AN INDUSTRIAL DYNAMICS STUDY OF MANAGEMENT PRODUCT POLICIES

by

John Weibel, Jr.

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M. S., Purdue University (1950)

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Signature of Author . .
School of Industrial Management

Certified by. . . .
Faculty Advisor of the Thesis

6 Rotherwood Road
Newton Centre 59, Massachusetts
May 15, 1962

Professor Philip Franklin
Secretary of the Faculty
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

Dear Professor Franklin:

In accordance with the requirements for graduation, I herewith submit a thesis entitled, "An Industrial Dynamics Study of Management Product Policies."

I wish to take this opportunity to thank Professor J. W. Forrester, Mr. A. L. Pugh, III, of his staff, and Professor G. B. Tallman, whose aid and advice were greatly appreciated.

Sincerely yours,

John Weibel, Jr., Sloan Fellow
School of Industrial Management
Massachusetts Institute of Technology

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Submitted to the School of Industrial Management on May 15, 1962, in partial fulfillment of the requirements for the degree of Master of Science.

ABSTRACT

A manager of an industrial organization must plan ahead to minimize the riskiness of his decisions.

In this thesis, the industrial dynamics approach to policy decision making is applied in establishing the design and development budgets for a company which manufactures a durable good that is sold in a saturated market. The company is one of four major companies which dominate the industry.

A mathematical system was developed which includes the company, competition, and the market. The customer's buying decision was based on factors which are affected by the policies being studied; i.e., price, showroom appeal, and reliability. All competing companies are assumed to have the same marketing procedures which are equally effective.

Twenty computer runs for various policies were analyzed. The results indicated that for a company selling an established product in a saturated market, the customer expects to pay a competitive price for a competitive product. Increases in product showroom appeal and reliability, with associated increases in price, are detrimental to the company's position. The reverse is also true. The best results are obtained when efficiencies are introduced which allow a product of increased showroom appeal and reliability to be sold at the same price as competition.

The model implied that new product development is more effective than increases in showroom appeal or reliability above the competitive value on the established product. (This assumed that the competitive value was satisfactory but not the best that could be obtained.) This new product would allow the company to enter a growth market.

Thesis Advisor: Jay W. Forrester

Title: Professor of Industrial Management

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CHAPTER I

INTRODUCTION

The manager of an industrial organization is a decision maker and a risk taker. He must plan ahead to minimize the riskiness of his decisions. This thesis uses the industrial dynamics approach to making a policy decision in order to reduce the riskiness of that decision.

The policy decision is made in the light of the organization's being part of a system which is made up of all the factors that are affected by the decision. The success of the decision depends upon the interdependence of all the parts of a system, for a change in any part of the system, i.e., a policy change, changes the environment of the other parts of the system, and in turn influences the effect of the change and any future changes.

The School of Industrial Management at the Massachusetts Institute of Technology initiated a program in 1956, under the direction of Professor Jay W. Forrester, to develop a more scientific approach to management. Emphasis was placed on the problem of policy decision making by top management.

Industrial dynamics[1] evolved from the program mentioned above. It incorporates information-feedback control theory, decision-

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[1] Jay W. Forrester, Industrial Dynamics (Cambridge, Mass.: M.I.T. Press, 1961).

making process theory, and the experimental approach to systems analysis in analyzing a policy decision. The complex system problems that are devised would be too time consuming and expensive to solve if it were not for the digital computer. The computer is the tool which allows the industrial dynamics approach to be feasible for a business enterprise.

1.1 Thesis Problem and System Model

The industrial dynamics approach to policy decision making is applied in establishing the design and development budgets for a company which manufactures a durable good which is sold in a saturated market. The industry of which the company is a member is dominated by four major companies. The thesis company is one of the major companies.

The system developed includes company, competition, and market. Since the analysis is essentially of engineering budget policy decisions, no attempt was made to incorporate marketing in the system model. The assumption is that the marketing procedures are the same and equally effective for all competing companies. The customer's buying decision is based only on factors that can be affected by the engineering policy, i.e., showroom appeal, reliability, and price. (An industrial dynamics approach to advertising policy decisions has been devised.[2])

No attempt was made to document the data used in establishing

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[2] Ibid., pp. 187-207.

the company or the market. The data used were the concensus of the intuitive feelings of many of the Sloan Fellows of M.I.T., and their wives, who were asked informally about their approach to the problems which arose in designing the system model.

1.2 System Model's Reaction to Policy Changes

The system model was designed in such a way that a state of equilibrium existed among all competing companies before the policy change was made. After the change, the reaction of the system model was compared to the conditions which existed during equilibrium.

Twenty computer runs of various policy changes are analyzed in Chapter VI. The results are qualitative and should be considered only as trends.

The system described indicated that the market had established its image of what the product should be and was very price conscious. Best results were achieved when the product was comparable to competition in all respects. If, however, the company was able to introduce efficiencies which would allow a reduction in cost, the best policy would be to increase the reliability and showroom appeal of the product and maintain the same price rather than continue to manufacture at the same level of reliability and showroom appeal and reduce the price; i.e., give the customer more for his money rather than a reduced price.

The system model implied that in a saturated market the greatest advantage can be realized by (1) developing new products or dramatic changes in the useful features of the old products which would essentially change the market to a growth market, and (2) develop marketing procedures which would psychologically sway customers to purchase the product which is comparable to competition.

CHAPTER II

INDUSTRIAL DYNAMICS: A BRIEF DESCRIPTION

"Industrial dynamics is the investigation of the information-feedback character of industrial systems and the use of models for the design of improved organizational form and guiding policy."[1]

2.1 Foundation of Industrial Dynamics

Information-feedback control theory, decision making process theory, the experimental approach to systems analysis, and digital computers have all gone through their greatest development during the past fifteen years. Industrial dynamics has evolved from these earlier developments using those parts of each which best describe the industrial system.

Incorporation of information-feedback in the industrial systems model is the most important advancement of industrial dynamics. Information from any part of the model can be fed back to any other part of the model. Policies can be incorporated which are dependent on levels or rates of flow in the model.

An example of information-feedback is the manufacturing costs, price, and sales situation. Manufacturing costs are dependent on production, which is dependent on sales, which are dependent on price,

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[1] Ibid., p. 13.

which is dependent on manufacturing cost. If manufacturing costs are reduced, it would therefore stimulate sales, which further would reduce manufacturing cost.

By incorporating information-feedback the model more accurately represents the "real world." In addition to feedback loops, information delay time is also incorporated. This combination produces some of the most interesting results of the model.

Information-feedback systems owe their behavior to structure, delays, and amplification. The structure tells how the systems parts are related, delays exist in the availability of information, and amplificiation is the unexpected effect of other parts of the system.

Decision-making process theory was developed in the 1950's during the automatization of military tactical operations. It considers that meaningful decisions are not "free will" but rational and are based on the environment from which the decision must be made. Policies can be established which govern such decisions and anticipate what the decisions will be.

Experimental approach to systems analysis is sometimes called simulation. A mathematical model is developed which simulates the whole system being investigated. The model is the apparatus on which experimental policies are tried.

The digital computer is the tool without which the industrial dynamics approach would be too costly and time consuming to be practical. The speed at which the calculations are made enables the experimental approach to be feasible.

A computer program called DYNAMO[2] has been developed for industrial dynamics. Equations and data describing the situation are presented to the computer, which calculates, prints, and plots the results.

2.2 A Management Tool

Industrial dynamics is a tool to aid management. It requires that before a policy is made, management must establish what factors will be affected by the policy and how these factors affect one another. For example: a policy on the design and development budget could affect (1) product style, (2) product reliability, (3) product features, (4) manufacturing costs, (5) price, (6) sales, (7) profit, (8) ability to meet payments of budgeted design and development costs. If the relationship between each of the above items is established with any other item, then a change in any one will have an effect on all the others.

