such as product characteristics, quality, company service and many other factors which a potential buyer associates when making the purchasing decision.

Promotion and advertising are really lines of communication between the producer organization and the prospective buyer. Whether the customer will buy or not the product depends on many factors as the product and the utility that the prospective buyer has attached to it; the price, promotional effort, money availability, and other aspects

involved in the marketing process. The effect of advertising was illustrated in Figure 4.6.

Many economic models have considered price as an important variable and tend to emphasize the effect of price in demand without considering other factors such as customer psychological reaction to increases or decreases in price, competition, price determination in short and long term analysis, and other factors which are important.

Several practices of pricing have been applied in practice, some of them are:

(1) Market Penetration Objective - It establishes that some companies set a realtively low price in order to stimulate the growth of the market and to capture a large share of it. Several conditions may favor a low price setting such as: (a) The market appears to be highly price-sensitive, so a lower price may bring additional buyers into the market. (b) The unit costs of production and distribution decrease with increased output. (c) A low price would discourage actual and potential competition.

This is represented in Figure 4.9.

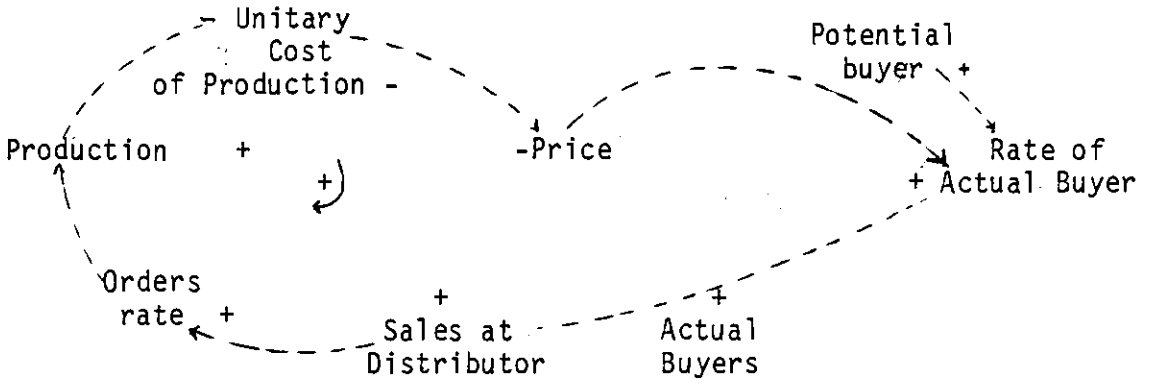

Figure 4.9. Effect of Price reduction in Market Penetration Objective

(2) Market-Skimming Objective - The objective of skimming pricing is to gain profit from the initial buyers which for several reasons are willing to pay a higher price for a product, and only gradually reduce the price to draw in the more price-elastic segments of the market. Several conditions favor this policy such as: a) There exists a sufficiently large number of buyers with the disposition of paying a higher price. b) The unit production cost of producing a smaller volume is not so much higher than the advantage of charging the higher price.

(3) Early Cash Recovery Policy - This policy leads to set a price to a product which can lead to a rapid recovery of cash. Usually it exists when a company requires funds or is uncertain about the future of the market or market response to their product in the future.

Other pricing policies are based on rate of return goal of the company, product-line promotion objective, demand oriented pricing, markup pricing and competition oriented pricing.

Other decisions that must be made in any marketing system such as production rate, shipping rate, advertising rate and some others will be explained later. We have just focused in what we believe are the more important feedback loops of the system and which dominate the time pattern response of sales in the marketing system that we have assumed.

Some of the variations in a simple life cycle time history to be studied here are different times of peak point of sales. The time when the peak occurs may vary depending on different policies and consumer response (see Figure 4.10).

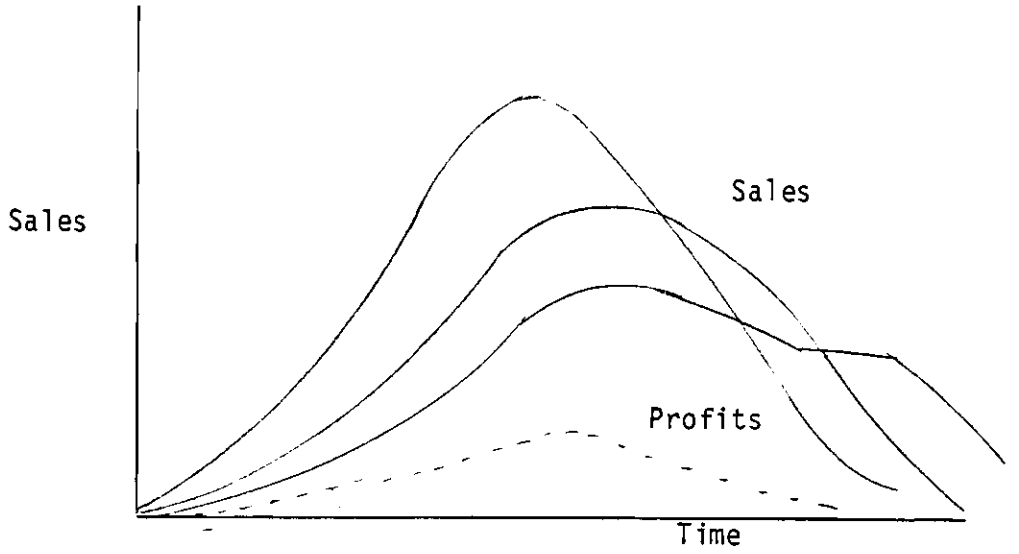

Figure 4.10. Simple Life Cycle Variations to be Studied

The growth of sales is associated with the positive loop of promotional effort influencing sales and decreasing price as a result of increasing production output. The initial stage of the life cycle is characterized by a low volume of sales, potential customers are minimum and price is usually high due to low volume of production. Growth starts when the product begins to make rapid sales gains due to cumulative effects of introductory promotion and distribution. At the maturity stage sales growth continues but at a declining rate; this is due to the declining number of potential customers in the market. Finally the life cycle may exhibit maturity which is a level of stable sales, reaching gradually the decline stage characterized by the decreasing rate of potential customers in the market.

Product profits are usually absent in the introductory stage, tend to increase substantially in the growth stage, slow down and then stabilize in the maturity and saturation stages, and decrease in the declining stage.

Since all the stages of the life cycle have different characteristics, it is important to analyze the effect of the marketing variables under control such as price, advertising and distribution at different stages of the life cycle.

In this study we will analyze these different stages with different pricing, advertising and distribution strategies.

Simple variations of the life cycle of a product to be explored in this study are mainly concerned with peak time, sales growth, sales decline and profitability (see Figure 4.10).

CHAPTER V

MODEL STRUCTURE

A. Introduction

After defining the marketing system and the main elements to be included in the analysis we then proceed to formulate the model.

The system diagram is exhibited in Figure 5.1. Other diagrams representing each subsystem are included along with the discussion of each subsystem.

The mathematical equations for the variables are represented in this chapter. Parameters are estimated within reasonable ranges and initial values are selected.

We will first describe the producer subsystem, followed by the distributor and finally the consumer subsystem will be discussed.

B. Producer Subsystem

The producer subsystem to be considered is very simple but adequate to meet our objectives. A flow diagram is illustrated in Figure 5.2.

It is considered that after some marketing effort in the initial stage, orders arrive at the producer as requisition orders from the distributor.

Unfilled orders at the producer sector may be represented as:

$$L\ UOP.K = UOP.J + (DT) * (OR.JK - ASHR.JK)$$

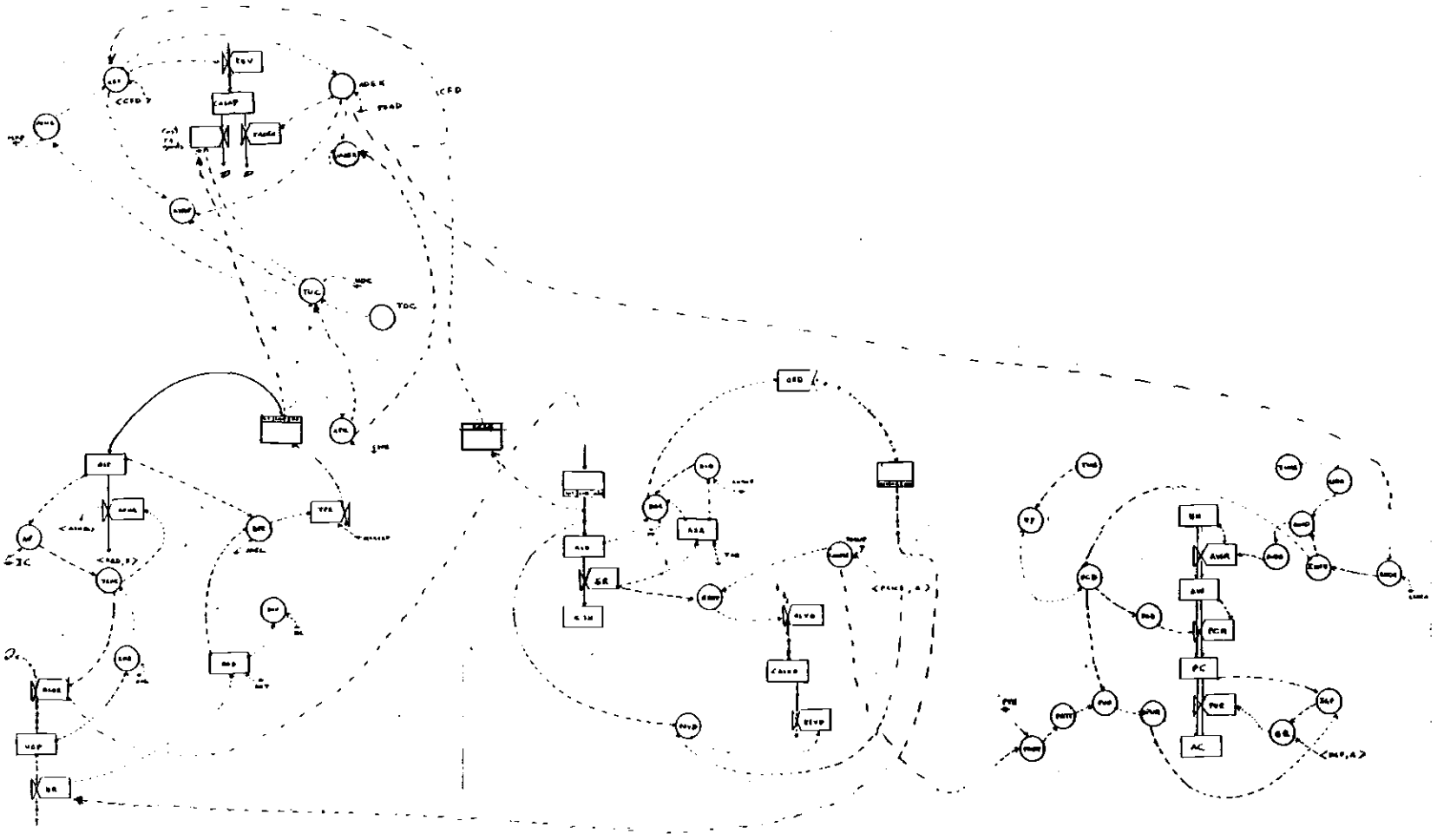

Figure 5.1. Model Flow Diagram

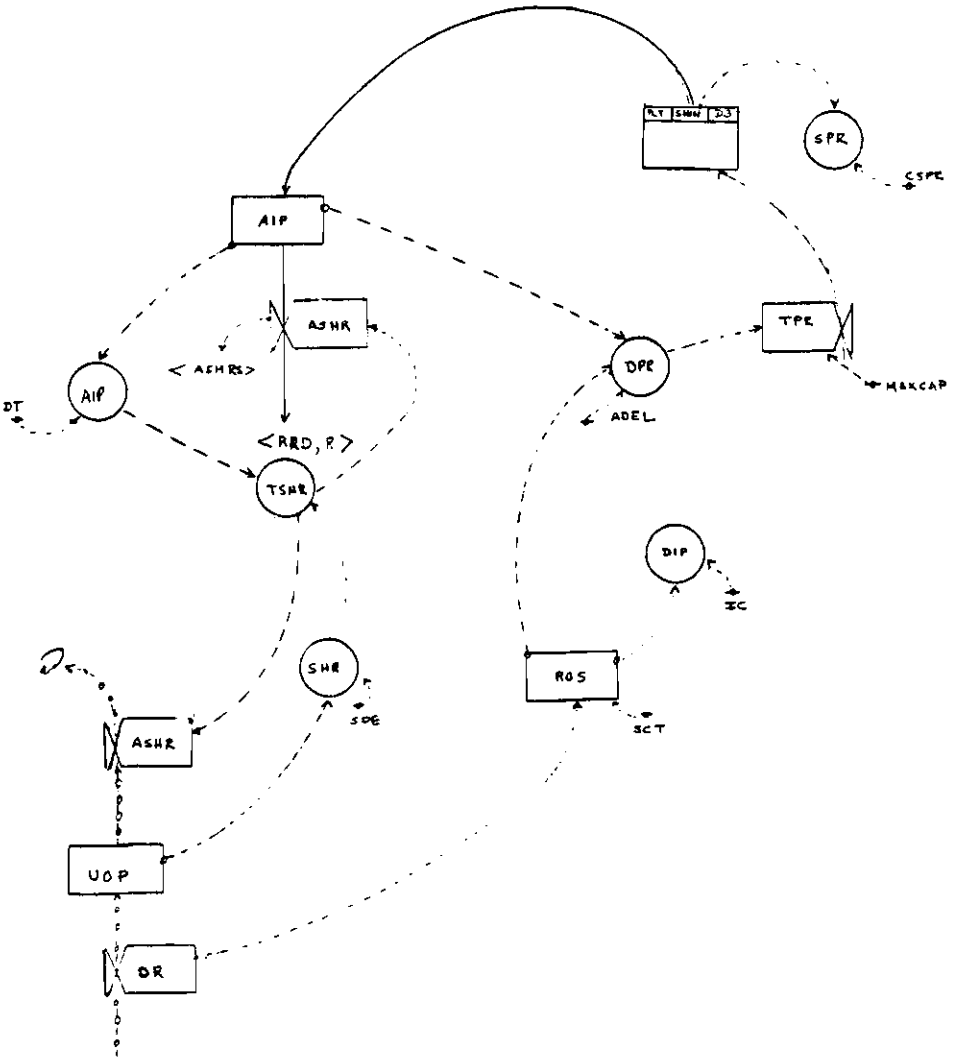

Figure 5.2. Flow Diagram of the Production Sector

UOP Unfilled orders at producer (units)

OR Order rate from distributor (units/week)

ASHR Actual shipping rate at producer (units/week)

DT Time interval (weeks)

Unfilled orders will be shipped to the distributor depending on the availability of inventory at the plant and considering a constant shipping delay.

R ASHR.KL = MIN (UOP.K/SDE, AIP.K/DT)

ASHR Actual shipping rate to distributor (units/week)

UOP Unfilled orders at producer (units)

AIP Actual inventory at producer (units)

SDE Delay (weeks)

The order rate from the distributor is smoothed over a period of time since this infromation will be helpful in estimating desired inventory availability. This is represented by a smooth equation of the form:

L ROS.K = ROS.J + (1/SCT) * DT * (OR.JK - ROS.J)

C SCT = 4

ROS Order rate from the distributor smoothed over a period of time. (units/week)

OR Order rate from distributor (units/week)

SCT Smoothing constant (weeks)

Desired inventory at the producer will be based on the smoothing equation for order rate previously described multiplied by a

time constant that represents the weeks of provision desired:

A DIP.K = (IC) * (ROS.K)

DIP	Desired inventory at producer	(units)
IC	Weeks of provision desired	(weeks)
ROS	Order rate from the distributor smoothed over a period of time	(units/week)

The actual inventory at the plant is a level, this accumulation of goods is expressed as the difference between the plant production rate and the actual shipping rate of goods to the distributor. The equation is represented as:

L AIP.K = (DT) * (SHIN.JK - ASHR.JK)

AIP	Actual inventory at producer	(units)
SHIN	Shipping of goods from production to plant inventory	(units/week)
ASHR	Actual shipping rate from producer to distributor	(units/week)
DT	Time interval	(weeks)

The desired production rate subject to the maximum capacity limitation of the facility will be based on the company's requistion orders smoothed and the consideration of desired and actual inventory at the plant.

$$A\ DPR.K = ROS.K + \left(\frac{1}{ADEL}\right)(DIP.K - AIP.K)$$

DPR	Desired production rate at producer facility	(units/week)

DIP Desired inventory at producer (units)

AIP Actual inventory at producer (units)

ADEL Adjustment delay (weeks)

After defining the desired production rate we need to consider the plant maximum capacity limitation, so the effective production rate is expressed as:

R PR.KL = MIN(DPR.K, MAXCAP)

PR Effective production rate at plant (units/week)

DPR Desired production rate at plant (units/week)

MAXCAP Maximum capacity installed of production at plant (units/week)

MIN DYNAMO decision function (minimum value)

The shipping of goods to plant inventory will be expressed as a third order delay. This is expressed by the following equation:

R SHIN.KL = DELAY3(PR.JK, PLT)

SHIN Shipping of goods from production to plant inventory (units/week)

PR Production rate at plant (units/week)

PLT Production lead time (weeks)

The actual shipping rate to the distributor smoothed over a given period of time is an equation represented as:

$$L\ ASHRS.K = ASHRS.J + \left(\frac{1}{STCT}\right) * (DT) * (ASHR.JK - ASHRS.J)$$

ASHRS Actual shipping rate to distributor smoothed (units/week)

STCT Smoothing time constant (weeks)

DT Time interval (week)

ASHR Actual shipping rate to distributer (units/week)

The average production rate over a given period of time is represented by the following equation:

A SPR.K = SMOOTH (SHIN.JK,CSPR)

SPR Average production rate (units/week)

SHIN Shipping of goods to plant inventory (units/week)

CSPR Smoothing constant (weeks)

C. Distributor Sector

A flow diagram of the distributor sector is shown in Figure 5.3.