A model of the situation is said to exist when the relationships among all of the factors are determined. Various policies are tried on the model and the reaction of the model is observed. The policy which gives the desired reaction is considered the most effective.

When a running model is established, i.e., a model which will give logical results for a known policy, management has a tool which

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[2]Alexander L. Pugh, III, Dynamo User's Manual (Cambridge, Mass.: M.I.T. Press, 1961).

could possibly represent the "real world." As more policies are tried and refinements are made, confidence in the model grows. When confidence is attained, management has developed, with the aid of this new tool industrial dynamics, a "guinea pig" on which to try new policy ideas.

The time delays reported by the model give management an indication of the time that should be allowed before results from a policy can be expected. Or, conversely, when enough time has been allowed to establish whether the policy has been effective.

2.3 Data for the System Model

After all the factors are determined and their relationship is established in verbal language, it is necessary to change the word description to a mathematical description. In many cases, the relationship will require data to describe the relationship. For example, when describing the relationship of price and sales it is not sufficient to state that sales increase as price decreases; the amount of increase and decrease must also be supplied.

Whenever data are required the question of the amount of accuracy required must be answered. This question is answered by the model itself.

The data are originally supplied to the model from existing sources or intuitively. After the model is completed and in running condition, the data for each factor are changed in independent runs to determine the effect of the change on the model. If the data change has little or no effect, the data supplied need not be accurate but only indicate the type of relationship that exists. However, if the model reacts to small changes in data, the data must be accurate.

The factors which require accurate data are the pulses of the situation, not only in the model but in the "real world." Data from these factors should be kept up to date and made available to management so that they may keep their "fingers on the pulse" of the situation. Equally important, the model indicates what data are not important as indicators of changes in the situation and need not be gathered.

2.4 Qualitative Results

The results obtained from industrial dynamics are exactly what would happen if the "real world" was precisely described by the model.

The model is, however, an accurate simulation of what management thinks the "real world" is like. It should be remembered that the relationship between the various parts of the system were established by actual data, by intuition, and by extrapolation of historical data. All were based on the past, and on the knowledge and skill of the manager.

The results are qualitative and give a good indication of what changes can be expected in the system as the result of policy changes. The results are as accurate as the accuracy of the system model which, in turn, is as good as the manager who described it.

CHAPTER III

THE PRODUCT

The product is not specifically designated, but is described below. It is a product which has characteristics which are present in the products of many industries. It is suggested that the approach used in this thesis may be used for any product with these characteristics; the curves will vary only in the numerical values which are ascribed to them.

3.1 An Established Product

The product has established itself as a necessity to the extent that the sales are not growing dramatically. The sales do change from year to year, but this change is not caused by new customers entering the market but by the varying length of ownership time. Customers are swayed to buy sooner or later by product design, price, and economic conditions. More products can be sold by reducing the ownership time.

Since the product is established, the owner has definite expectations and has the opportunity to compare his product with others. Ownership satisfaction for various brands can be established from "over the back fence" conversation. Certain performance standards have become established, and when a brand does not meet the standards (too many service calls, for example), it becomes news and is discussed. In this way, customers learn what to expect from the product.

Complete knowledge of all brands of the product is gained by the customer through advertising. The efficiency of the advertising of all companies is considered the same. In this thesis, advertising does not create desire for the product, but rather the product itself creates the desire to buy.

3.2 Showroom Appeal

Customers are attracted to a certain brand of the product by its style and features. It is these characteristics which have the greatest effect on attracting customers who are dissatisfied with the brand they now own. These features also sway satisfied owners to rebuy the same brand sooner in order to keep up to date. These features are classified as showroom appeal.

Showroom appeal items can vary from items that pertain to style to those pertaining to comfort; i.e., from fins on automobiles to more room in the back seat. Anything that can sway the customer in the showroom can be classified as showroom appeal.

To keep swaying the customer and to minimize the time between rebuys, the showroom appeal is changed yearly. This has been called "dynamic obsolescence" and is one of the reasons for the yearly model change which exists in many industries.

The products produced by competition have a showroom appeal that is constant. Every year the same proportion of customers like, but do not necessarily buy, the product. This does not mean that competition is not changing style and features but rather that they command enough of the market to determine what is expected in show-room appeal. They are the basis for comparison. If all the competing brands have the same showroom appeal, the customers will base their decision to buy on other factors.

3.3 Reliability

The product is of a functional design; it performs a task. During the performance of the task the product may fail. Upon failure, the owner must either have the product repaired or buy a new product. In either case, some action is required of the owner which is made known to other owners. "I had to have the service man out today . . ." or "I'm going to get a new one; I'm not going to continue paying repair bills . . ." are statements that are commonly heard.

The product is designed and manufactured with a given reliability. Tests are made by engineering which determine the per cent of failures that are expected in a given length of time. Quality control weeds out those products which are believed to be faulty. But there are still failures in the field.

Data on the field failures, service calls, can be obtained from servicemen's records, and plotted against the reliability designed and manufactured before the Quality Control Department weeded out the rejects. This plot must be made from data on the particular product.

Figure 1 shows the curve used in the thesis. If the reliability

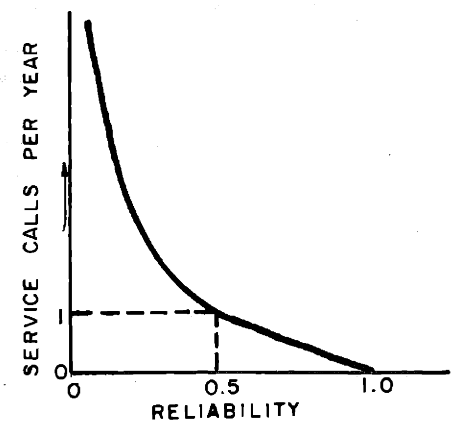


FIG. I. Relationship of Reliability to Service Calls

manufactured is 1, then 100 per cent of the products manufactured will run the expected life time. There would be no service calls required if the reliability manufactured is 1. As the reliability decreases, the service calls per year increase, as shown on the curve. For this thesis, at a reliability of 0.5, the average service calls per year are one per product. The curve ascends more steeply as it approaches zero reliability when all products would fail.

3.4 Price

The price of the product has an important effect on sales. The product is priced high enough to eliminate the effect of impulse buying. The customer has planned the purchase of the product.

The product price is not inflated to the point where changes in design can be made without affecting the price. The various brands are very competitive. The market is very price sensitive and a reduction in price is the most effective way to increase sales. To insure the profit expected by the stockholders, any change in costs requires a change in price.

There is one exception to the above statement on price. The company can place a ceiling on the price and reduce profits if it feels the market will not support the price desired.

Price changes are made effective at the time of the introduction of a new model. No changes are made during the model year.

The study of price changes and their effect on the market would be interesting indeed, but is not considered in this thesis. The thesis does show that price is an important factor in sales.

CHAPTER IV

THE COMPANY

The company is classified as one in the <u>one million units per year class</u>. It has the facilities to design, develop, manufacture, and market products at a normal volume of one million units per year.

The company is as efficient in its operations as the average of its competition. Therefore, the companies all manufacture a product of equal characteristics and enjoy the same rate of profits before policy changes.

Management policies may be changed on the showroom appeal budget, the reliability budget, and the price, to try and capture more profits for the company. Policies on price are only minor in this thesis, since the study is pointed toward showroom appeal and reliability.

4.1 The Budgets

The company management may establish the desired budget in any way it desires. The budget may be set exogenously or may be made dependent on some market or company variable. The effect of various methods of setting the budget will be discussed in Chapter VI, Analysis of Policies.

After the desired budget is established, it is presented to the various departments, principally engineering, to be used to develop the product. An increase in the budget will increase the product's characteristics affected by the budget, and thereby increase its acceptability in the market; a decrease will decrease its acceptability.

After the Engineering Department receives its budget, it must divide its funds between projects which pertain to showroom appeal and those which pertain to reliability. This division of funds is made in the knowledge of the type of product that top management wants to manufacture.

With any increase or decrease in budget, a certain length of time elapses before the budget becomes effective. This time is required to hire and train new men or to release those who are no longer needed, and to buy or dispose of equipment. The average delay time to increase or decrease the budget is one year in this thesis.

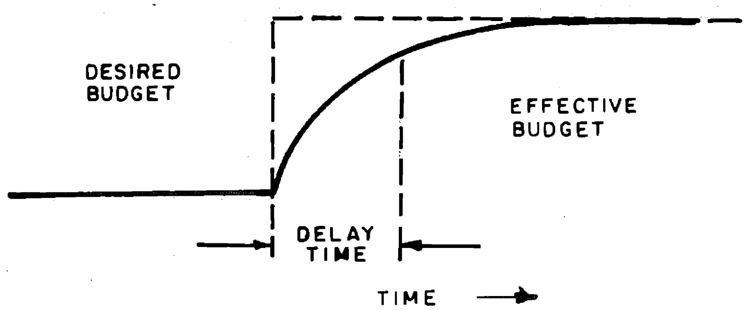


FIG. 2. Budget Leveling

Figure 2 shows how an abrupt budget increase becomes effective. The buildup is rather rapid to begin with, but slows down after a year. After the budget change is announced, many changes are immediately put into effect, e.g., requisitions for men and equipment. The shelf items are obtained almost immediately, but others take longer. Small changes in the budget follow the same trend as the large ones.

4.2 Design and Development Cost

It is necessary to establish a scale by which the effectiveness of the design and the development budget may be measured.

Two factors must be taken into consideration when establishing the scale--the class of the company, and the type and cost of the product.

The class of the company is important since there are both economies and expenses in size. (The company, as stated above, is in the one million units per year class; this class is held constant, independent of sales.) A large company can absorb changes that might prove quite expensive to a small organization. People can be shifted; equipment may be available. Changes in the actual size of the company due to changes in manufacturing schedule will not affect the effectiveness of its design and development activities. The company class establishes the design and development effectiveness based on facilities which do not change.

The type and cost of the product are needed to establish the relation between showroom appeal and reliability budgets. The basic variable cost establishes the dollar value to be placed on a unit of reliability or showroom appeal.

The basic variable cost is the labor and material cost to produce a product of minimum showroom appeal and reliability. In this thesis, the basic variable cost is set at $50.

The basic variable class cost is the basic variable cost required to manufacture the product at the schedule equal to company class. If the company produced units at its designed capacity and these units had the minimum showroom appeal and reliability, the amount of labor and material required to produce these units would be the basic variable class cost. This is the unit which will be used to compare design and development costs.

4.3 Showroom Appeal Budget

The showroom appeal designed into the product is based on the showroom appeal factor, which is the ratio of the effective showroom appeal budget to the basic variable class costs.

The showroom appeal that is designed into the product is related to the showroom appeal factor as shown in Figure 3. From this curve the budget required to sustain a given showroom appeal can be obtained. Low values of showroom appeal are very easy to obtain. Having a design that is not distinctive or comparable to competitive brands requires little innovation, and therefore a small budget. For higher values of showroom appeal, the product must be distinctive, and stand out as a leader in style and features. Products of high showroom appeal require large budgets to maintain their position as leaders in style and features.

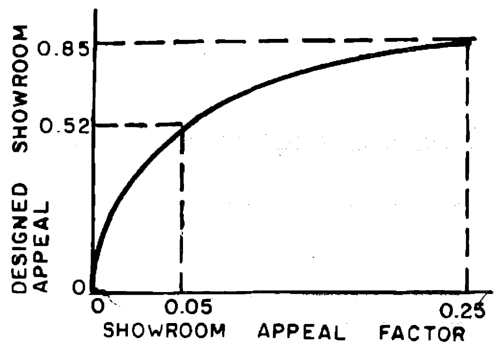


FIG. 3. Designed Showroom Appeal

At no time will a product receive 100 per cent acceptance for style and features. A showroom appeal of 0.85--85 per cent of the customers like the product--is the maximum possible in this thesis.

Low values of showroom appeal have a much larger marginal increase than high values for the same increase in budget.

4.4 Reliability Budget

The effectiveness of the reliability budget in producing a reliable product is dependent on the showroom appeal of the product. Products with high showroom appeal have high style and many meaningful features which require reliability effort. If showroom appeal is increased without an increase in the over-all reliability effort, the very fact that more items are in the design requires a dilution of the reliability effort on each item.

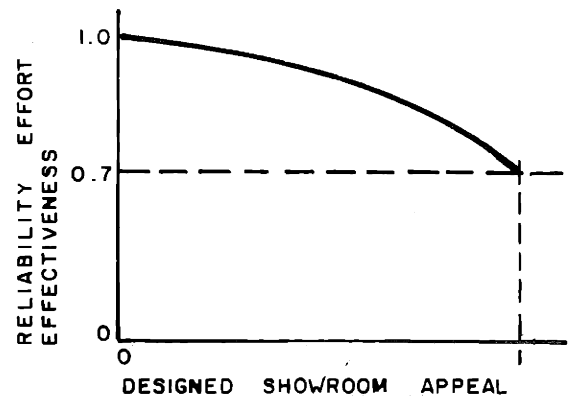


FIG. 4. Reliability Effort Effectiveness

Figure 4 shows the reliability effort effectiveness based upon designed showroom appeal. The effectiveness decreases as the showroom appeal increases. The effectiveness is a maximum of 1, 100 per cent effective, when the showroom appeal is zero. It decreases following the curve until it reaches a minimum of 0.7, 70 per cent effective at a showroom appeal of 1. At low values of showroom appeal, the slope of the curve is much less than it is at high values.

The reliability designed into the product is based on the reliability factor. The reliability factor is the ratio of the effective budget to the basic variable class cost multiplied by the reliability effort effectiveness.

The designed reliability, as shown in Figure 5, follows a curve very similar to the showroom appeal curve. Reliability of a final model is the product of the reliability of each of its parts. Therefore, if a product is made up of 16 vulnerable parts, each with a reliability of 0.99, the reliability of the product would be 0.99^{16} or 0.85. Although 99 per cent of the parts would not fail, only 85 per cent of the products would not fail, for if one of the 16 parts fails the product fails.

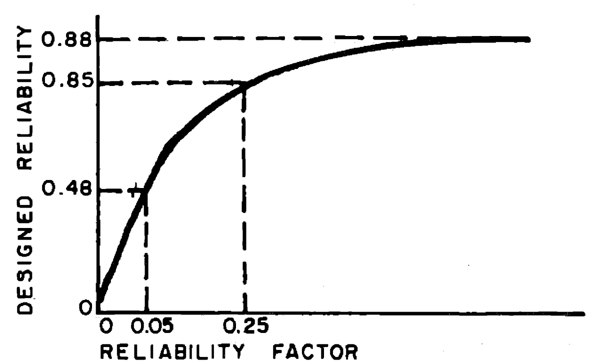


FIG. 5. Designed Reliability

The curve, therefore, has a reliability maximum above which the product cannot be manufactured at any price. This maximum is considered 0.88 for this thesis. The curve has a steep slope at low reliability factors, indicating that for products with poor reliability, an increase in the effort would show a definite increase in the reliability. As the reliability factor increases, the curve becomes less steep, until it approaches 0.88.