The distributor sector is an important part of the total system due to the impact that delays and ordering policies have on the overall system.

The distributor sector has been simplified in order to focus our attention more in the variables that we believe have a major influence on the system; such as, ordering decision, desired inventory level, cash and profit position.

We will descirbe briefly the equations associated with this sector.

Equations for the Distributor Sector

One important decision that the distributor must take is the order rate. The desired order rate is calculated considering the factors:

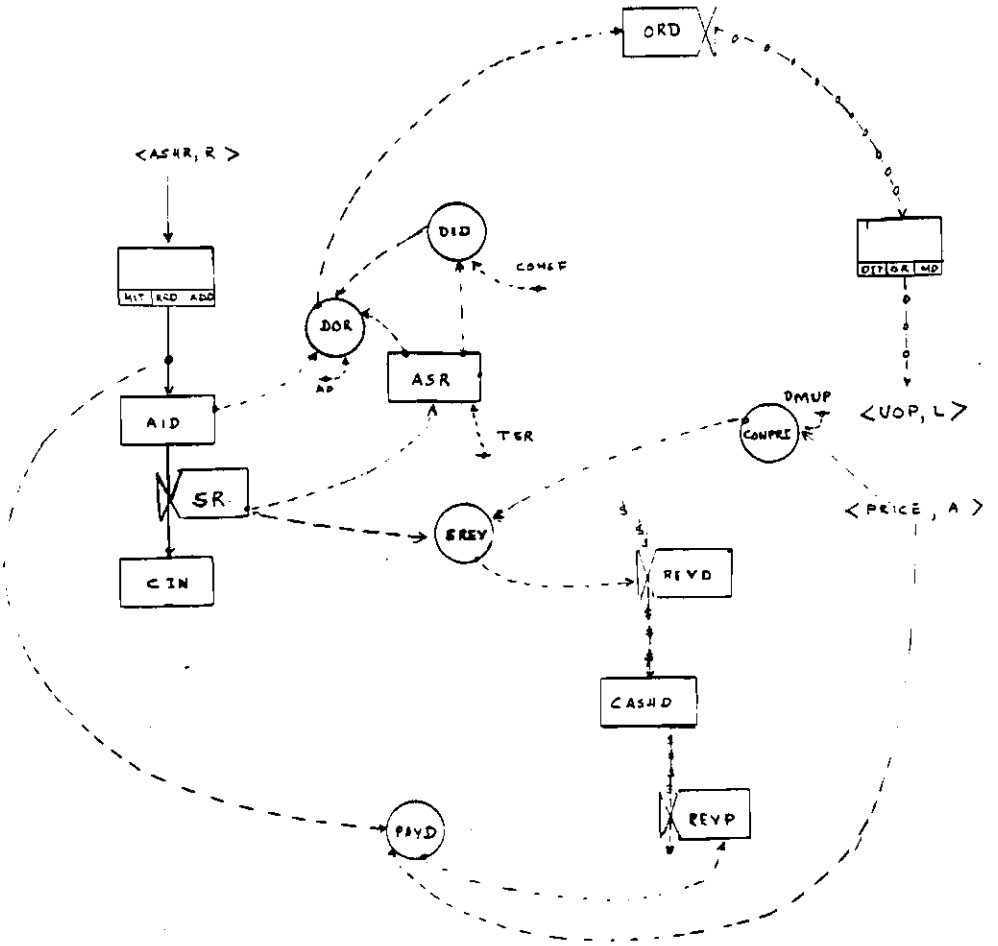

Figure 5.3. Flow Diagram of the Distributor Sector

desired inventory, actual inventory and average sales rate. This equation is expressed as:

A DOR.K = ASR.K + (1/AD) (DID.K - AID.K)

DOR Desired order rate (units/week)

ASR Average sales rate (units/week)

AD Adjusted Delay (weeks)

DID Desired inventory at distributor (units)

AID Actual inventory at distributor (units)

The average sales that the distributor makes may be calculated as a smoothing equation expressed:

L ASR.K = ASR.J + (1/TSR) (DT) (SR.JK - ASR.J)

ASR Sales rate smoothed (units/week)

TSR Smoothing time (weeks)

SR Sales rate (units/week)

The actual order rate involves a delay which may be represented as a third order delay. This consideration is expressed as:

R OR.KL = DELAY3 (ORD.JK,MD)

OR Order rate from distributor (units/week)

ORD Order rate decision (units/week)

MD Mail delay (weeks)

The desired inventory at the distributor is based on the average sales and a constant factor. This is represented by the equation:

A DID.K = (ASR.K) * (CONSF)

DID Desired inventory at distributor (units)

ASR Average sales rate (units/week)

CONSF Constant factor (weeks)

In order to formulate the equation for the actual inventory at the distributor, we need to specify the receiving rate equation and the sales rate equation.

The receiving rate of goods from the manufacturer may be expressed as a third order delay:

R RRD.KL = DELAY3 (ASHR.JK, ADD)

RRD Receiving rate at distributor (units/week)

ASHR Actual shipping rate from manufacturer (units/week)

ADD Arriving delay (weeks)

The sales rate is determined by the flow of people from the potential level to the actual customer level. A unit of flow in the consumer sector between these two levels will be equivalent to a unit of flow of product from the distributor's inventory to the customer inventory level.

The equation for the sales rate will be discussed in the consumer sector.

The actual inventory at the distributor is a level equation represented as:

L AID.K = AID.J + (DT) * (RRD.JK - SR.JK)

AID Actual inventory at distirbutor (units)

RRD Receiving rate of goods from producer (units/week)

SR Sales rate of goods to customers (units/week)

The order rate decision is based on the desired order rate, this is expressed as:

R ORD.KL = DOR.K

ORD Order rate decision at distributor (units/week)

DOR Desired order rate (units/week)

The equations concerning financial position are described in the financial sector.

D. Consumer Sector

Purchase behavior although very complex is best understood if we start with practical definitions of the concepts of demand and product.

The essence of these comcepts as pointed by Wasson C. [22] does not lie in the easily seen objective manifestations of them but in the highly varied subjective reactions of individuals.

The demand observed as a desire for some physical product is really a desire for satisfaction of some set of internal needs which the buyer believes will be gratified once he purchases the physical object.

Thuesen, G.J. [14] defines the purchasing action as when the buyer having money available, believes that the product has equal or greater utility for him than the amount required to purchase it. He defines utility as the power to satisfy human wants and that the utility that an object has for the individual is determined by him. Thus, the utility of an object is not inherent in the object itself but is inherent in the regard that a person has for it.

It is important to consider the complexity that consumer behavior has, and the difficulties involved in trying to simulate consumer behavior.

This sector of consumer behavior is an attempt to simulate with a very simple model consumer response to product characteristics such as utility, and to promotional efforts such as pricing strategies and advertising.

It has been suggested by some authors [27] that the task of advertising is to move the consumer from a state or disposition of unawareness of a product's existence to the state or disposition of being brand loyal to the product.

Others have argued that advertising only has the task of moving the consumer from a lower disposition state to a higher disposition state. This would involve a process such as:

UNAWARE ⟶ AWARE ⟶ INTEREST ⟶ PURCHASE

An important conclusion is that advertising has an effect in disposition states.

Another model proposed by Howard J. and Sheth J. [28] suggests the following model:

Nead arousal ⟶ Information search ⟶ Evaluation Behavior ⟶ Purchase Decision ⟶ Postpurchase Feelings

The model emphasizes that purchase decision making starts before the actual purchase and encourages the marketer to focus on the process rather

than on the sale.

In our model of the consumer sector we will consider three hypothetical states in which a consumer may be before deciding to purchase the product. These are:

UNAWARE ⟶ AWARE ⟶ POTENTIAL

It will be assumed that an important task of advertising is to move people from the unaware state to the awareness level. Although we will not give a detailed consideration to all the elements of the advertising process the rate of people becoming aware of the product will depend mainly on the company's advertising expense.

Hypothetically people in the aware state will attach a utility value to the product. This utility value will be incorporated in the simulation program as an auxiliary being function of time. People will move to a potential customer state depending on the disposition state at the awareness stage.

The use of attitudinal scales for simulation has been done by Amstutz A. [26] in his simulation model of competitive market response and will be used here also for the purpose of simulation.

Finally the purchase decision will be based on the interest in the product, the price effect and the advertising effort. The higher the value of these three factors combined together , the more likely it is that the consumer will buy in a shorter period of time. Forrester suggests that the time of purchasing may vary depending mainly on the advertising effort and on the change in consumer needs. This involves

a variable delay of several weeks up to several years. This criteria will be used in this model concerning the delay involved in the purchasing decision from prospective purchases of the product.

The following section of this chapter will include the equations for this sector.

Equations for the Consumer Sector

A flow diagram of the consumer sector is shown in Figure 5-4.

We shall begin by identifying four levels of people at the consumer sector. The unaware level includes people who have never heard of the product, the awareness level includes people who have been exposed to advertising and know about the product, the potential customer level includes people who after being exposed to advertising and information about the product have the interest of purchasing it. Becoming adopters is the last level denominated as "actual customer level".

The following equation for the unaware level is based on the consideration of a fixed population (single level) from which flows a single output rate, the equation for UN (Unaware People) is then expressed as:

$$L\ UN.K = UN.J + (DT) * (-AWR.JK)$$

UN	Unaware people	(people)
AWR	Awareness rate	(people/week)
DT	Time interval	(weeks)

The second equation, describing the number of people in the aware stage, is indicated considering the inflow rate, this is people

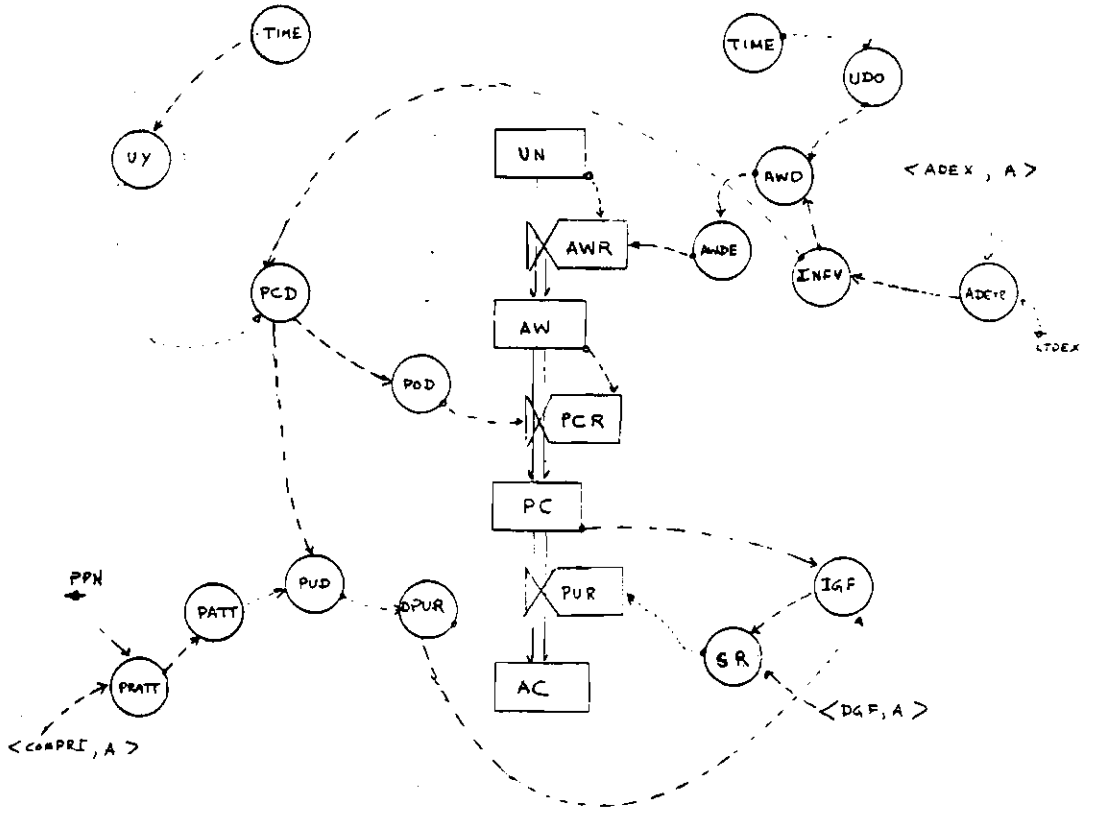

Figure 5.4. Flow Diagram of the Consumer Sector

aware per week, and the outflow rate which is people interested in the product per week and who become potential customers. This equation is a level represented as:

L AW.K = AW.J + (DT) * (AWR.JK - PCR.JK)

AW	Level of aware people	(people)
AWR	Awareness rate	(people/week)
PCR	Potential customer rate	(people/week)

The third equation is also simple and describes the people who state in the system as potential customers, this equation is a level and is represented as:

L PC.K = PC.J + (DT) * (PCR.JK - PUR.JK)

PC	Potential customers	(people)
PCR	Potential customer rate	(people/week)
PUR	Actual Purchasing rate	(people/week)

It is assumed that when people transfer from the potential customer level to the actual customer level each person will buy only one product unit provided that it exits at the distributor's inventory. A conversion factor is included in the equation of sales rate to be described later.

The fourth equation describes the number of people who actually have bought the product, we will describe it as the actual customer level and is represented as:

L AC.K = AC.J + (DT) * (PUR.JK)

AC	Actual customers	(people)
PUR	Actual purchasing rate	(people/week)

The actual purchasing rate considering the availability of inventory is expressed as sales rate, assuming that one unit is sold when one person becomes an actual customer, i.e.,

$$\left(\frac{\text{people}}{\text{week}}\right)\left(\frac{\text{Unit}}{\text{people}}\right) = \left(\frac{\text{units sold}}{\text{week}}\right)$$

This will be explained later when describing the actual purchasing rate equation.

The equations for the consumer levels are simple and straight forward; however the equations for rates are not so easily obtained and require a deeper understanding.

We will describe the awareness rate equation, i.e., people becoming aware of the product. As discussed previously, one of the major functions of advertising is to create awareness of the existence of the product.

It will be assumed that mainly advertising will influence awareness and also the use descriptor value of the product. The hypothetical use descriptor value as explained by Amstutz [30] is a probability of use of the product.

The awareness rate will be formulated as a function of unaware people and a variable delay determined by advertising and the use descriptor value.

Advertising will be identified as information value. The effect that advertising will have in the variable delay will depend on the ratio, advertising expense and saturated advertising expense.

The following equations are then required:

A UDO.K = TABHL (YUDO,TIME.K)

UDO Use descriptor opportunity (dimensionless)

In order to quantify the total effect of advertising and use of the product the following relationship is assumed:

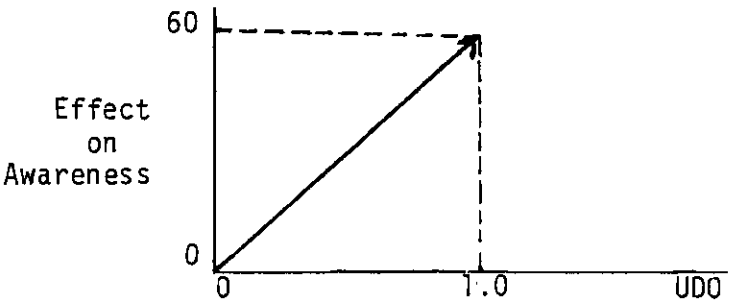

Figure 5.5. Effect of Use Descriptor on Awareness

It will be assumed also a linear effect depending on the advertising ratio. This is represented by Figure 5.6.

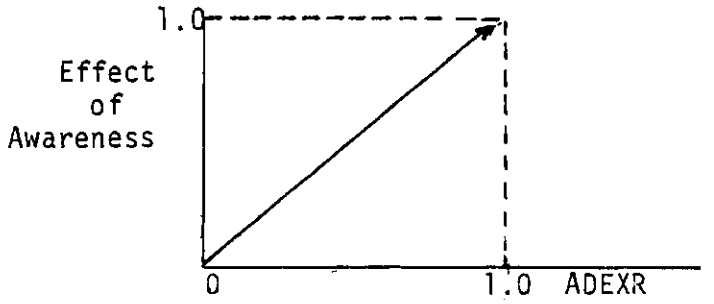

Figure 5.6. Advertising Ratio Effect

The advertising ratio is just an auxiliary expressed as:

$$A\ ADEXR.K = \frac{ADEX.K}{LTDEX}$$

ADEXR	Advertising expense ratio	(diminsionless)
ADEX	Weekly advertising expense	($/week)
LTDEX	Saturated advertising expense	($/week)

Both effects are expressed as an additive function:

A AWD.K = INFV.K + UDO.K

AWD	Additive effect in awareness delay	(dimensionless)
INFV	Advertising effect	(dimensionless)
UDO	Probability of use effect	(dimensionless)

Where INF.K is a table function; A INFV.K=TABHL(YINFV,ADEXR.K)

The variable delay will be then expressed as a table function:

A AWDE.K = TABHL(YAWDE,AWD.K,0,2,INC)

AWDE	Awareness delay	(week)
AWD	Effect on awareness delay	(dimensionless)

We will assume a large value of the delay for small values of AWD and short values of the delay for larger values of AWD. Two extreme values used for simulation were 200 weeks and one week. See Figure 5.7.

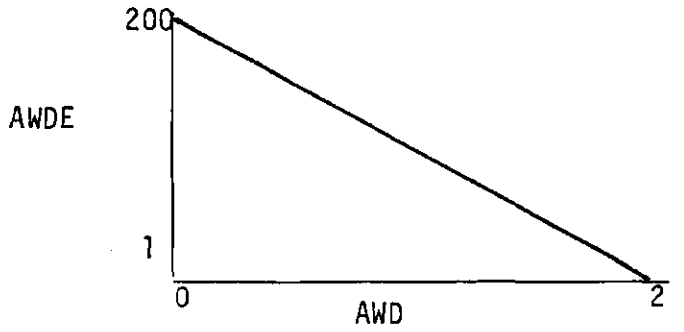

Figure 5-7. Awareness delay as a Function of Awareness Effect

The awareness rate is then expressed as:

$$R\ AWR.KL = \frac{UN.K}{AWDE.K}$$

AWR	Awareness rate	(people/week)
UN	Unaware people	(people)
AWDE	Awareness delay	(weeks)

The next rate equation to be considered is the potential customer rate equation. We will assume that in order to become a potential customer two major considerations exist. First, a positive attitude toward the product; this is based on the utility that the product has for the person and is a degree of satisfaction that he derives from it.

The utility of the product may remain constant or change during the project's life. It will be represented as a table function:

A UY.K = TABHL (YUY,TIME.K)

UY	Utility of product	(dimensionless)

The utility value will be quantified in a scale of 0 to 1.

Second, advertising has also an influence on the delay in becoming a potential customer. The potential customer disposition will be considered as an additive effect of promotion and utility.

A PCD.K = INFV.K + UY.K

PCD	Disposition state affecting potential customer delay	(dimensionless)
INFV	Advertising effect	(dimensionless)
UY	Utility attached to the product	(dimensionless)

Increases in this disposition state will reduce the delay in becoming a potential customer. This delay is expressed as a table function.

A POD.K = TABHL(YPOD,PCD.K,0,2,1)

We will again assume that the higher the value of PCD the shorter the delay in becoming a potential customer.

The rate equation that will relate the flow from aware to potential customer is expressed as:

$$R\ PCR.KL = \frac{AW.K}{POD.K}$$

PCR	Potential customer rate	(People/week)
AW	People aware level	(people)
POD	Potential customer delay	(weeks)

The purchasing decision involves the consideration of several factors. A quantitative form to evaluate the impact of these factors is again considering an additive effect of potential customer disposition and the price effect.

Assuming an additive effect, the higher the disposition state toward purchasing the shorter the delay in purchasing.

The following equations are involved in the purchasing decision:

A PUD.K = PCD.K + PATT.K

PUD	Purchasing disposition	(dimensionless)
PCD	Potential customer disposition	(dimensionless)
PATT	Price effect	(dimensionless)

The purchasing disposition depends then on four factors: promotion, utility, price and opportunity of use of the product.

The purchasing delay will depend on this quantitative measurement of purchasing disposition, this delay is expressed as a table function:

A DPUR.K = TABHL(YDPUR,PUD.K)

DPUR	Delay in purchasing	(weeks)
YDPUR	Table values for the delay	(weeks)
PUD	Purchasing disposition	(dimensionless)

The price effect is also a table function that depends on the ratio of price of the product and an average normal price for the product. This is expressed as:

$$A\ PRAT.K = \frac{CONPRI.K}{PPN}$$

PRAT	Ratio of consumer price and perceived value of the product	(dimensionless)
CONPRI	Consumer price	($/unit)
PPN	Average price of the product	($/unit)

The price effect is represented as a table function:

A PATT.K = TABHL (YPATT,PRAT.K)

The values assumed for YPATT are indicated in the Appendix.

The purchase rate will then be expressed as:

$$A\ PURD.K = \frac{PC.K}{DPUR.K}$$

PURD	Purchase rate	(people/week)
PC	Potential customers	(people)
DPUR	Delay in purchasing	(weeks)

The equation above is expressed as an auxiliary since we need to consider the product availability at the distributors inventory. The sales rate equation is then expressed:

R SR.KL = MIN (AID.K/DT, PURD.K * CONF)

SR	Sales rate	(units/week)
AID	Inventory of distibutor	(units)
DT	Time interval	(weeks)
PURD	Purchase rate	(people/week)
CONF	Conversion factor	$(\frac{1 \text{ unit}}{\text{people}})$

E. Financial Sector

A simplified financial sector will be considered for the producer subsystem. A flow diagram of this sector is represented in Figure 5.8.

First it is assumed that the producer has an estimate of its total overhead costs during the life of the project. Total overhead costs will be represented by the equation:

A TOC.K = TABHL(YTOC, TIME.K)

YTOC = values for overhead costs during projects' life.

A constant direct cost associated with the product will be expressed as:

C UDC = 20

UDC Utility direct costs ($/unit)

It will be assumed constant during the project's life.

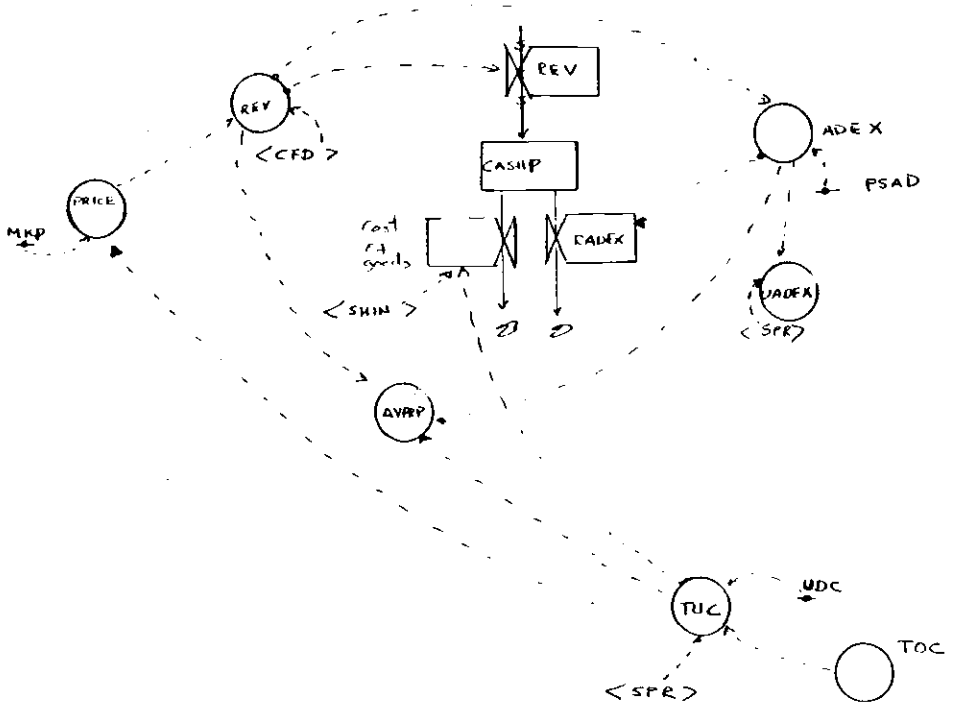

Figure 5.8. Financial Sector at Producer

Overhead as used here includes taxes insurance, interest, rent, depreciation and maintenance of buildings, furniture and equipment, and salaries of factory supervision.

We will assume in this study a very small enterprise, with limited resources and we will focus our analysis in only one product.

Considering the average production rate the overhead cost spread over each unit of production leads to the following equation:

$$A\ UOC.K = \frac{TOC.K}{SPR.K}$$

UOC	Unitary overhead cost	($/unit)
TOC	Total overhead cost	($/unit)
SPR	Average production rate	(Units/week)

The total cost per unit produced is expressed as the sum of the direct cost and the unitary overhead cost:

$$A\ TUC.K = UDC + UOC.K$$

TUC	Total unitary cost	($/unit)
UDC	Constant direct cost	($/unit)
UOC	Unitary overhead cost	($/unit)

The cost above mentioned does not consider the advertising expense, the cost of advertising associated with each unit of product produced will be expressed as:

$$A\ UADEX.K = \frac{ADEX.K}{SPR.K}$$

UADEX	Cost of advertising per unit of product produced	($/unit)
ADEX	Advertising expense at producer's sector	($/unit)
SPR	Average production rate	(units/week)

Considering that the producer will price the product on a fixed mark up policy, the price given to the distributor is:

A PRICE.K = (TUC.K)(1 + MKP)

PRICE	Price to distributor	($/limit)
TUC	Total unitary cost	($/unit)
MKP	Markup at producer as percentage.	(dimensionless)

Assuming that the distributor pays the product upon receipt, cash received from sales at producer is expressed as:

REV.K = (CFD.JK)(PRICE.K)

REV	Revenue from sales at producer	($/week)
CFD	Acknowledgment of units received at distributor and payment	(units/week)
PRICE	Producer price	($/unit)

The term CFD is just a third order delay of the receiving rate at the consumer.

R CFD.KL = DELAY3 (RRD.JK,ARRD)

CFD	Acknowledgment of units received at distributor sector	(units/week)
RRD	Receiving rate at distributor	(units/week)
ARRD	Payment delay	(weeks)

The advertising expense will be assumed to be a fraction of the sales revenue. It is therefore represented:

A ADEX.K = (REV.K)(PSAD)

ADEX	Advertising expense	($/week)
REV	Review from sales at producer	($/week)
PSAD	Fraction of sales allocated to advertising	(dimensionless)

The profit at the producer based on price and products cost also considering the advertising expense is expressed as:

A AVPRP.K = (PRICE.K - TUC.K)(CFD.JK) - ADEX.K

AVPRP	Profit at producer	($/week)
PRICE	Producer's price	($/unit)
CFD	Units received at distributor	(units/week)
ADEX	Advertising expense at producer sector	($/week)

The profit rate is just expressed in terms of the auxiliary function.

R AVPRR.KL = AVPRP.K

The accumulation of profits during the project's life is expressed as:

L TAPP.K = TAPP.J + (DT)(AVPRR.JK)

TAPP	Accumulated profits at producer	($)
AVPRR	Profit at producer	($/week)
DT	Time interval	(weeks)

Cash at the producer sector is a level represented by the following equation:

L CASHP.K = CASHP.J + (DT)(CFD.JK)(PRICE.J)
- (DT)(SHIN.JK)(TUC.J) - (DT)(RADEX.JK)

CASHP	Cash at producer sector	($)
CFD	Acknowledgment of units received of product at Distributor	(units/week)
PRICE	Producter's price	($/unit)
SHIN	Production rate	(units/week)
TUC	Total unitary cost	($/unit)
RADEX	Advertising expense rate	($/week)
DT	Time interval	(weeks)

The rate equation for advertising is expressed as:

R RADEX.KL = ADEX.K

RADEX	Advertising expense rate	($/week)
ADEX	Advertising expense	($/week)

CHAPTER VI

MODEL SIMULATION

A. Introduction

In this chapter we will analyze the behavior of the original model based on the assumptions previously established. The simulation language used was DYNAMO III.

Several plots are presented in this chapter, varying some parameters, or changing certain policies such as pricing and advertising. The plots presented here are for a 500 week project's life and results are plotted every 15 week interval. Only the behavior of the most important variables is plotted on the graphs.

The main objective of working with the initial model is to obtain a better understanding of the system and analyze the influence that different policies and parameters values might have on the system.

The variables shown in the plots exhibited in this chapter are summarized in Table 6.1. The letters at the top of the plots represent the variables.

The following section will deal with the original model behavior and the analysis of different simulation runs.

Table 6.0. Variables Shown in Plots

Variable	Variable Name	Symbol
People aware	AW	A
Revenue from sales at producer	REV	$
Average profit at producer	AVPRP	*
Accumulated profit at producer	TAPP	I
Actual inventory at at producer	AIP	V
Actual inventory at distributor	AID	D
Sales rate of product	SR	S
Shipping of product to producer's inventory	SHIN	P

T Thousand
M Million

B. Original Model Behavior

The behavior of the original model through 600 weeks of simulation will be presented first. The interval of time chosen is 15 weeks. The plot is shown in Figure 6.1.

As described previously in the dynamic hypothesis chapter, it is expected that the life-cycle sales for one-time purchased products starts very low in the introduction stage and then rise to a maximum level, falling at the decline stage when no potential buyers are left.

Products that are purchased infrequently are exemplified by household appliances, furniture, and many durables. We will assume as a product a small household appliance.

Estimating sales is a very difficult task. There is no way to estimate future sales with certainty. Phillip Kotler (18) refers the purchase intention as a function of affect (attitude), social factors and anticipated situational factors. But purchase intention may not result in the actual purchase of the intended object. Purchase behavior he says, is a function of the purchase intention and the nonpredictable situational factors. The decision of an individual to modify, postpone, or avoid a purchase decision is heavily influenced by perceived risk. Buying therefore is not a single act but a multicomponent act influenced by innumerable factors.

In this study we have simplified the purchasing decision considering only four elements: information value, utility, use opportunity, and price.

The fixed costs per week during the life's project are assumed to

increase each 100 weeks. These are represented by the following equation:

A TFC.K = TABHL(YTFC,TIME.K,0,600,100)

T YTFC = 2000/2500/3000/3500/4000/4500/5000

The cost of production per unit is therefore affected by the level of production since the total fixed cost per unit decreases as production increases. The variable cost per unit will be assumed to be $20.

The pricing policy in the original model is based on a markup of 98% for the producer and 38% for the distributor. The price decision is therefore based on a cost basis.

The advertising decision is based on a percentage of sales. Initially this percentage will be assumed to be 4%.

The inventory decision for the producer and distributor is based on average sales, actual inventory and desired inventory. It has been assumed three hypothetical stages in which a consumer may be prior to reaching the purchasing decision. These states are: unaware, aware and potential customer.

Our first task will be to analyze an adequate marketing strategy for the introduction stage of the product.

It is important to mention that this model is not intended to be predictive, but rather an initial step that could lead us to understand the system assumed and obtain a better insight of market dynamics.