4.5 Manufacturing the Product

After the product model is designed and developed, prints of the engineering drawings are issued to the Manufacturing Department. From these prints the tools and equipment are designed and built or purchased.

Design changes are made throughout the year and are issued to the Manufacturing Department. These changes are divided into two groups--the showroom appeal group, which are put into production once a year at model change time, and the reliability group, which are put into production as soon as possible after being received.

A product retains its showroom appeal rating for a model year. Each model manufactured has a showroom appeal which does not change throughout the model year. It is true that some drastic style changes do not "catch on" when first introduced but gain acceptance during the model year.

Drastic changes usually require large outlays of tool and equipment money and are, therefore, only modified for the next two or three model years. The later acceptance is taken into account by not changing the showroom appeal during the year (consider it an average) but by changing it in subsequent years.

Figure 6 shows the delay between a drastic budget change and the change effected in the product. The first year after the increase shows no effect on the product. After the first year, the largest change is seen with a dramatic jump in the showroom appeal of the product. If the budget is kept the same, each subsequent year shows a smaller increase in showroom appeal due to design changes and acceptance of the design, until the product maintains a level of acceptance which does not change.

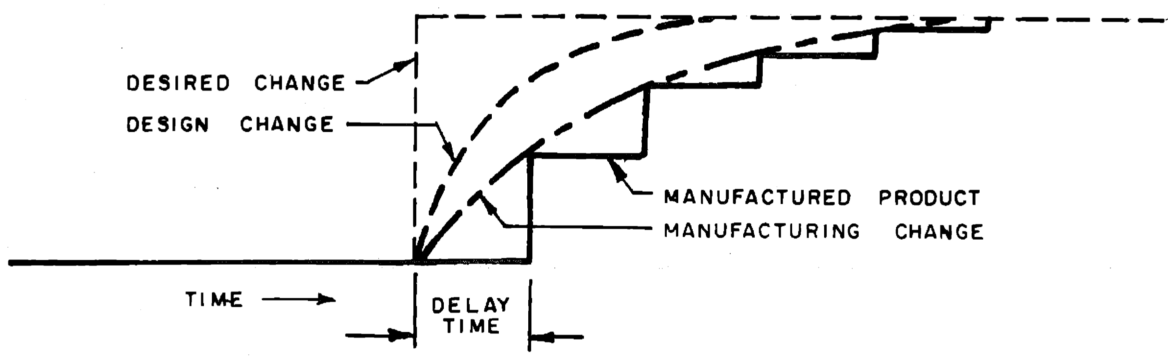


FIG. 6. Delays in Showroom Appeal Change

Changes in reliability are made throughout the model year. If a part of the product fails excessively, changes in design will be made during the model year in order to eliminate this cause for complaint. Reduction in reliability may be caused by the poor design of a part in a particular model of the product. It is not necessary to issue a new model to change the design of the part. Therefore, a change in reliability is possible during the model year.

Figure 7 shows the change between a budget change and the effect on the reliability of a product being manufactured. It should be observed that the only difference between Figure 6 and Figure 7 is that the changes in the product are continuous for reliability and yearly for showroom appeal.

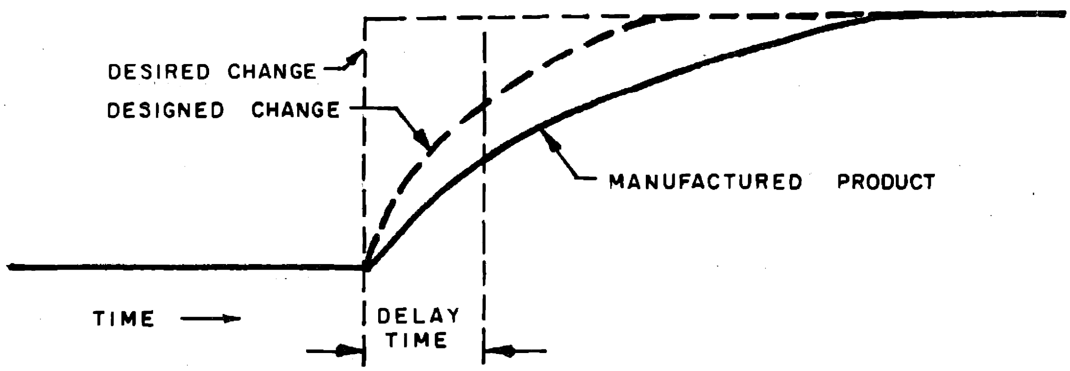


FIG. 7. Delays in Product Reliability

4.6 Cost

The product cost is made up of those costs that do not vary with the number of units produced--fixed costs--and those costs that do vary with the number of units produced--variable costs.

The fixed costs considered are: (1) design and development costs; (2) equipment, tool, and overhead expense; (3) administrative and selling expense.

1. Design and development costs are the budgets for showroom appeal and reliability. The budgets are the money actually spent on the design and development of the product.

2. Tool, equipment, and overhead expense is based on the size of the design and development budgets. When the design budget is large, it is expected that the designs will require more elaborate tools and

equipment. This expense is, like the design and development budgets, dependent upon the product and company class.

The tool, equipment, and overhead expense was determined in the following way:

a. The design and development cost ratio was determined as the ratio of design and development budgets to the basic variable class costs.

b. Using the design and development cost ratio, the equipment, tool, and overhead expense ratio was determined from Figure 8. This ratio is the ratio of the equipment, tool, and overhead expense per product to the basic variable product cost. The equipment and tool costs are the costs that are being amortized.

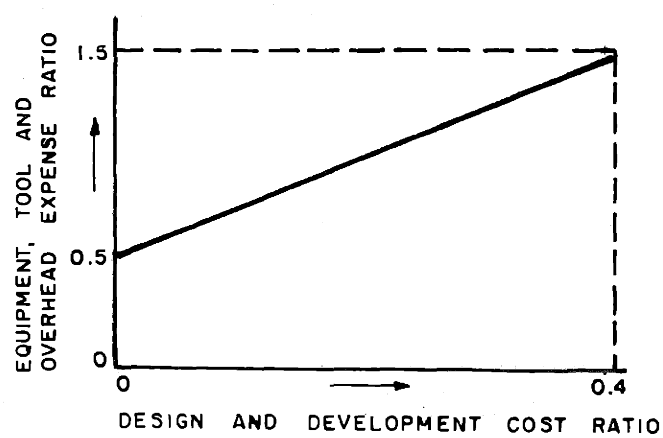


FIG. 8. Equipment, Tool and Overhead Expenses

No differentiation is made between the equipment and tools for showroom appeal and reliability. The variation was not considered significant for this thesis. The equipment and tool costs are considered to vary directly with design and development costs.

c. The equipment, tool, and operating cost is the product of the equipment, tool, and operating cost ratio and the basic variable product cost. These costs are leveled over a one-year period to match the showroom appeal and reliability being manufactured into the product.

3. Administrative and selling expense is considered a constant for this model. It is not being investigated and does not vary. It is considered independent of any variable in the model. It is the expense from manufacturer to consumer. In this model it is set at $25 million.

The variable costs are the material and labor costs. These costs are twice the equipment, tool, and overhead expense.

4.7 Product Price

The product price is set once a year. It is established from the following: (1) the costs being spent at the time the price is set; (2) the expected product sales for the coming year; and (3) the expected profit.

1. The costs are the variable and fixed costs mentioned above. The variable costs are known per product. The fixed costs are known per year and are divided by the expected sales to determine the fixed costs per product. The sum of these costs is the product cost.

2. The expected product sales is the sales level over the past year. This makes the company optimistic when sales are declining and

pessimistic when sales are increasing. No effort was made to have economic conditions feed back into the sales forecast. The sales forecast policy is simply, "We'll do as well as we did last year."