The initial run is exhibited in Figure 6.1. The reader may observe that at the introduction stage sales are at a low level, profits are

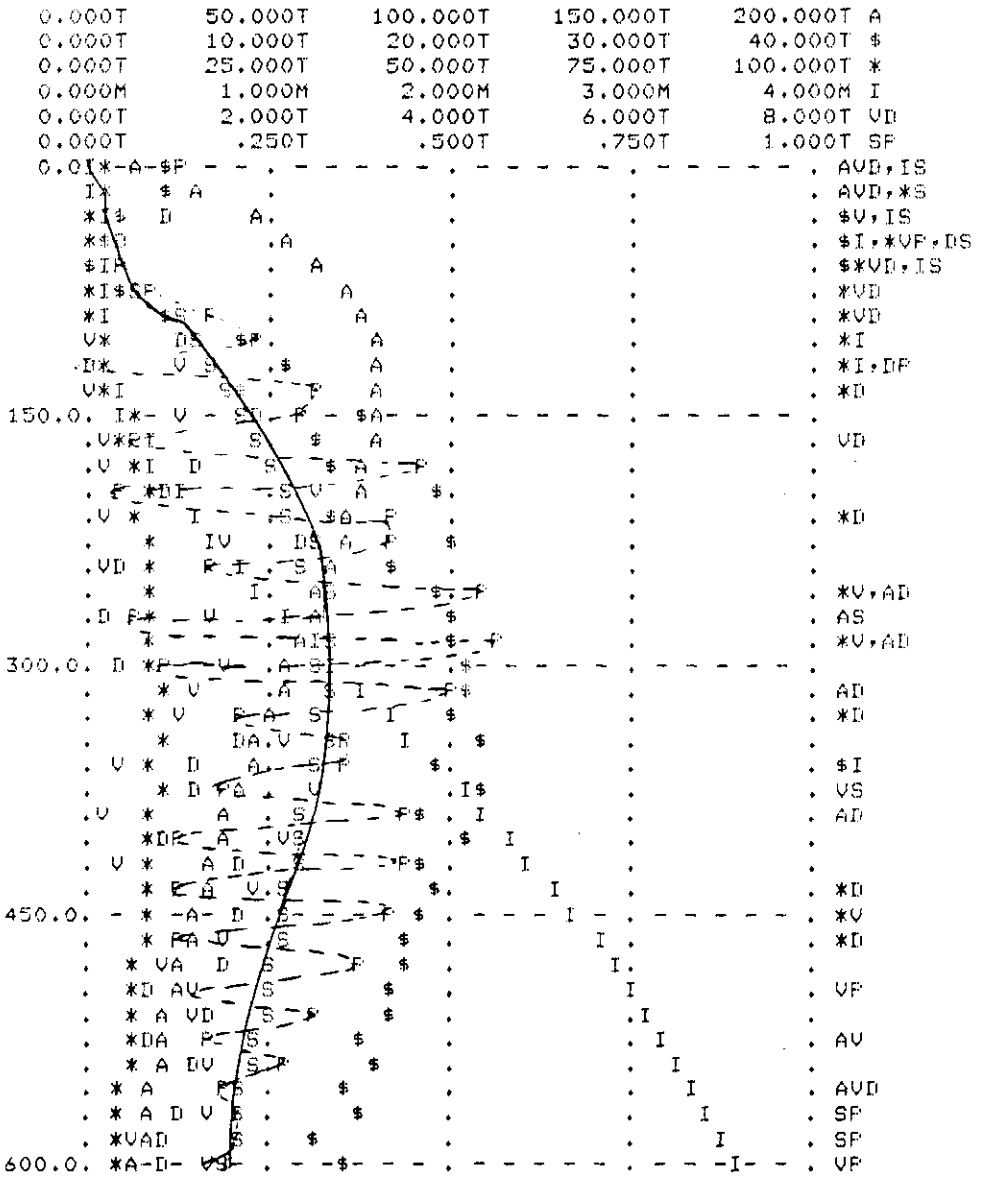

Figure 6.1. Behavior of the Original Model

absent, and that this stage is characterized by a slow growth in sales.

The main reasons for the slow growth in sales at the introduction stage are mainly: (1) costs are high due to relatively low output rates, (2) setting advertising and promotional effort as a percentage of sales revenue slows even more the sales rate at this stage, and (3) takes time to increase the disposition state of the potential market toward the purchasing decision.

It is important to mention that it has been assumed a constant utility value of 0.5 for the product and also a constant use descriptor value of 0.5 during the simulation period.

Analyzing the growth stage we observe that approximately at week 100, sales begin to increase from 150 units per week to approximately 350 units per week at time 300 weeks. During this stage price reductions take place since pricing is on a markup basis, so as production increases, unitary costs decrease so final price also decreases.

It can be observed that at the maturity stage sales remain in a range of 300 and 275 units per week from week 300 to 425 approximately.

Finally sales begin to decline in this case not so rapidly, however costs of production increases again and also this slowdown in the rate of sales growth has the effect of producing some overcapacity in the producer sector.

It is important to observe the behavior of other variables of the system. As stated before profits are absent at the introduction stage, profits accumulate through the life cycle of the product reaching a final value of 3.5 million at the end of the products life cycle.

Another run, not shown, plotting the cost of production variable

shows that due to the low level of production in the introduction stage, the cost of production per unit is high and this cost decreases as production reaches higher output levels. Since the pricing decision is on a cost basis the consumer price is high at the initial stage, declines as sales grow, stabilizes at the maturity stage and then increases again as sales diminish in the declining stage. This pricing policy based on cost of production and a markup creates several problems which will be discussed later. The main problem is that markups should vary inversely with production costs so more stable prices could be attained.

C. Behavior of the Original Model with Selected Changes in Policies

In this section the original model's behavior will be analyzed when several changes are made. An interesting point to analyze is the variations exhibited by the production rate variable. An analysis of these variations was focused on the production rate decision. After running several simulations changing the values of IC which is the constant affecting desired inventory we found that instead of using IC = 4 weeks a value of IC = 10 weeks reduced the production rate variation, but also increased the value of actual inventory at the producer. Here on a value of IC = 10 weeks is assumed for further simulations. A plot with this change in the constant affecting the desired inventory decision is shown in Figure 6.2.

It can be observed from Figure 6.2 that production rate exhibits less oscillation compared with Figure 6.1 which considers IC = 4 weeks.

The oscillation exhibited by the production rate in Figure 6.1 may be explained considering that the production rate decision is based on

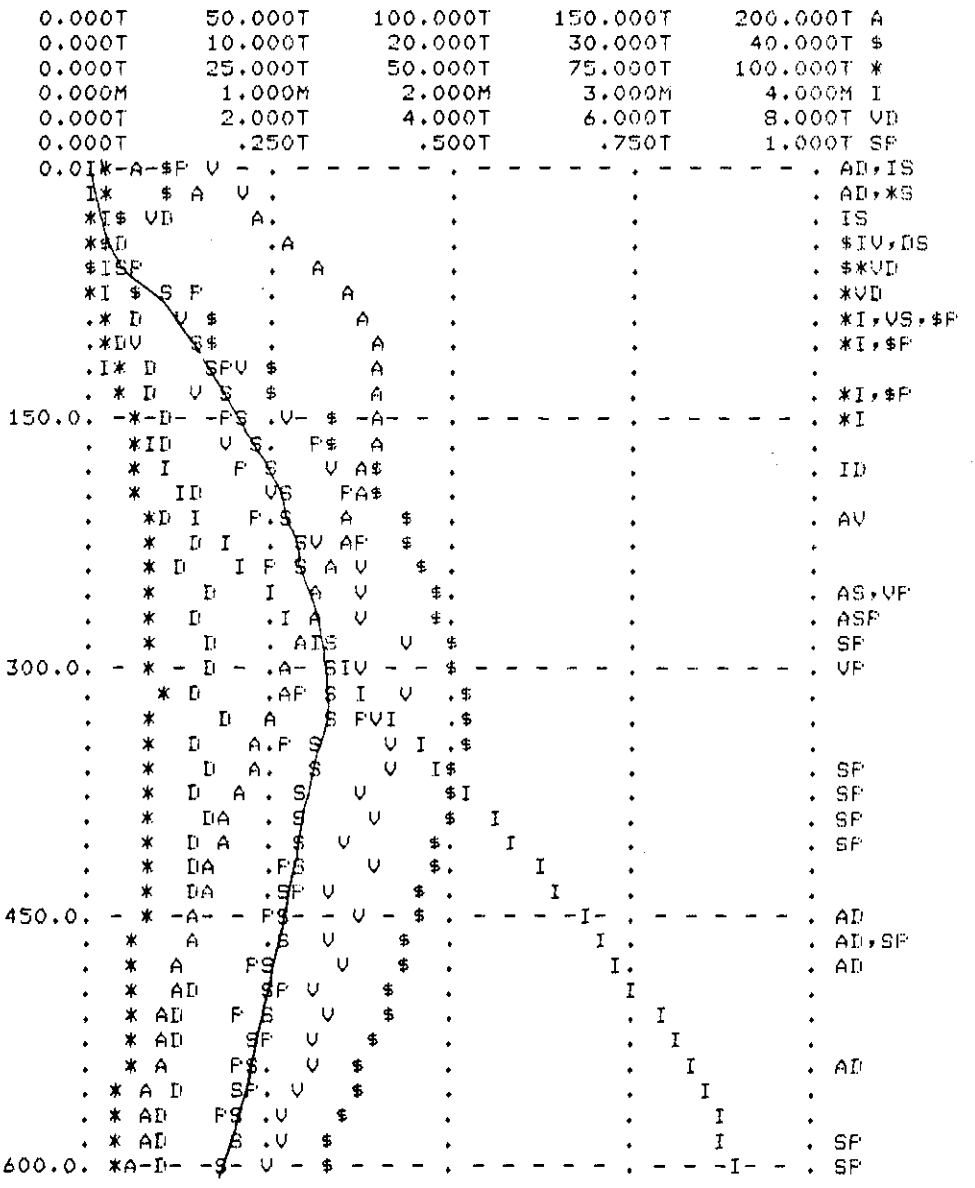

Figure 6.2. Original Model Behavior with IC = 10

requisition orders from the distributor smoothed over a certain period of time, the actual inventory at the producer and the desired inventory at the producer. In this case, four weeks of desired inventory is not enough to compensate the increased sales at the distributor sector, so the variations of the actual inventory at the producer contributes to the variations in the production rate decision.

It will be analyzed the effect of low and high promotion and a low or high initial price at the introduction stage. Policy 1 will be identified as a high promotion and high initial price strategy. (High profile strategy). Policy 2 will be identifed as a high price and low promotion level strategy. (Selective penetration strategy) Policy 3 will be identified as a low price and high promotion level strategy, (Pre-emptive penetration strategy) and Policy 4 will consist of launching the product with a low price and low promotional effort. (Low profile strategy)

It will be assumed that a producer's price of $50 per unit will be a low price for the product, while $70 per unit will be a high price to be paid for the product.

Also a high promotional effort will be, since in this case advertising is expressed as a percent of the revenue from sales, as 15%; while a low promotional effort will be considered to be 4% of the sales revenue.

A high-profile strategy consists of launching a new product with a high price and a high promotion level. This strategy tries to meet mainly two objectives: charging a high price enables the company to recover as much as possible gross profit per unit of product;

and the second objective attained by a high promotional effort is to accelerate the rate of initial sales of the product.

As pointed out by Philip Kotler (18) this marketing strategy is useful when (a) most of the potential market is unaware of the product, and (b) initial buyers will pay a higher price for the product.

The following equations will be related with this strategy:

A TPRICE.K = (TUC.K) * (1+MKP)

TPRICE	Tentative price per unit	($/unit)
TUC	Cost of production per unit	($/unit)
MKP	Producer's markup	(expressed as percentage)

A PRICE.K = MIN(TPRICE.K,IPRI)

PRICE	Price set up by the producer	($/unit)
TPRICE	Tentative price based on cost of production and producer's markup	($/unit)
IPRI	Initial price for the product at the introduction stage	($/unit)

In order to achieve a high promotional level at the introduction stage, we will assume that advertising expense is high at the introduction stage of the product and decreases as the number of actual customers increases. This will be represented as a table function and the equations relating this policy are expressed as:

$$A\ MARR.K = \frac{AC.K}{ESTM}$$

MARR	Ratio of actual customers and estimated initial market	(dimensionless)
AC	Number of people who have bought the product, actual customers	(people)
ESTM	Estimated initial market	(people)

Advertising expense will be based on a percentage of revenue from sales. We will assume that this percentage will be high at the initial stage and will eventually decrease as the ratio of actual customers and estimated market increases. This is represented as a table function.

```
A PSAD.K = TABHL(YPSAD,MARR.K,0,1, 0.5)
T YPSAD =  0.15/0.04/0.02
```

The results obtained using a high profile marketing strategy are illustrated in Figure 6.3. The plot corresponds to an initial producer price of $65/unit.

It can be observed from the results obtained in Figure 6.3, that sales reach almost 250 units per week at week 150; sales peak at time 255 weeks at approximately 580 units/week. From data in the printing section we observe that producer's price is reduced from the initial $65/unit to $55/unit. We need to remember that price in this case is on a markup basis.

The growth stage is characterized by high profits. Average profits reach a maximum value at time week 300, and after this week they gradually decline as sales decrease during the declining stage of the product.

Several simulations were run assuming a high profile strategy. A summary of the results obtained is exhibited in Table 6.1.

Table 6.1. Summary of Results with High Profile Strategy

Price per Unit at Producer	Peak Time on Sales (weeks)	Accumulated Profits When Peak Occurs
65	255	$1,082,500
70	265	$1,135,400
75	270	$1,330,200
80	270	$1,228,800

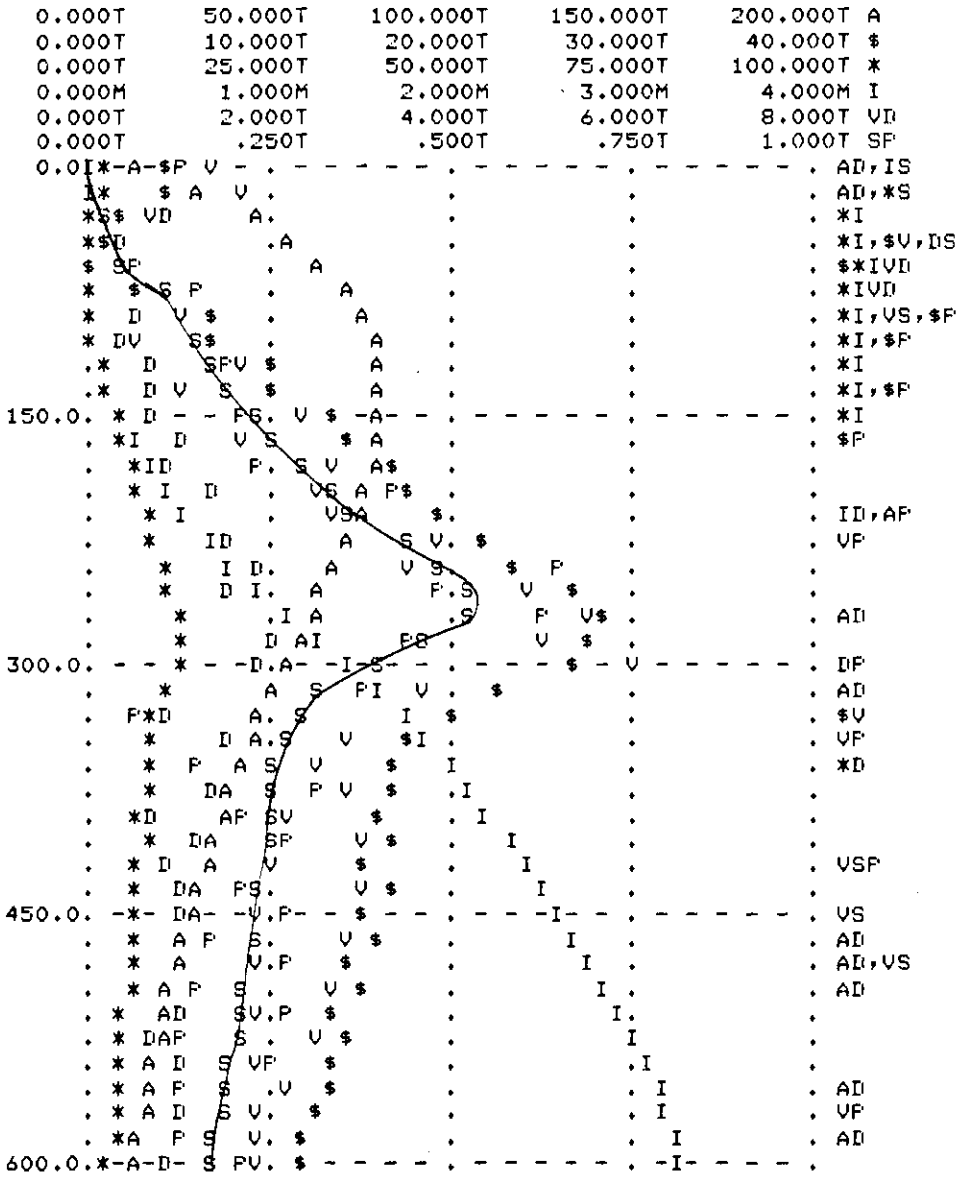

Figure 6.3. Original Model Behavior with High Profile Policy
IPRI = 65

Some important conclusions may be derived from the analysis of the high profile policy, these are:

(a) The high initial price and high promotional level allows the producer to compensate the initial high costs of production and at the same time accelerate the rate of market penetration.

(b) The reduction in price occurring at approximately week 180 favors the potential customers disposition toward purchasing thus increasing the sales rate of the product during the growth stage of the product. Also the increase in sales revenue increases the promotional effort.

The second marketing strategy to be tested is the selective penetration strategy. This strategy consists of launching the new product with a high price and a low level of promotion. The purpose of the high price is to recover as much as gross profit per unit as is possible, and the purpose of the low promotion is to keep marketing expenses down.

The results obtained using a selective penetration strategy are represented by Figure 6.5 with an initial price of $65/unit.

We can observe that the life cycle curve reaches a maximum sales value at week 315 approximately with 331 units/week. The introduction stage is characterized by slow growth as well as the growth stage which does not show a notorious increasing rate. The advertising expense is at a low level during the introduction stage; approximately $250/week, and gradually increases during the growth stage to approximately $500/week at week 180.

As indicated in the printing section, the price of $65/unit is

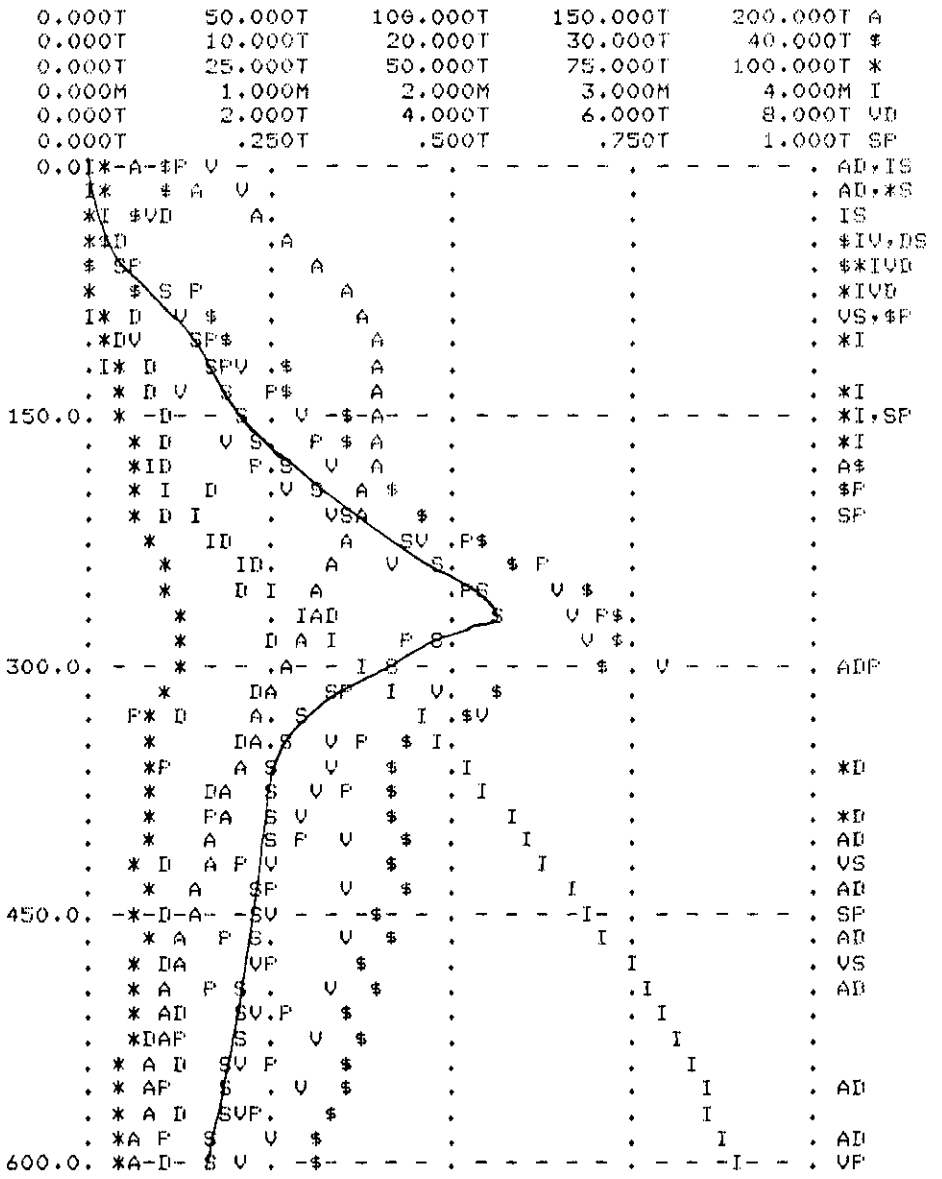

Figure 6.4. Original Model Behavior with High Profile Strategy
IPRI = 70

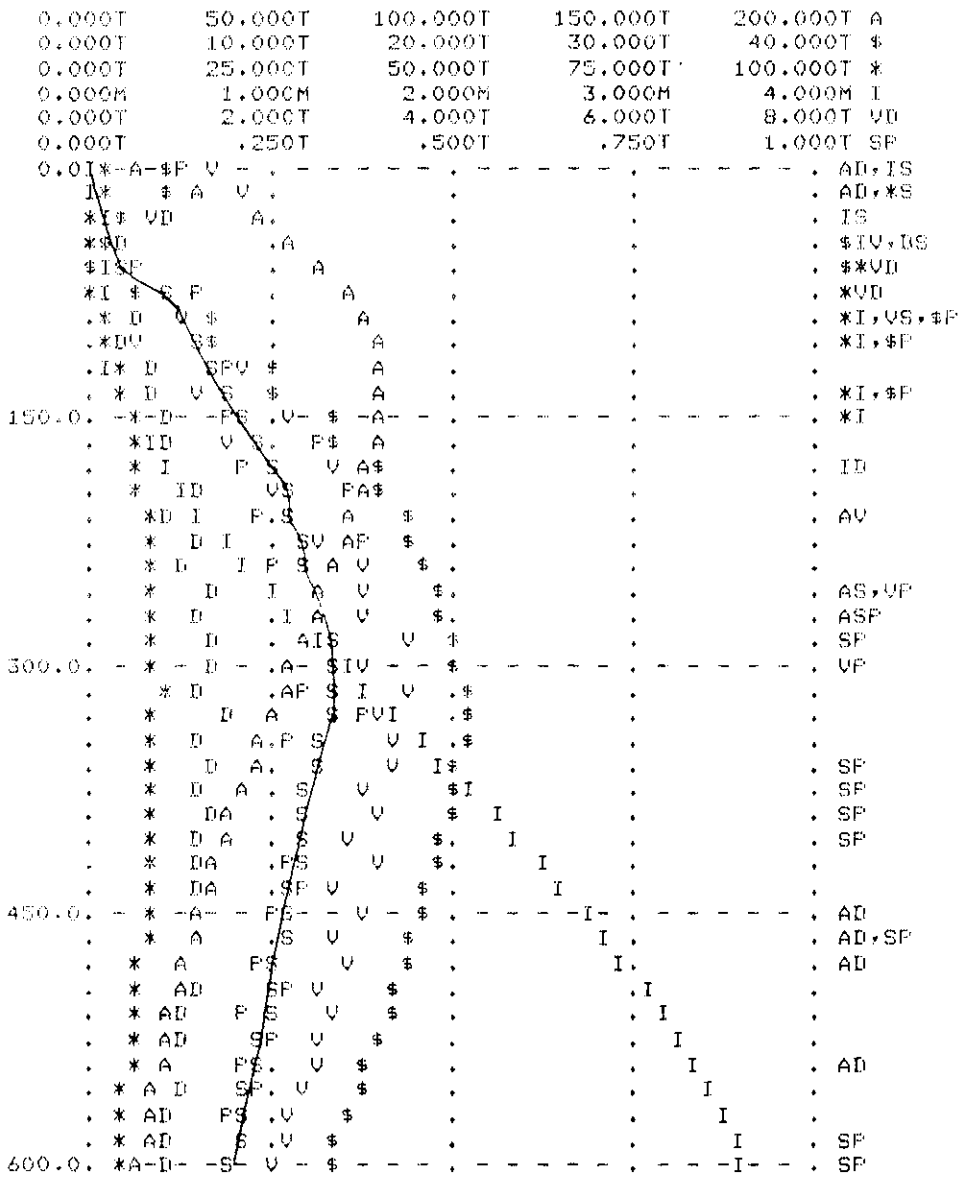

Figure 6.5. Original Model Behavior with Selective Penetration Strategy
IPRI = 65

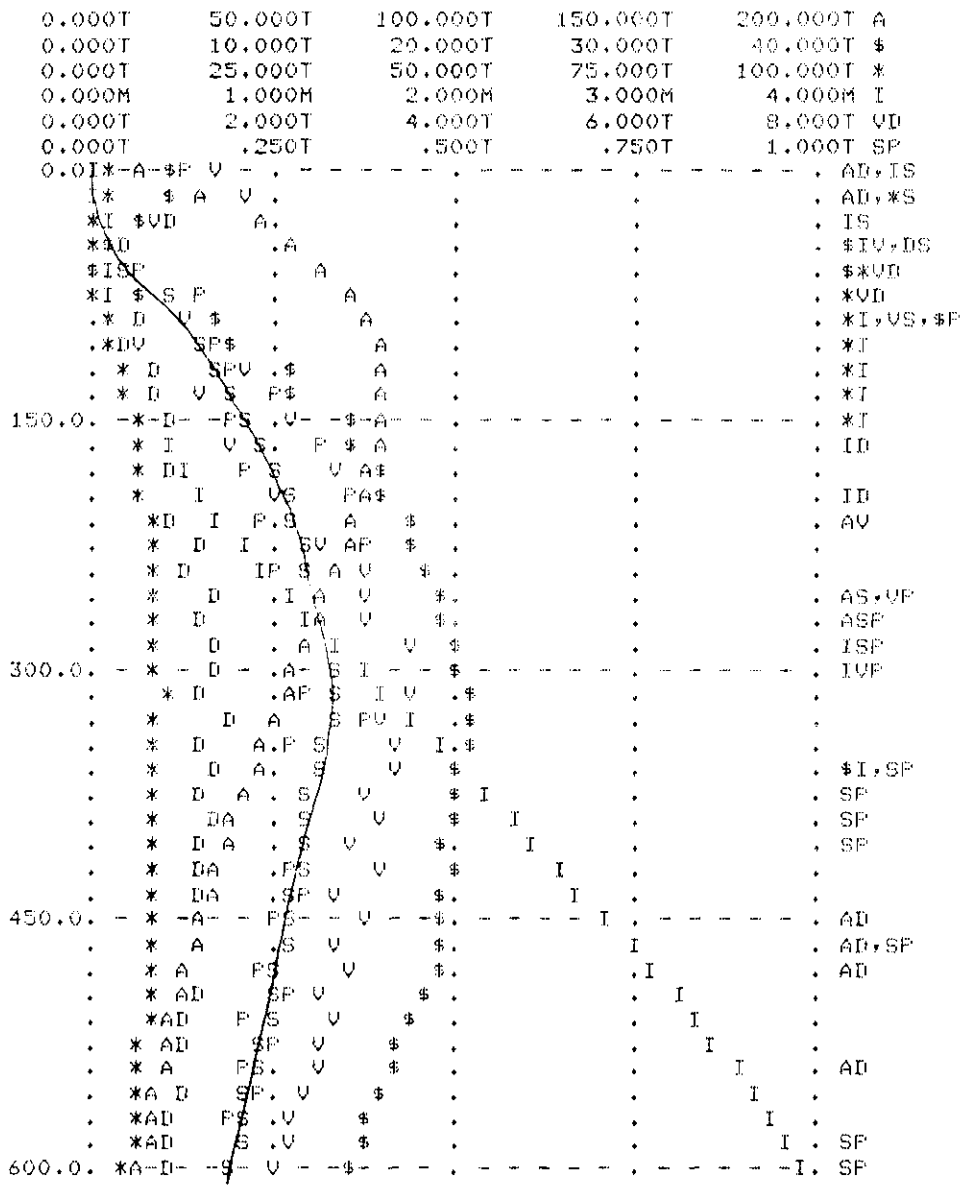

Figure 6.6. Original Model Behavior with Selective Penetration Strategy
IPRI = 70

kept up to week 195, price begins to decrease at this time to week 300 reading a final value of $61.50. This price reduction does not accelerate significantly the sales rate during the growth stage of the life cycle, however sales after reaching the peak point remain relatively stable during the mature and declining stages of the product's life cycle.

This strategy, in contrast with the high profile strategy, leads to a lower level of sales and also to a later sales peak time.

Several simulations with different prices per unit were run with this type of strategy. A summary of the results from these simulations is exhibited in the following table:

Table 6.2. Summary of Results with Selection Penetration Strategy

Price per Unit at Producer	Peak Time on Sales (weeks)	Accumulated Profits When Peak Occurs
65	315	$1,386,200
70	300	$1,474,300
75	323	$1,623,500
80	330	$1,845,000

Considering this strategy the following conclusion is obtained:

Compared with the high profile strategy, time of sales peak is delayed, also the number of units at the sales peak has a lower number.

The third marketing strategy that is to be analyzed is the pre-emptive penetration strategy. This strategy consists of launching the product with a low price and high promotion. This strategy should bring

a fast rate of penetration in the potential market.

The results obtained with this strategy are exhibited in Figure 6.7. We can observe that this strategy in effect accelerates the rate of initial penetration. Sales reached a value of approximately 800 units/week at time 120 weeks; profits however are totally absent up to week 90 and are better during the growth stage of the product. Sales peak at week 180 reaching a level in sales of 451 units/week. Although a low price has a positive effect in the consumer's disposition toward purchasing, as well as the high promotion level, the increase in sales does not bring, however, a good profit figure. At a producer's price of $50/unit, accumulated profits at the end of the project's life are only $2,265,900.

This strategy is applicable when most of the buyers are price-sensitive as in this case. Since we have assumed a price effect equation, price has an effect on the customer's disposition toward purchasing.

Another important piece of information derived from this strategy is that sales attain higher levels due to the price and promotional efforts; this favors a reduction in the manufacturing cost of the product. Profits however are not adequate for a producer's price of $50/unit. Figure 6.8 shows the results of the same strategy but considering a producer's price of $55/unit.

Analyzing the results obtained from Figure 6.8 and the printing section, we observe the sales peak at week 210, reaching a level of sales of 407 units per week. We can observe that the rate of penetration is high during the introduction stage, the growth stage is not as high as with the lower price strategy; however, in the mature stage 150 to 300 week sales are kept at a good level of approximately 350 units/week,

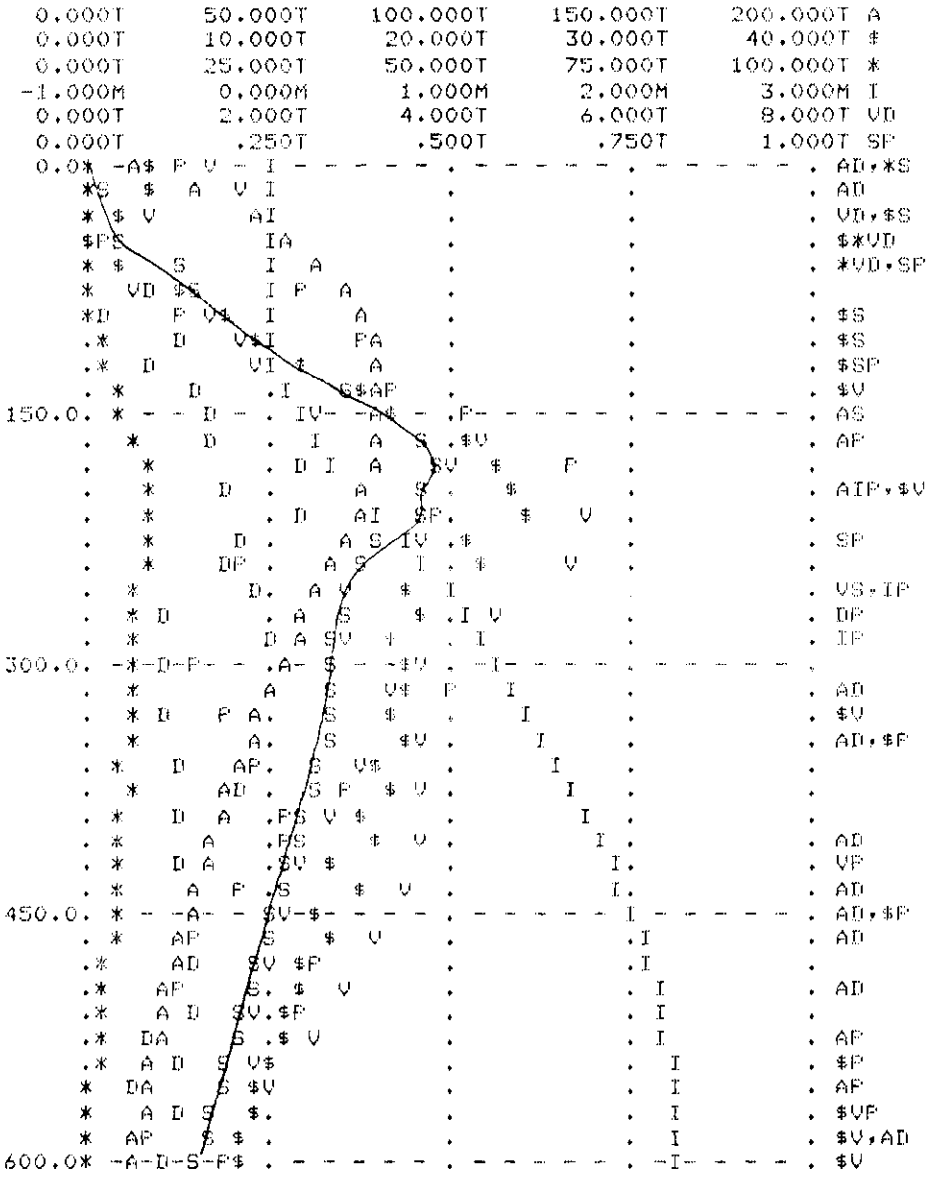

Figure 6.7. Original Model Behavior with Preemptive Penetration Strategy
IPRI = 50