3. The expected profit is held constant at 25 per cent of costs, except when a decision rule is used which states that the price will not be more than 125 per cent of competition.

The product price is set at expected costs plus expected profit at the beginning of the model year.

4.8 Inventory

The company is assumed to be able to supply the product to the customer when purchase is made. No sales are lost due to lack of products; products are available at all times.

The model does this without inventories. There are no reservoirs in which products may be stored or from which products may flow in order to smooth production schedules. The company is flexible in manufacture and can meet any production schedule required.

Inventories are necessary for the smooth operation of a business, and in this respect, the model is faulty. But, for the study for which the model is intended, inventories would not affect the results.

An inventory could be considered in the model and the products drawn from it as sales are made. This inventory would have to be managed so that no products are in inventory when a new model is introduced. There could be no overruns or shortages.

In Industrial Dynamics, Forrester discusses company policies pertaining to inventory.

4.9 Profits

Determination of the profit of the company is greatly simplified by the lack of inventory. The earnings of the company can be compared with the costs and expenses directly. All products built are sold in the same accounting period.

The profit earned by the company is the measure of its success only if the profits can be maintained. The company is investigated over a fifteen-year period to insure that the profits are not momentary but lasting.

CHAPTER V

THE MARKET

5.1 The Competitors

The model consists of four major companies competing for the customer. The companies are divided into Company X, which is the thesis company and will be examined closely, and Company Y, which is an aggregate of the three other companies. Company Y is the average of the three companies and is considered the baseline. Although Company Y is said to manufacture a product of given showroom appeal, reliability, and price, it should not be implied that Company Y is static. The values given are for computation purposes and should be used for comparison purposes only. For example, a product with a showroom appeal of 0.5 (50 per cent of the customers liked the product) in 1950 would have a much lower showroom appeal if introduced today. A company cannot be static and hold its position in the marketplace.

5.2 Owners Not in the Market

After the product is purchased, the average owner does not enter the market for three years. This does not mean, however, that all owners enter the market at three years. Some enter almost immediately--customers who got a "lemon" or for some other reason are completely dissatisfied or require a new product. Other customers are style conscious or require the latest features and enter the market after about a year's ownership. Still others have purchased the product for its functional use and will remain out of the market for more than the three-year average.

The owners enter the market at the rate shown in Figure 9.

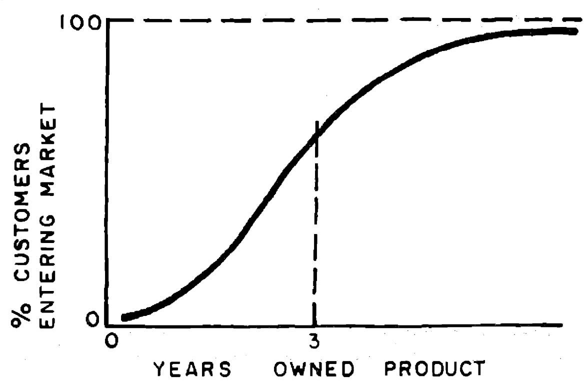


FIG. 9. Owners Entering the Market

5.3 Owners in the Market

When an owner decides that he is interested in purchasing a new product, he enters the market. At this time he has owned a product of Company X or Company Y long enough to make certain decisions about the product and answer questions that will determine when and what product he will buy. If he is satisfied he enters the market as a satisfied owner; if not, he enters as a dissatisfied owner.

I. Am I a Satisfied or Dissatisfied Owner?

A satisfied owner is one who feels that the product he owns has better reliability than other products in the market. He determines whether he is satisfied or not by comparing the level of service calls that have been required over the past four years, with special emphasis on recent years, for competitive brands to the number of service calls required on his product. This compares his personal experience with the experiences of owners of other brands of the product over his average ownership time (the three years not in the market and the one year in the market). From this comparison, the owner establishes a <u>reliability image</u> of the company.

Figure 10 shows the effect of reducing the service calls required on a new product model on the level of service calls that the owner of a competitive product believes is required. Time is required to remove products requiring the original number of service calls from the field. When these products are removed, the new level will be established.

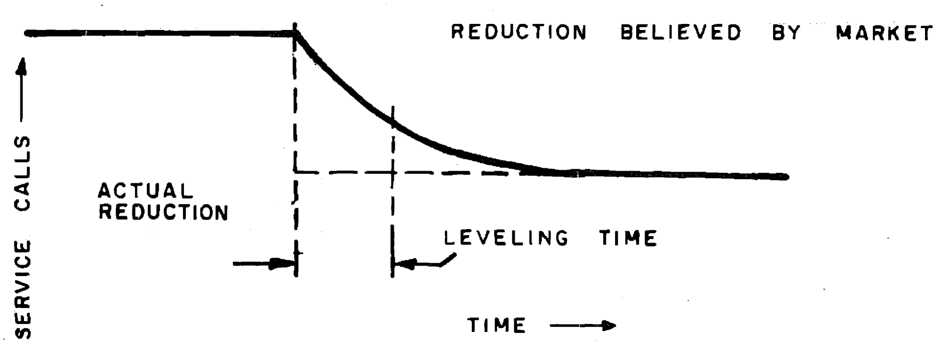


FIG. 10. Service Call Reduction Effect

From the reliability image established for the company, the owner decides whether or not he is satisfied. A satisfied customer is defined as one who would, all other things being equal, buy his next product from the same company. If it is felt that his product is as reliable as all others (reliability image equals 1), 40 per cent of the owners in this model are satisfied. Never will more than 82 per cent of the owners in this model be satisfied. The satisfaction curve is shown in Figure 11. When reliability image is less than 1, the product is considered less reliable; when it is greater than 1, the product is considered more reliable.

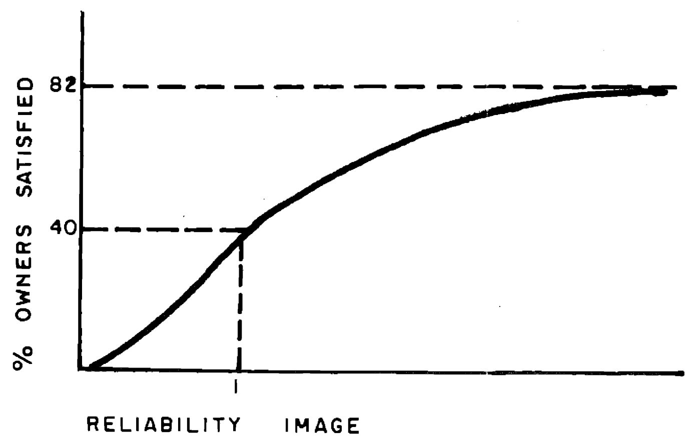


FIG. 11. Relationship of Reliability Image to Percent Owners Satisfied

Dissatisfied owners are simply those owners who are not satisfied.

II. When Will I Decide to Buy?

Now that the owner has decided that he is interested in buying a new product, he must decide when to buy. The time required to make this decision is based on four factors for this model.

1. Is he a satisfied or dissatisfied owner?

Satisfied owners on the average remain in the market longer than dissatisfied owners. They are satisfied with their product and are not inclined to get rid of it as soon as possible due to some disagreeable aspect. Satisfied owners are more inclined to "shop around" or wait for the "good deal."

For this model, satisfied owners were in the market for an average of two years, while dissatisfied owners remained an average of only one year. It should be noted that this is the time from the first thoughts of purchasing a new product to its actual purchase.