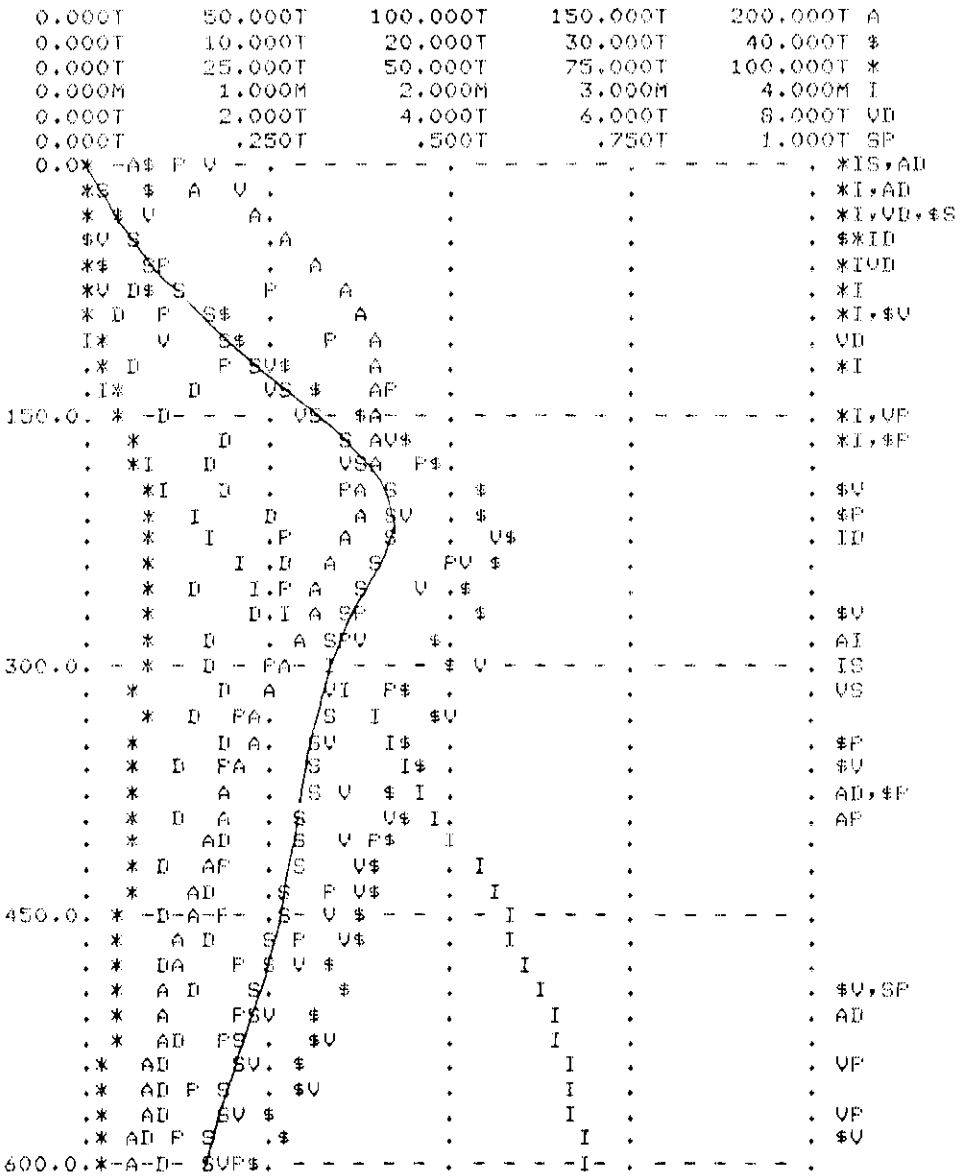

Figure 6.8. Original Model with Preemptive Penetration Strategy
IPRI = 55

gradually then decreasing during the decline stage.

This strategy was tested with different prices per unit. A summary of the results obtained is exhibited in Table 6.3.

Table 6.3. Summary of Results with Preemptive Penetration Strategy

Price per Unit at Producer	Peak Time on Sales (weeks)	Accumulated Profits When Peak Occurs
50	180	$345,800
55	210	$550,600
60	255	$934,000

The fourth strategy to be tested is the low-profile strategy. This strategy consists of launching the new product with a low price and a low level of promotion. The low price will encourage the market's rapid acceptance of the product; at the same time the producer keeps the promotion cost down in order to achieve more net profit.

The results obtained are illustrated in Figure 6.9. An initial producer's price of $50/unit will be considered. It can be observed that a low price accelerates the sales rate even though the level of promotion is low. Sales start at a low level and increase by week 115 to approximately 250 units/week. Sales peak at approximately week 280 with a sales rate of 383 units/week. Although the growth stage is not substantial, sales reaching the mature stage continue at an acceptable level of approximately 325 units/week. The introduction stage is characterized with no profits at all and showing some improvement by

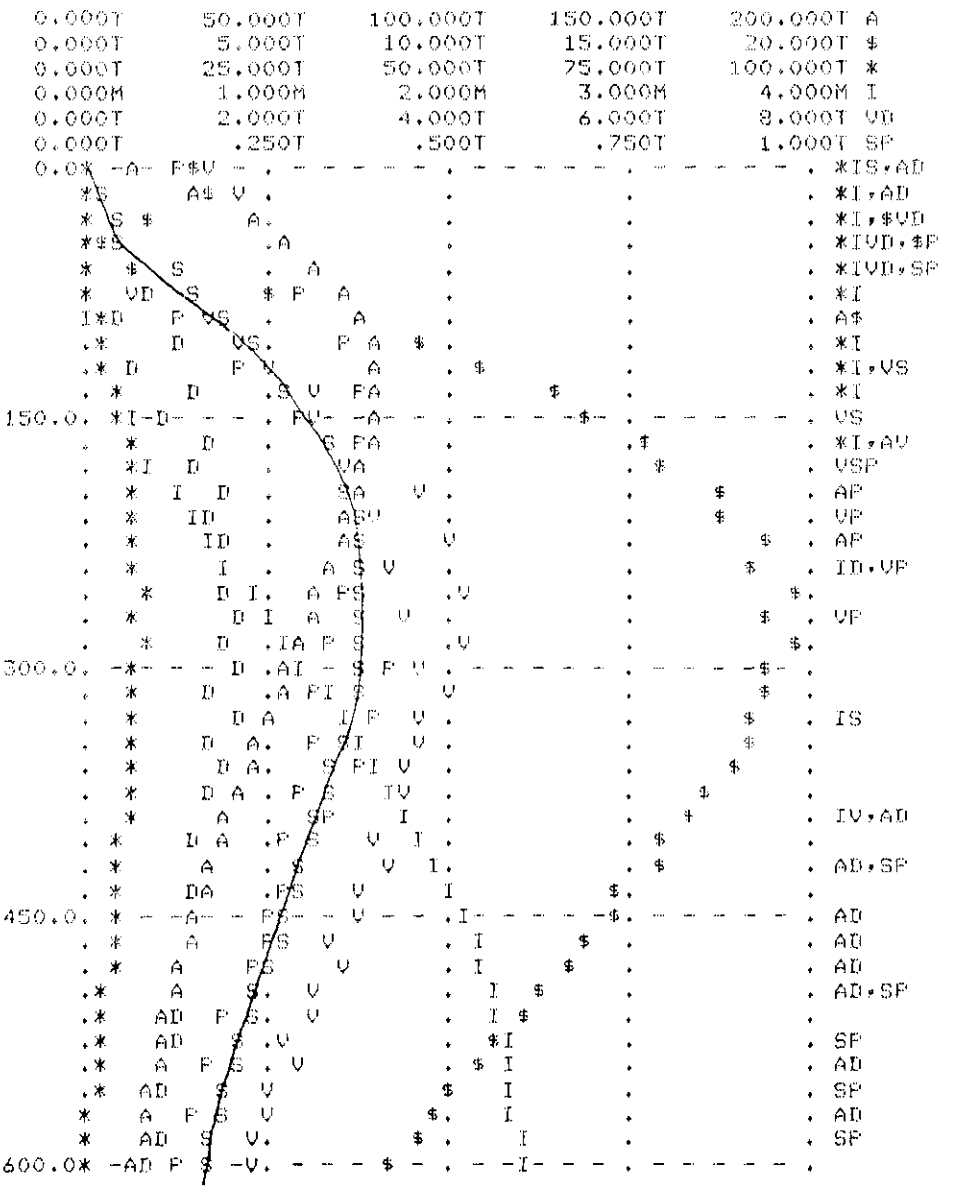

Figure 6.9. Original Model Behavior with Low Profile Strategy
IPRI = 50

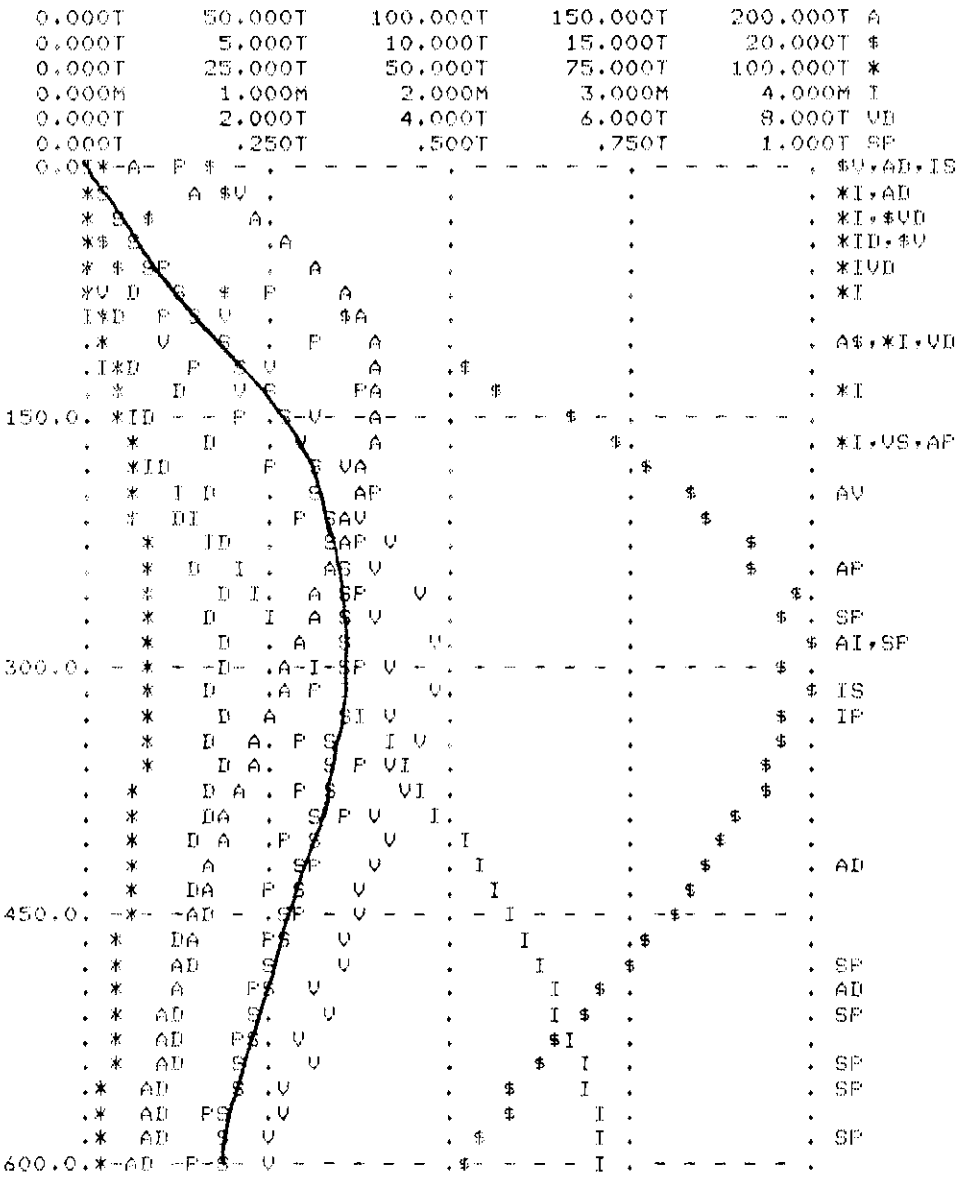

Figure 6.10. Original Model Behavior with Low Profile Strategy
IPRI = 55

week 90 of approximately $1,150/week.

After sales had reached the peak point they begin to decrease gradually from approximately 383 units/week at time 280 weeks to a rate of 159 units/week at the end of the simulation period.

The results obtained assuming various initial prices with this strategy are summarized in Table 6.4.

Table 6.4. Summary of Results with Low Profile Strategy

Price per Unit at Producer	Peak Time on Sales (weeks)	Accumulated Profits at Time of Peak
50	280	$ 984,500
55	270	$1,030,600
60	300	$1,326,100

D. Behavior of the Original Model with Changes in Influential Parameters and Initial Conditions

In this section several changes in parameters and initial conditions in the original model will be analyzed to test the response to these factors.

Sensitivity will be considered for the four different policies stated in the last section. A producer price of $70 per unit as high price and $50 per unit as low price will be assumed. High promotion will be based on a higher percentage (15%) of sales revenue, while low promotion will be based on a lower percentage of sales revenue (4%). The

equations for promotion are those described at the beginning of section C of this chapter.

Comparisons between the different results obtained from the selected changes in some parameters and initial conditions will be based on cumulative profits and the time when the peak of sales occurs. A table will be constructed for comparative purposes and some graphs will be included for the sensitivity analysis of some parameters.

The four policies will be tested when changing the following parameters:

1) Double market size. In this case the initial estimated market of 180,000 people will be changed to 360,000 people.

2) Another interesting change is an increase in the number of people aware of the product. As for example, analyze the effect if 20% of the potential market would have been already aware of the product.

3) The analysis of an increase and decrease of 20% the delay influenced by promotion, i.e. the awareness delay.

4) The analysis of the sensitivity of the delay influenced by price, the time before purchase. An increase and decrease in this delay of 20% will be used.

5) A parameter in the producer sector that might be thought to be sensitive is the delay in the production decision PLT. A change of ±20% in this parameter will be analyzed. Also in the distributor sector, the parameter MD which is the ordering delay, will be considered with a ±20% variation.

A summary of the results obtained from the simulation runs is exhibited in Tables 6.5 and 6.6. The first table is based on comparative

cumulative profits for different conditions and the second table is based on comparative peak time on sales. It should be recalled that these results are based on the assumptions made for the theoretical model under study.

Based on the results obtained it is observed that the selective strategy results in the greatest profit, although for a larger market, the profit differences between policies are small. The size of the market appears to be an important variable which is sensitive to the different policies that we have tested.

As it can be observed in Table 6.5, an increase in the market leads to important results. Doubling the initial estimated market from 180,000 people to 360,000 people, leads to differences for the different policies that are very sensitive when compared to the normal conditions in which the selective strategy produced the most profit.

It is important to notice that with a larger market, the low profile and preemptive strategies lead to very much improved results when compared with the normal conditions run. The high profile strategy shows only an increase of 90% in cumulative profits with a larger market. The selective strategy shows a 75% increase in cumulative profits. The reasons for the dramatic improvement in the low profile and preemptive results are not clear. However, the change does make the choice of a best policy uncertain. Additional analysis of market size influences is needed.

Analyzing the effect of doubling the size of the initial market for the case of the selective strategy, it appears that this strategy should be used when the estimated market is limited in size.

Table 6.5. Comparative Cumulative Profit for Different Conditions (Thousands)

Conditions/Policy	High Profile High Price High Promotion	Selective High Price Low Promotion	Preemptive Low Price High Promotion	Low Profile Low Price Low Promotion
Normal	3,579	3,901	2,265	2,386
Larger Market	6,796	6,839	6,257	6,263
20% of the Estimated Market is Aware of the Product	3,595	3,973	2,673	2,611
Awareness Delay 20% Increase	3,478	3,760	2,072	2,201
Awareness Delay 20% Decrease	3,624	4,012	2,456	2,567
Purchasing Delay 20% Increase	3,398	3,669	2,095	2,220
Purchasing Delay 20% Decrease	3,705	4,087	2,569	2,544
Change of PLT = 8	3,562	3,886	2,266	2,399
Change of PLT = 2	3,583	3,902	2,261	2,383
Change of MD = 5	3,537	3,995	2,257	2,368
Change of MD = 1	3,580	4,039	2,258	2,381

Table 6.6. Comparative Peak Time for Different Conditions (weeks)

Conditions/Policy	High Profile High Price High Promotion	Selective High Price Low Promotion	Preemptive Low Price High Promotion	Low Profile Low Price Low Promotion
Normal	265	300	180	280
Larger Market	180	210	120	240
20% of the Potential Market is Aware of the Product	210	270	120	210
Increase of 20% on Awareness Delay	300	330	210	300
Decrease of 20% on Awareness Delay	240	270	180	240
Increase of 20% on Purchasing Delay	285	330	210	300
Decrease of 20% on Purchasing Delay	240	270	180	240
Change of PLT = 8	270	300	180	270
Change of PLT = 2	270	300	180	270
Change of MD = 5	270	300	180	270
Change of MD = 1	270	300	180	270

This strategy in contrast with the high profile strategy leads to a lower level of sales and also to a later sales peak time. However, at the end of the simulation period the cumulative profits are better when this strategy is selected.

Another important result that can be observed from Table 6.5 is for the preemptive strategy. This strategy shows a 276% increase in cummulative profits when compared with the normal conditions run. It appears then that this policy leads to good results when the initial market is larger in size than the one initially assumed.

The fourth strategy also leads to interesting results when the initial market is doubled in size. Cumulative profits show an increase of 262% when compared with the normal conditions run. This strategy appears to be also adequate when the initial market is larger in size, although for this case the cumulative profits were near the same as with the preemptive strategy policy.

An important conclusion may be reached at this point stating that the market size is a very important and sensitive parameter for the four policies tested with the model.

Analyzing the condition of having 20% of the estimated market aware of the product, the high profile strategy did not show a significant profit improvement compared with the initial condition run, although as observed from Table 6.6, the peak in sales decreases from week 265 to week 210. For the selective policy case the increase in cumulative profits is also very small (2%) and the peak in sales decreases from week 300 in the normal conditions run to week 270. For the preemptive policy the cumulative profits increase is 18%, and the peak in sales decreases from 180 weeks in the normal conditions to 120 weeks. The last policy

which is the low profile shows an increase in profits of 9% when compared with the normal conditions run, and the peak in sales decreases from week 280 to week 240.

An important conclusion is that this change was more significant for the preemptive strategy case.

An increase of 20% in the awareness delay, as expected, increases the time of the peak in sales and leads to less cumulative profits at the end of the simulation period. A decrease however, of 20% in the awareness delay shortens the time of the peak in sales and also leads to a better figure in the final cumulative profits as may be observed from Table 6.5. This result is also expected since based on the model formulation people at the unaware state will eventually buy the product so an increase or decrease in the awareness delay influences how fast or how slow a potential customer will become an actual customer. This is of course a major limitation in the model since outflows from the different levels of the consumer sector should have been provided. Figures 6.11 and 6.12 exhibit the effect of the increase and the decrease of the awareness delay by 20% under low promotion and high promotion considerations. It can be observed that in general a decrease in the awareness delay will result in higher cumulative profits. An increase of 20% in the purchasing delay, also as expected, increases the time of the peak in sales and leads to less profits compared with the normal conditions, while a decrease of 20% favors the final cumulative profits as may be observed from Table 6.5. Figures 6.13 and 6.14 show the effect of increasing and decreasing by 20% the purchasing delay for the low promotion and high promotion conditions.

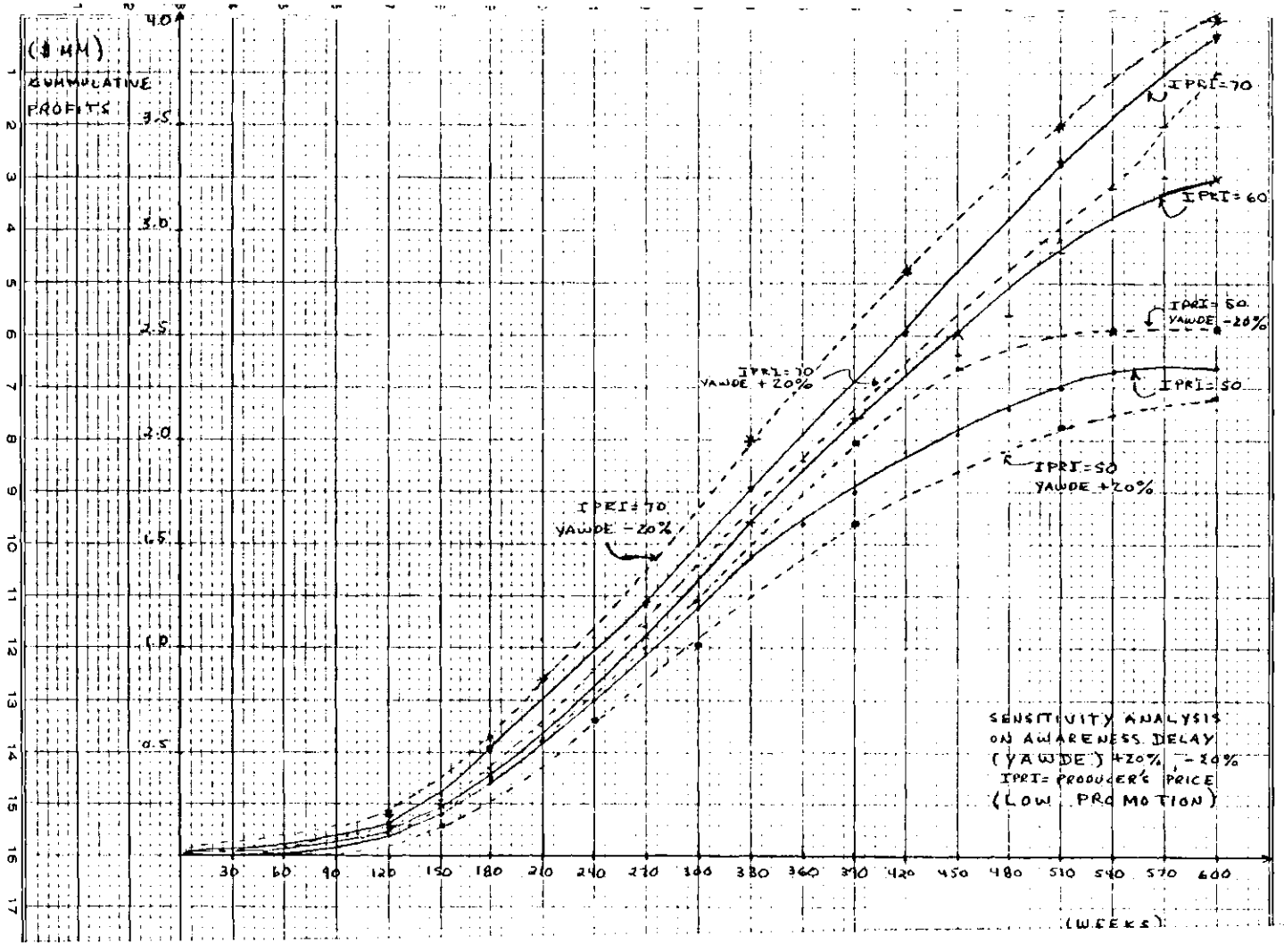

Figure 6.11. Sensitivity Analysis on Awareness Delay (Low Promotion)

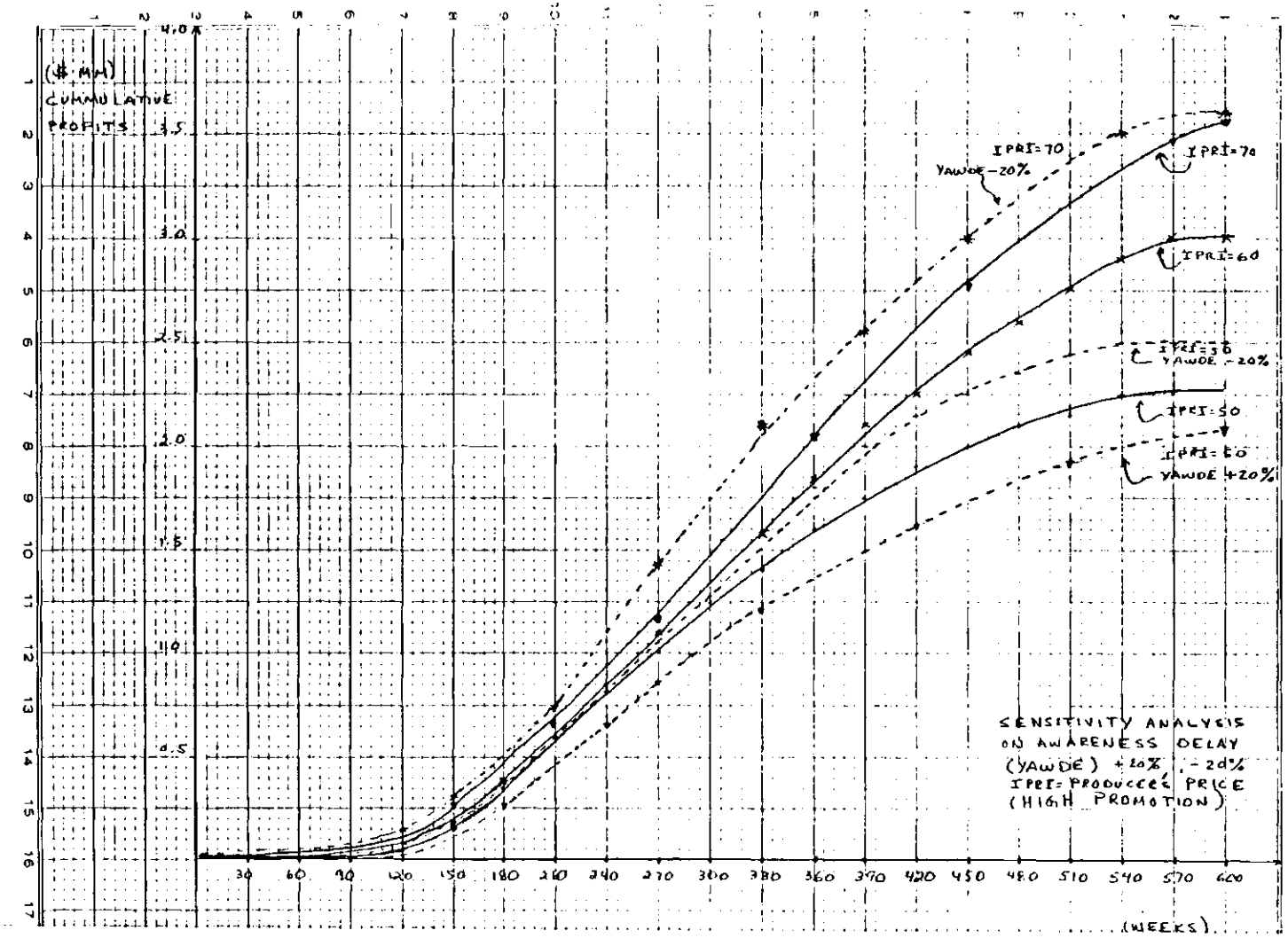

Figure 6.12. Sensitivity Analysis on Awareness Delay (High Promotion)

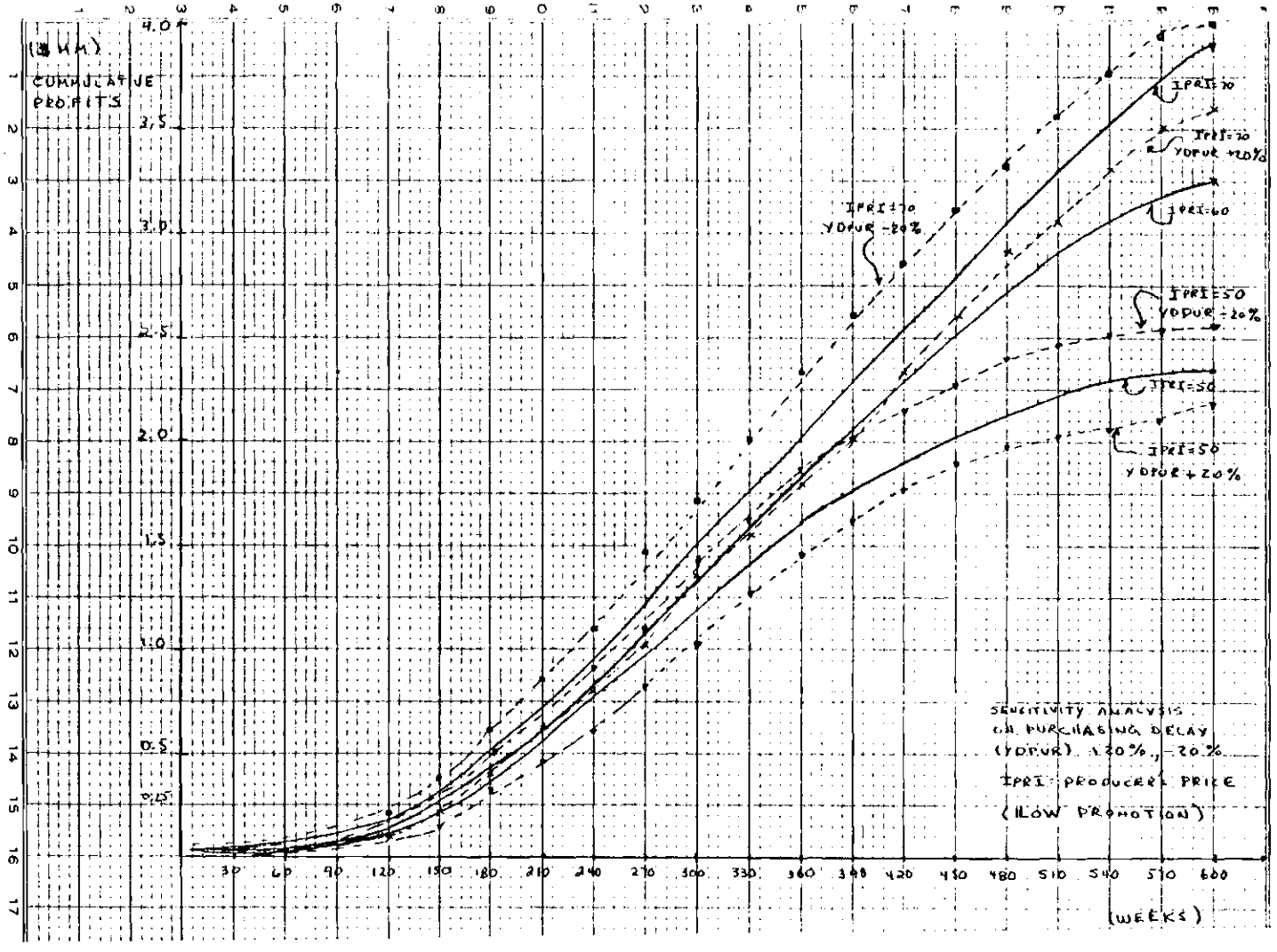

Figure 6.13. Sensitivity Analysis on Purchasing Delay (Low Promotion)

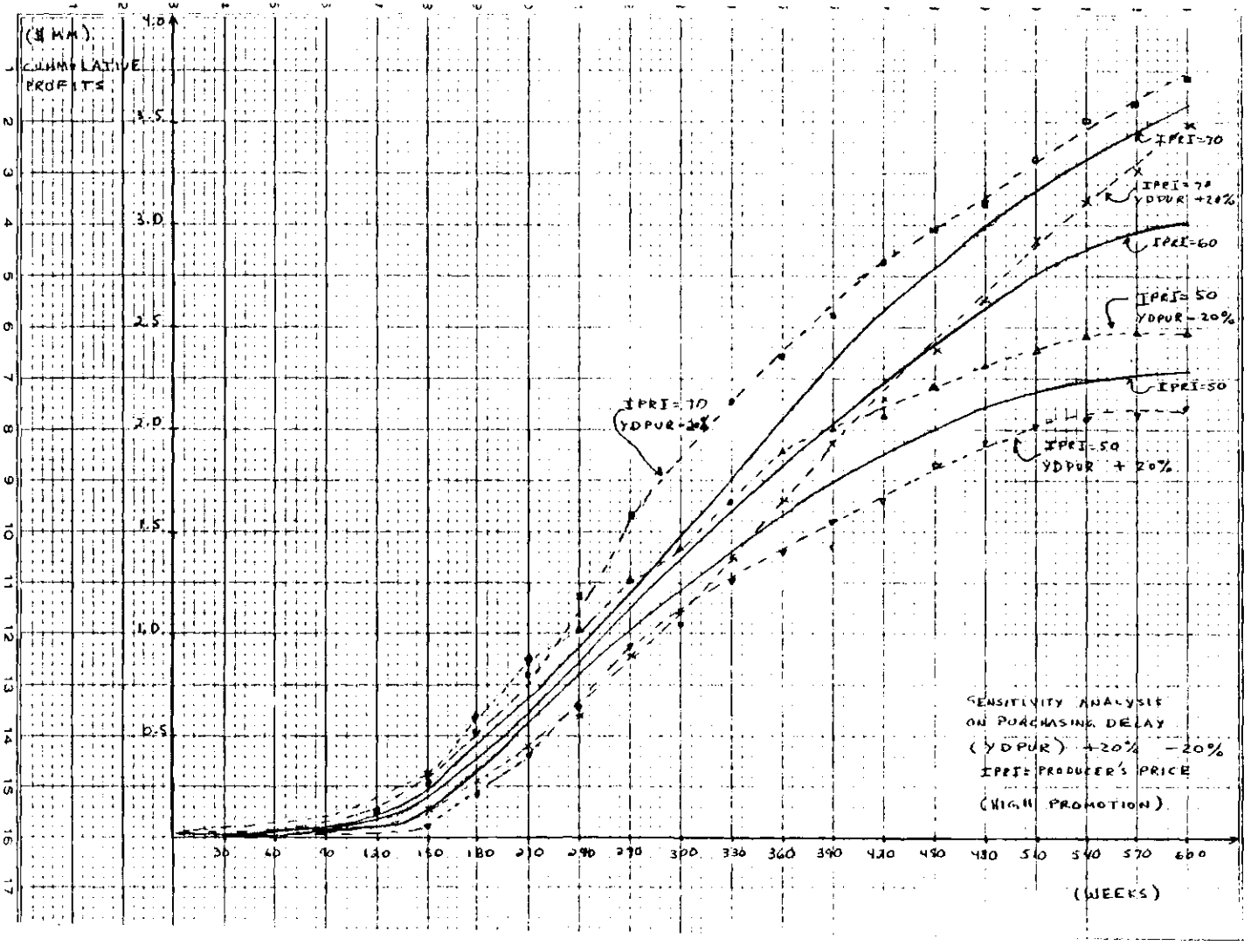

Figure 6.14. Sensitivity Analysis on Purchasing Delay (High Promotion)

An increase of 20% in the purchasing delay decreases the cumulative profits by the following percentages with respect to the normal conditions; for the high profile strategy the decrease is of 5%, in the case of the selective strategy the decrease in cumulative profits is 6%, and 8% with the selective strategy. Considering the low price policies the decrease is 8% for the preemptive strategy and 7% for the low profile strategy.