2. What are the economic conditions?

Definitely, the customer's and the country's economic conditions have much to do with the purchase of a major consumer good. The U. S. Department of Commerce reports[1] that the sales of durable goods vary on a five-year cycle. In this model the economic conditions' effect on sales is said to either increase or decrease the length of time a customer remains in the market. This economic change is considered sinusodial about the average time spent in the market with a maximum increase or decrease of nine months.

[1] U. S. Department of Commerce, U. S. Income and Output (Washington: Government Printing Office, 1958), p. 23.

3. What are the prices?

The price of the product is an important factor in the movement of customers from the market. Unfortunately, the product price is not completely explored in this thesis. Price in this thesis is dependent upon cost only, except for the decision that price cannot be greater than 20 per cent above competition. But, the customer is very price sensitive.

The price of the product does change in this thesis, and therefore must be considered.

Price affects the time owners spend in the market only if the price today differs from the price level over the past year. Therefore, if the average price of all the competitors' products today is less than the average price level of all the competitors' products over the past year, the effect will be to reduce the time the owners will spend in the market. If the price is reduced, more customers buy. Using the same reasoning, if the price is increased, more time is spent in the market and sales will decrease.

This ratio of average price today to average price level over the past year is called price ratio of the market in this thesis. Its effect on the time spent in the market is shown in Figure 12. The curve is steep at the value of one, which indicates that changes in price have a large effect on the time spent in the market. There is an upper limit, however, since the product does wear out after a certain length of time. It has a lower limit because the product is functional, expensive, and requires some time to make the decision to buy.

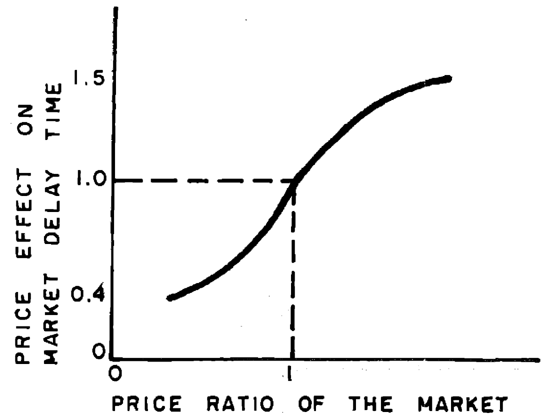


FIG. 12. Price Effect on Market Delay Time

4. What is the showroom appeal of the product?

Customers are very style conscious. If a dramatic style change is made that is accepted by the market, it can affect the time spent in the market. Not only style, but features can also have a decided effect. The American consumer wants to be "up to date." As new features are developed and new styles are conceived, these designs are incorporated into products which whet the appetite of the consumer. When these designs are accepted they can, as we have experienced in recent years, increase sales and thereby reduce the time spent in the market.

Using the same reasoning as was used on price, a showroom appeal ratio of the market is established which is the ratio of average showroom appeal today to the average showroom appeal level over the past three years. Three years is used for showroom appeal as compared to one year for price since price must be remembered while the showroom appeal of past products is visible.

The effect of the showroom appeal ratio is shown in Figure 13. It should be noted that unlike price, which had a steep slope at the value 1, showroom appeal is fairly flat, which suggests that big changes in showroom appeal are required to change the time spent in the market. The consumer expects a change in showroom appeal yearly. The yearly model change has become an institution. The curve has upper and lower limits for the same reason as the price curve; i.e., products wear out and there is a minimum market delay time. The greater the showroom appeal ratio, the less time spent in the market.

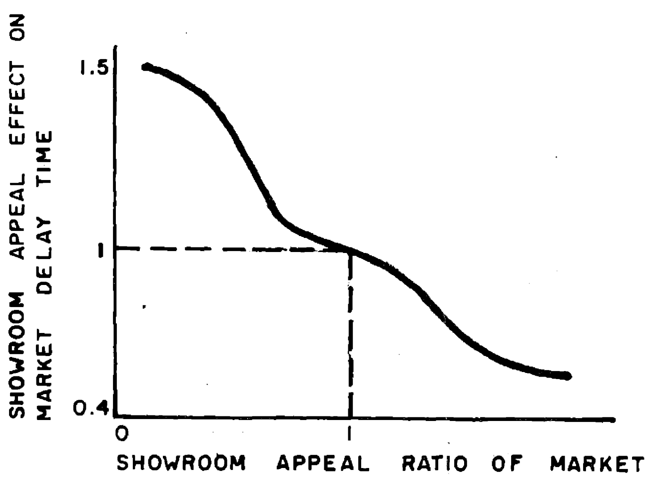


FIG. 13. Showroom Appeal Effect on Market Delay Time

III. <u>What Brand of Product Am I Going to Buy?</u>

When the owner becomes a customer he has decided that he will buy now and will buy a certain brand. How does he make this decision?

In this thesis he has three factors which he may use to determine which brand of product he will buy. These factors are price, showroom appeal, and reliability.

With the three factors mentioned above, the customer must answer two basic questions, not necessarily in this order: (1) Which brand of the product do I like best?; (2) Am I willing to pay the price asked?

It is not always the most accepted product in style and features that captures the most customers. The price must be right!

* * *

A Digression

It would be well now to stop and look at where we are in the discussion of the market and where we plan to go.

We have followed customers who had just become owners of products. During their ownership they had become either satisfied or dissatisfied with the product, had decided to go to the marketplace and investigate the purchase of a new product, and are now making the decision on which product to buy.

The owners of each brand of product who are ready to buy a new product are divided into two groups--those who are satisfied with the product they now own and those who are not.

From these eight groups (satisfied and dissatisfied customers from four competing companies) must be developed the four groups of customers who buy products, one group to each of the competing companies. This is simplified by combining three of the competing companies into one company with characteristics equal to the average of the characteristics of the three companies combined.

The satisfied customers will determine whether to buy the same brand of product they now own by the price that is charged for the product. If the price is exceptionally low, it will not only induce satisfied customers to rebuy but will sway some dissatisfied owners to buy the same brand that they are presently dissatisfied with. If the price is high, few satisfied and no dissatisfied owners will rebuy. The owners who rebuy are called loyal.

Those customers who do not rebuy, disloyal, will buy from a competitive company. The company which captures them does so by price and showroom appeal.

The loyal customers and the captured customers become owners, completing the loop and starting the cycle of owners to prospective customers to buyers over again.

* * *

1. Which brand of the product do I like best?

The question could be restated as "Which brand would I most like to own?" The answer to this question will have an effect on the final decision on which product to buy.

Satisfied owners, by definition, would like to buy the same brand they now own.

Dissatisfied owners do not like the brand they now own, but like another brand. Dissatisfied owners of Brand X, "our" company, will like a brand of one of the companies that make up the aggregate Company Y. It is not necessary to define which particular brand; Brand Y is sufficient.

Company Y, as stated before, is made up of three companies or three brands. A dissatisfied owner of one of the brands of Company Y may like Brand X, or one of the other two brands in Company Y.

The proportion of dissatisfied owners of products from Company Y who like Brand X is determined by the ratio of the showroom appeal of Brand X to the sum of the showroom appeal of all brands competing for the customers. Showroom appeal is the decimal equivalent of the percentage of customers who like the product. For example: Three companies are competing for a group of prospective buyers. The customers investigate the products and 50 per cent of the group like each of the products. Then the showroom appeal of each product is 0.5. Now, since each of the products has the same showroom appeal, it would be expected that if customers bought because of showroom appeal alone, each of the companies would sell the same number of units. Or, one-third of the customers would buy from each company.

$$\text{Proportion who would like to own Brand X because of showroom appeal} = \frac{.5}{.5 + .5 + .5} = .33$$

If the poll of customers showed that 75 per cent of the customers liked Brand X and the competing brands remained at 50 per cent, then:

$$\text{Proportion who would like to own Brand X because of showroom appeal} = \frac{.75}{.75 + .5 + .5} = .43$$

The increase of showroom appeal of 50 per cent over competition has increased the effect of showroom appeal on probable sales only 30 per cent.

Once the dissatisfied owners of a brand in Company Y who like Brand X are determined, the dissatisfied owners remaining must like another brand in Company Y.

It has now been established which brand each customer would like to own.

2. Am I willing to pay the price asked?

The customer determines the price he is willing to pay for a product by a comparison of the various brands' past performance and present price.

The comparison of past performance is compiled under the name of company image. Company image is defined as the ratio of the product of the showroom appeal level over the past three years and the ownership satisfaction level over the past four years of one brand to the same factors for competition.

The showroom appeal and ownership satisfaction levels have emphasis on recent years' performance. The company image is a performance rating. If it is greater than 1, the company is considered better than competition. If it is less than 1, the company is worse than competition.

The company image described is the image established by customers who do not own a product of the company. It is made up of the field's experiences, or levels, and not of actual personal experiences. This company image will be used when establishing the price that dissatisfied owners are willing to pay. This has been designated company image in the market.

Satisfied owners do have personal experiences with the brand that they are willing to buy. These personal experiences should be taken into account when establishing the price that they are willing to pay. After investigating various ways to recognize these experiences, it was decided that satisfied customers would have a company image 20 per cent higher than the market image. Therefore, company image for loyal customers is defined as 1.2 times the company image in the market.

The company image is needed to determine the expected price ratio for the brand, Figure 14.

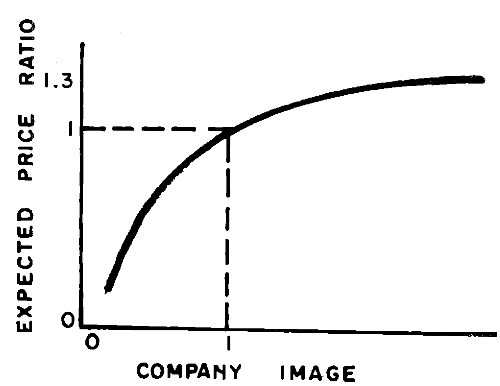


FIG. 14. Relationship of Company Image to Expected Price Ratio

When the company image is 1, the expected price ratio is 1. Customers would expect to pay the same price for various brands that had the same past performance, The expected price ratio is the ratio of the price of a given brand to competition's price. As shown on the curve, if the company image is less than 1, the expected price ratio is less than 1. If the company image is greater than 1, the expected price ratio increases, but does not increase above 1.3

By using the same curve for both satisfied and market customers, satisfied customers would expect to pay more for their product since their company image is greater.

5.4 The Effect of Price

The actual price ratio, the ratio of the actual price to the price charged in the market, may or may not be equal to the expected price ratio. If the actual price is less than the expected price, more customers will buy; conversely, if the price is higher, fewer customers will buy.

Therefore, the ratio of what the customer must pay to what he expects to pay is an important one, and is called the effective price ratio; it is used to establish the price effect on customers, Figure 15.

The price effect establishes the proportion of customers who actually buy the brand of product that they like.

When the effective price ratio is 1, the price effect is 1. The price is what the customer expects to pay, and he buys. As the effective price ratio increases, the price effect decreases rapidly until it becomes less steep at the low values of price effect to pick up customers who are so loyal that they will buy at almost any price. But the price eventually gets too high even for them, and the price effect becomes zero.

As the effective price ratio becomes less than 1 (the price is less than expected), the price effectiveness becomes greater than 1. Customers are persuaded to buy even though they like another brand better when the price is lower than expected.

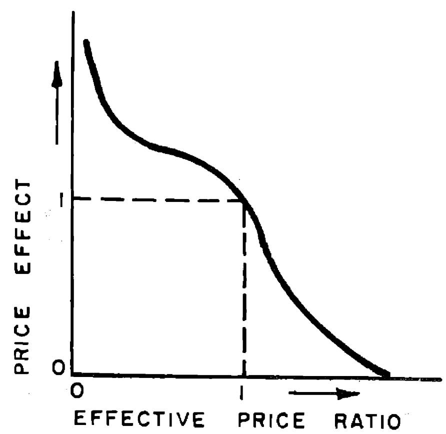


FIG. 15. Price Effect on Customers

CHAPTER VI

ANALYSIS OF POLICIES

The system model with its associated mathematical formulas is given in the appendix. The effect of various policies on the system is analyzed in this chapter.

The results are given as the variation from the equilibrium condition that existed between all competition before the policy change was made.

6.1 Market Conditions

The various policies were tried either on a market in which total sales did not vary at any time or on a market in which total sales varied because of the effect of price, showroom appeal, and the economic condition on the customer's buying decision.

Sections 6.2, 6.3, 6.4, 6.5, and 6.6 analyze the effect of changes in policy on a market in which sales do not vary. A policy change under this condition will only affect the customer's decision on what brand of product to buy. This is not a simulation of the "real world," but it does help in understanding the policy's effect on customers.

Section 6.9 analyzes the effect of policy changes on a market of varying total sales. This attempts to simulate "real world" conditions.

6.2 Increase the Budget

Two policies were tried to establish the effect of increasing the budget on a market in which total sales did not vary. The reliability budget was doubled--Figure 16, and the showroom appeal budget was doubled--Figure 17.

Price

The price of the product is a function of cost, but is allowed to change only once a year.

The price was increased one year after the policy change because of the increase in costs. It increased each year for four years and leveled when the cost of the product leveled at the value established by the budget.

Sales Rate

At the same time that the company increased the product price it also introduced a new model. In one example, the new model had an increase in reliability--Figure 16--while in the other, it had an increase in showroom appeal--Figure 17.

The customer found it hard to justify the price increase on the product with more reliability. As the product stood in the showroom, there was no tangible proof that the product would be more reliable than last year's model. A large proportion of customers would not pay the increase in price and the sales rate decreased.

The sales rate for the new model with more showroom appeal decreased also. The decrease was not as great as that experienced for