An important conclusion considering the 20% decrease in purchasing delay is that as observed from Table 6.5, the preemptive and low profile strategies lead to similar cumulative profit figures favoring slightly the preemptive policy. Analyzing the parameter PLT which is the delay in production decision which for normal conditions was set up to 4 weeks, it can be observed that no change is observed when varying this parameter to 8 or 2 weeks. Another parameter in the distributor sector which was thought to be sensitive is MD. It corresponds to the ordering delay. It did not show sensitivity at all when changed from 3 weeks to 5 and 1 week.

An important conclusion, however, as observed from Table 6.5, is that in the case of the high profile and selective strategies an increase in PLT decreases slightly the cumulative profit figure; but in the case of the preemptive and low profile strategies, the profit figure is slightly improved. The decrease of PLT increases the cummulative profit figure very slightly for the high profile and selective strategy, while for the preemptive and low profile strategy the cumulative profit figure is slightly lowered.

Analyzing for the parameter MD, an increase in this parameter decreased slightly the profit figure for the high profile, preemptive and low profile strategies as compared with the normal conditions run. However, for the selective strategy the profit figure was better by 2%. A decrease of MD produced more or less equal results except for the selective strategy which showed a 4% increase in the cumulative profit figure. An important parameter, tested later in additional runs and which demonstrated to have an effect in the system when varied, was the parameter PPN which is the perceived value of the product by the customer. In the original model this parameter was assumed to be $65 per unit. Changing this value to $90 per unit, the cumulative profits were much better during the project's life. This is illustrated in Figure 6.15. A higher perceived value from the customer than the price of sale from the distributor favored the customer response toward purchasing.

E. Limitations and Validation Section

Some selected changes in parameters and initial conditions have been explored. The results obtained cannot, however, be generalized. The model that has been assumed is theoretical. One of the major limitations in this model is that a competitive sector has not been considered. A competitive sector should have had a major impact on the system. It should have influenced the advertising and pricing decisions, and market share should have been an important variable to analyze.

Another major limitation has been the consumer sector; much more detail is required in developing an adequate consumer sector. In this model almost all the people in the initial estimated market eventually

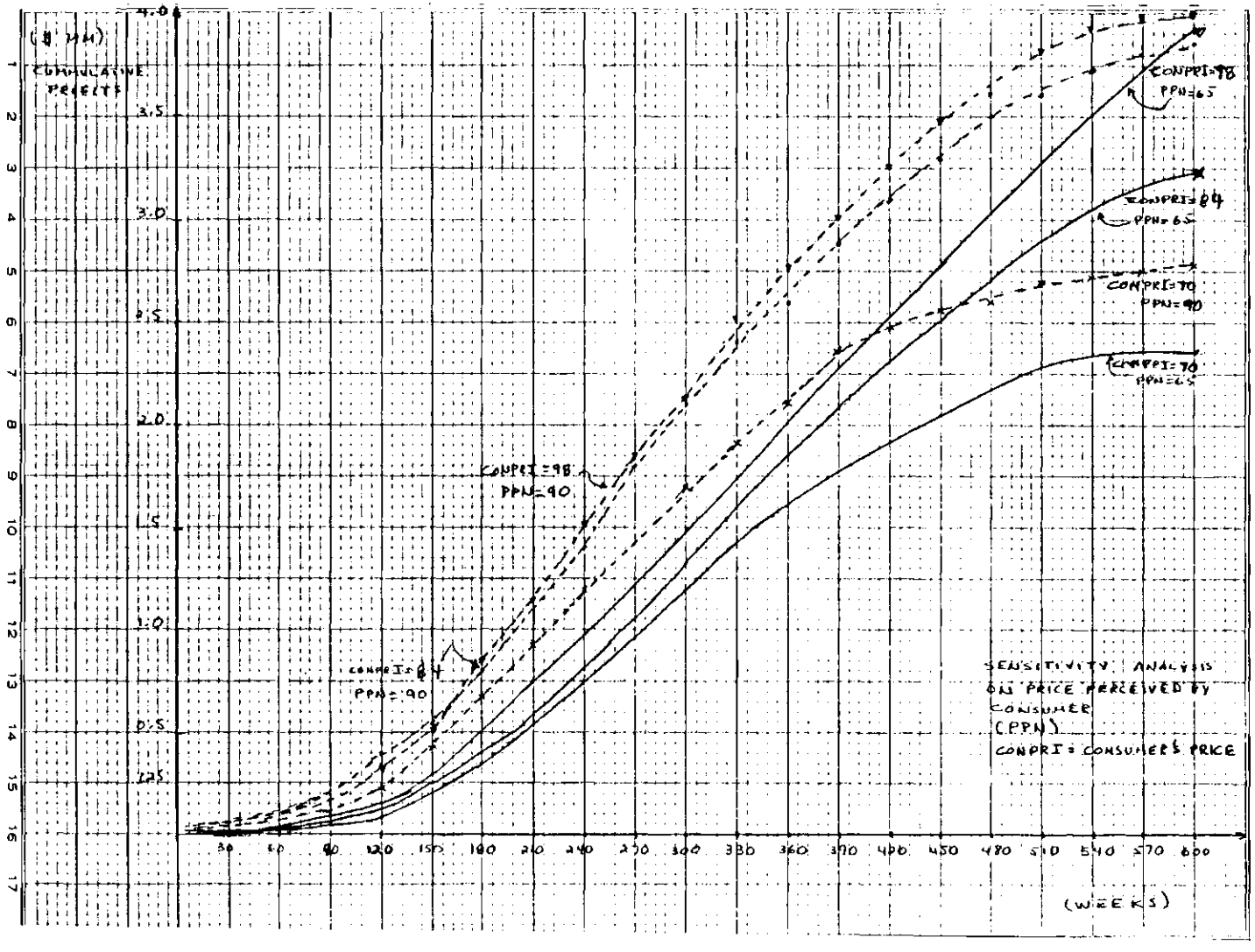

Figure 6.15. Change in the Parameter PPN

buy the product. This is of course an unrealistic assumption. People at the aware and potential levels may become non-buyers. Also there could be an influence from satisfied or disatisfied customers, such that potential customers may be reluctant to buy.

The purchasing decision was viewed here only in terms of a higher disposition state; in the real world there is a multicomponent act consisting of decisions involving product class, product form, brand, vendor, advertising, promotions, perceived risk and many other factors which affect the purchasing act.

Another important limitation is that products are viewed by consumers as multiattribute objects, and the consumer is likely to have a utility function for each attribute of the product. This model has included only one utility function.

Advertising should also be viewed as an important subsystem and not only in terms of one variable as has been done in this model.

By far extensive research is still required to improve the model presented. References from the literature instead of actual data have been used as a justification for the model. The sensitivity analysis for some important parameters have been included in this chapter to show that the conclusions reached by this study would not be greatly changed if different values were used. It is clear however that this model is an initial step toward market simulations.

Lastly, simulation of purchasing behavior, although a very complex area, has greatly improved with the aid of psychology and behavioral sciences. The consumer states assumed here as unaware, aware, potential and actual customers have been suggested in the literature as a consumer

buying process. However, the real behavior is much more complex than is assumed for this model.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

The theoretical model proposed for this study was explored in the last chapter. Under the conditions assumed and the limitations described earlier, a selective penetration strategy results in better overall cumulated profits.

It is found that the size of the market was a very important and sensitive parameter for the four policies tested.

Concerning the producer's policies of advertising as a percentage of sales revenue and pricing in a mark-up basis, both have certain limitations. At the introductory stage of the product substantial promotional effort is required. Since sales are at a low level during this stage, a fixed percentage of sales revenue produced inadequate promotion for the product at the initial stage.

The pricing policy on a mark-up basis also was not very practical. Mark-up pricing in this case should be a variable mark-up varying inversely with production costs. The reason is that prices resulted very high at low levels of production; this was avoided with a fixed price initial policy.

It has been identified that the major feedback loops related to growth of sales are the loop containing the price decision and the loop relating to sales and promotional effort. The limiting loop is the one

involving the fixed population of the consumer sector and not considering a repurchase activity.

One of the major limitations of this study is not having included a competitive sector. This has limited the analysis of the results obtained in this work.

A sensitivity analysis of various parameters and selected changes in initial conditions led to important results. For both cases, the normal market and a larger market, a selective policy produced more cumulative profits during the simulation period of 600 weeks. The results obtained when varying the awareness and purchasing delays were as expected. The model showed some sensitivity to these parameters although not significant.

Changes in the parameter PLT involving the delay in production decision led to equivalent results as in normal conditions. The same result was obtained when varying the ordering delay MD at the distributor sector.

A parameter which showed greater sensitivity was PPN which represents the perceived value of the product by the consumer. Cumulative profits were much better when this value was higher than the consumer price, i.e., the price offered by the distributor to the consumer.

The value of DT used for simulation was DT = 0.2 weeks. Smaller values of DT did not show variations in the final results.

Concerning future work in this area a first step should be to create a better model relating the consumer sector and simulate the consumer behavior after selecting a particular product. The selection of one product will permit one to focus the analysis on the attributes of the product selected and the utility functions attached by the potential

consumer to the product.

Also after selecting one product it may be possible to include curves relating price elasticity and promotion elasticity if these curves are known or also may be assumed with different values. Interesting results may be expected from this analysis.

Future work could also include an interesting area involving costs of distribution, ordering costs, and inventory holding costs. A more detailed financial sector would be helpful.

One of the most important factors to be included in a model of this sort in future work is a competitive sector. This sector should have an important influence on the pricing decision and on the sales variable.

Another interesting area to be explored would be an advertising subsystem. Many variables related with advertising could be analyzed in their impact on awareness and sales response. Feedback Dynamics would be extremely helpful in analyzing the effect of different advertising timing patterns such as concentrated continuous and intermittent messages with different variations such as rising, falling, alternating or continuous.

APPENDIX

```
LNP*
   1  L UOP.K=UOP.J+DT*(OR.JK-ASHR.JK)
   2  R SHR.KL=UOP.K/SDE
   3  C SDE=2
   4  R TSHR.KL=MIN(SHR.JK,AIP.K/DT)
   5  R ASHR.KL=MAX(0,TSHR.JK)
   6  L ROS.K=ROS.J+(1/SCT)*DT*(OR.JK-ROS.J)
   7  C SCT=10
   8  A DIP.K=MAX(IC*ROS.K,0)
   9  C IC=10
  1   L AIP.K=AIP.J+DT*(SHIN.JK-ASHR.JK)
  11  A DPR.K=ROS.K+(1/ADEL)*(DIP.K-AIP.K)
  12  C ADEL=10
 13   R PR.KL=MIN(DPR.K,MAXCAP)
  14  C MAXCAP=1000
  15  R SHIN.KL=DELAY3(PR.JK,PLT)
  16  C PLT=4
  17  A UOC.K=TOC.K/APR.K
  18  A TOC.K=TABHL(YTOC,TIME.K,0,LEN,INC)
  19  T YTOC=2000/2500/3000/3500/4000/4500/5000
  20  L APR.K=APR.J+(1/CSPR)*(DT)*(SHIN.JK-APR.J)
  21  C CSPR=50
  22  A TUC.K=UOC.K+UDC
  23  CUDC=20
  24  A UADEX.K=ADEX.K/ASHRS.K
  25  A TPRIE.K=(TUC.K)*(1+MKP)
  26  A PRICE.K=MIN(TPRICE.K,IPRI)
  27  C IPRI=65
  28  A REV.K=(CFD.JK)*(PRICE.K)
  29  C MKP=0.98
  30  A ASHRS.K=SMOOTH(ASHR.JK,STCT)
  31  C STCT=4
  32  A AVPRP.K=(PRICE.K-TUC.K)*CFD.JK-ADEX.K
  33  R AVPRR.KL=AVPRP.K
  34  L TAPP.K=TAPP.J+DT*(AVPRR.JK)
  35  R CFD.KL=DELAY3(RRD.JK,ARRD)
  36  C ARRD=20
  37  A ADEX.K=REV.K*PSAD
  38  C PSAD=.04
  39  A MARR.K=AC.K/ESTM
  40  L CASHP.K=CASHP.J+DT*AVPRP.J*CFD.JK
  41  A ADEXR.K=ADEX.K/LTDEX
  42  C LTDEX=5000
  43  R RADEX.KL=ADEX.K
  44  NOTE         DISTRIBUTOR SECTOR
  45  A TDOR.K=ASR.K+(1/AD)*(DID.K-AID.K)
  46  A DOR.K=MAX(0,TDOR.K)
  47  C AD=4
  48  L ASR.K=ASR.J+(1/TSR)*(DT)*(SR.JK-ASR.J)
  49  C TSR=4
  50  R ORD.KL=DOR.K
  51  R OR.KL=DELAY3(ORD.JK,MD)
  52  C MD=3
  53  A DID.K=ASR.K*CONSF
  54  C CONSF=4
  55  R RRD.KL=DELAY3(ASHR.JK,ADD)
  56  C ADD=2
  57  L AID.K=AID.J+DT*(RRD.JK-SR.JK)
  58  A UFCD.K=FCD/ASR.K
  59  C FCD=1000
  60  A TCPUD.K=PRICE.K+UFCD.K
  61  A CONPRI.K=(PRICE.K)*(1+DMUP)
  62  C DMUP=0.38
  63  A UPD.K=CONPRI.K-TCPUD.K
  64  L CASHD.K=CASHD.J+(DT)*(SR.JK)*(UPD.J)
  65  A AVPRD.K=(ASR.K)*(UPD.K)
```

```
NOTE           CONSUMER SECTOR
L UN.K=UN.J-DT*AWR.JK
R AWR.KL=UN.K/AWDE.K
L AW.K=AW.J+(DT)*(AWR.JK-PCR.JK)
L PC.K=PC.J+(DT)*(PCR.JK-PUR.JK)
R PCR.KL=AW.K/POD.K
L AC.K=AC.J+(DT)*(PUR.JK)
A PURD.K=PC.K/DPUR.K
A UY.K=TABHL(YUY,TIME.K,0,LEN,INC)
T YUY=.5/.5/.5/.5/.5/.5/.5
A UDO.K=TABHL(YUDO,TIME.K,0,LEN,INC)
T YUDO=.5/.5/.5/.5/.5/.5/.5
A INFV.K=TABHL(YINFV,ADEXR.K,0,1,.2)
T YINFV=.2/.2/.4/.6/.8/1
A PATT.K=TABHL(YPATT,PRAT.K,0,2,.5)
T YPATT=1/.5/0/-1/-1
A PRAT.K=CONPRI.K/PPN
C PPN=65
A AWDE.K=TABHL(YAWDE,AWD.K,0,2,.5)
T YAWDE=200/150/100/50/0
A AWD.K=INFV.K+UDO.K
A PCD.K=INFV.K+UY.K
A POD.K=TABHL(YPOD,PCD.K,0,2,1)
T YPOD=200/150/50
A PUD.K=PCD.K+PATT.K
A DPUR.K=TABHL(YDPUR,PUD.K,0,3,1)
T YDPUR=200/50/25/5
A IGF.K=MAX(0,PURD.K)
A DGF.K=MAX(0,AID.K/DT)
R SR.KL=MIN(IGF.K,DGF.K)
R PUR.KL=SR.JK
C CONVF=1
N UOP=ROS
N ROS=PC*CONVF/PURDN
C PURDN=4
C ESTM=180000
N AIP=IC*ROS
N AID=CONSF*ROS
N SPR=ROS
N ASR=ROS
N APR=ROS
N UN=ESTM
N AW=ESTM2
N PC=ESTM3
N AC=ESTM4
N CASHP=150000
N CASHD=150000
N TAPP=10000
C ESTM2=12000
C ESTM3=500
C ESTM4=500
C LEN=600
C INC=100
PLOT AW=A(0,200000)/REV=$/AVPRP=*(0,100000)/TAPP=I/AIP=V,AI
X R=S(0,1000),SHIN=P(0,1000)
PLOT PRICE=E/AVPRP=*/PRAT=R/UOP=N/OR=R/ADEX=A/PUD=U/SR=S
PRINT PRICE,CONPRI,ADEX,ADEXR,INFV
PRINT AWR,PCD,POD,PUD,DPUR,SR
SPEC DT=.2/LENGTH=600/PRTPER=0/PLTPER=15
OPT SNPRRN
RUN BASE
```

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