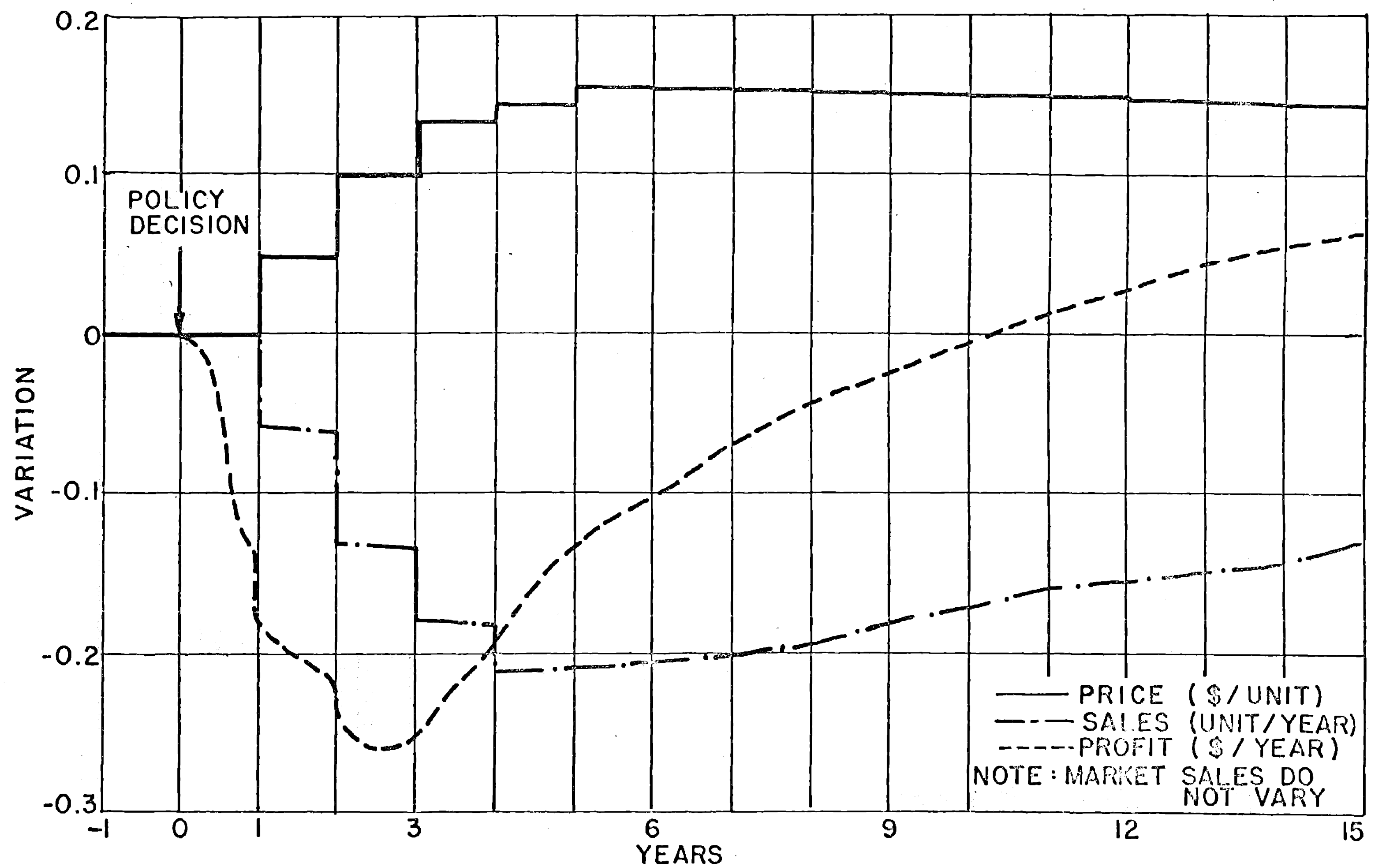


FIG. 16. POLICY DECISION
"DOUBLE RELIABILITY BUDGET"

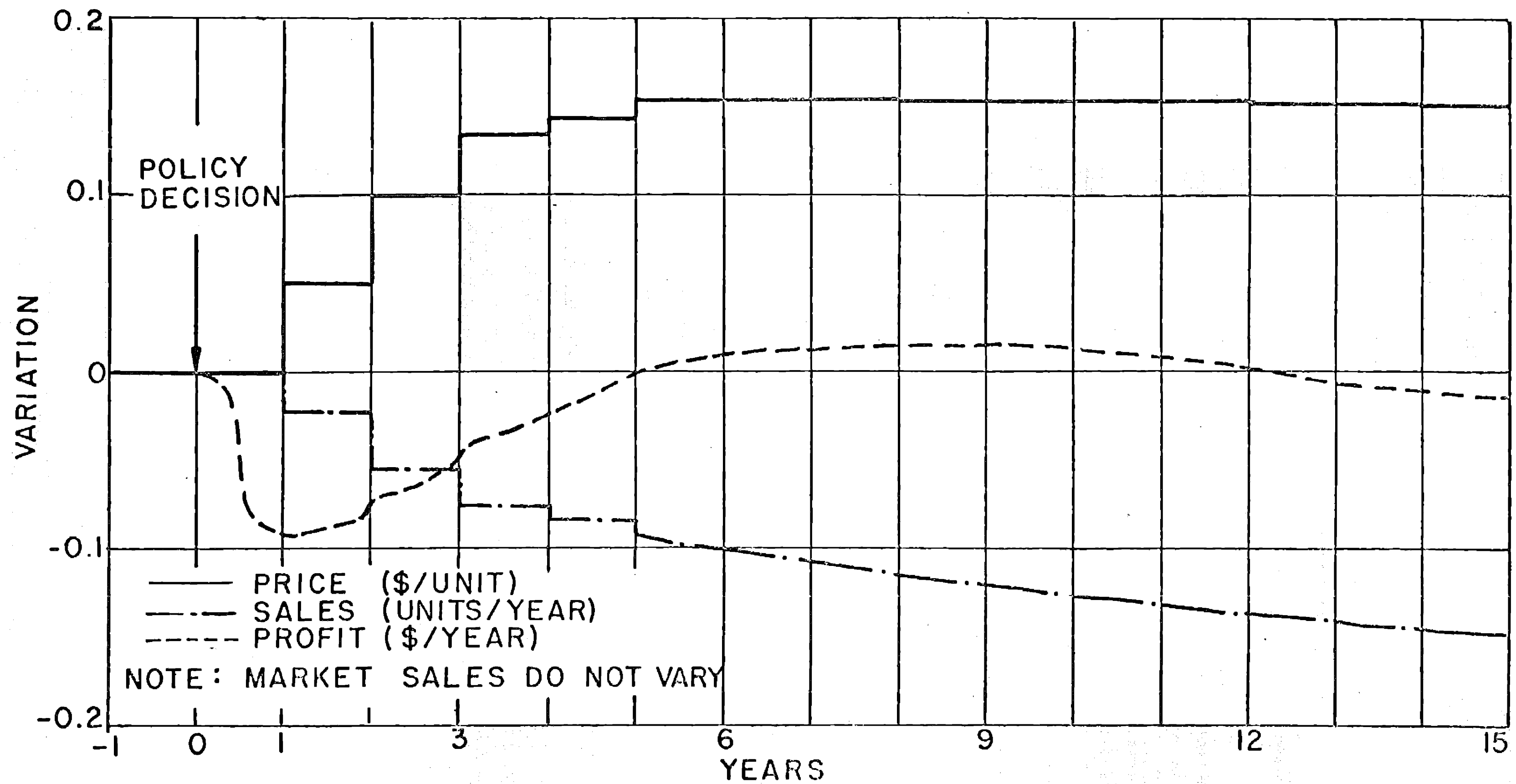


FIG. 17. POLICY DECISION
DOUBLE SHOWROOM APPEAL BUDGET

increased reliability because the same customers could justify a reason for the price increase; the product did have more appeal than competition.

In both of the cases stated above, however, the increase in price had more effect on sales than the increase in either reliability or showroom appeal.

As the company continues to build products with either greater reliability or more showroom appeal, the company image is increased. More customers become willing to pay a higher price for the product and consequently the marginal decrease in the sales rate becomes less. The sales rate would eventually level out if it were not for ownership satisfaction.

The product with more reliability had an increase in satisfied owners while the product with high showroom appeal actually had a decrease. (This was caused by the company not meeting the requirement that when showroom appeal is increased, more reliability effort is needed to maintain the same reliability.) After four years the price effect has decreased sufficiently and the number of owners who are re-entering the market has increased sufficiently to make ownership satisfaction the primary factor in determining sales rate. The sales rate of the product with more reliability increases while the sales rate of the product with more showroom appeal continues to decrease.

Profit Rate

The profit rate starts to decrease at the time of the policy change because the company has more expenditures with no increase in sales.

When the new model is introduced at the beginning of the second year, there is a change in both price and sales rate. In conditions where the per cent of variation in the sales rate decreases more than the per cent of variation in price is increased, the profit rate decreases. When the per cent of variation in the sales rate decreases less than the per cent of variation in price is increased, the profit rate increases.

The profit picture is better for the policy which increases showroom appeal during the first ten years. The increased reliability has a long-range effect, but shows profit increases every year after the third one. After the product has been established as a reliable one, the profits increase rapidly.

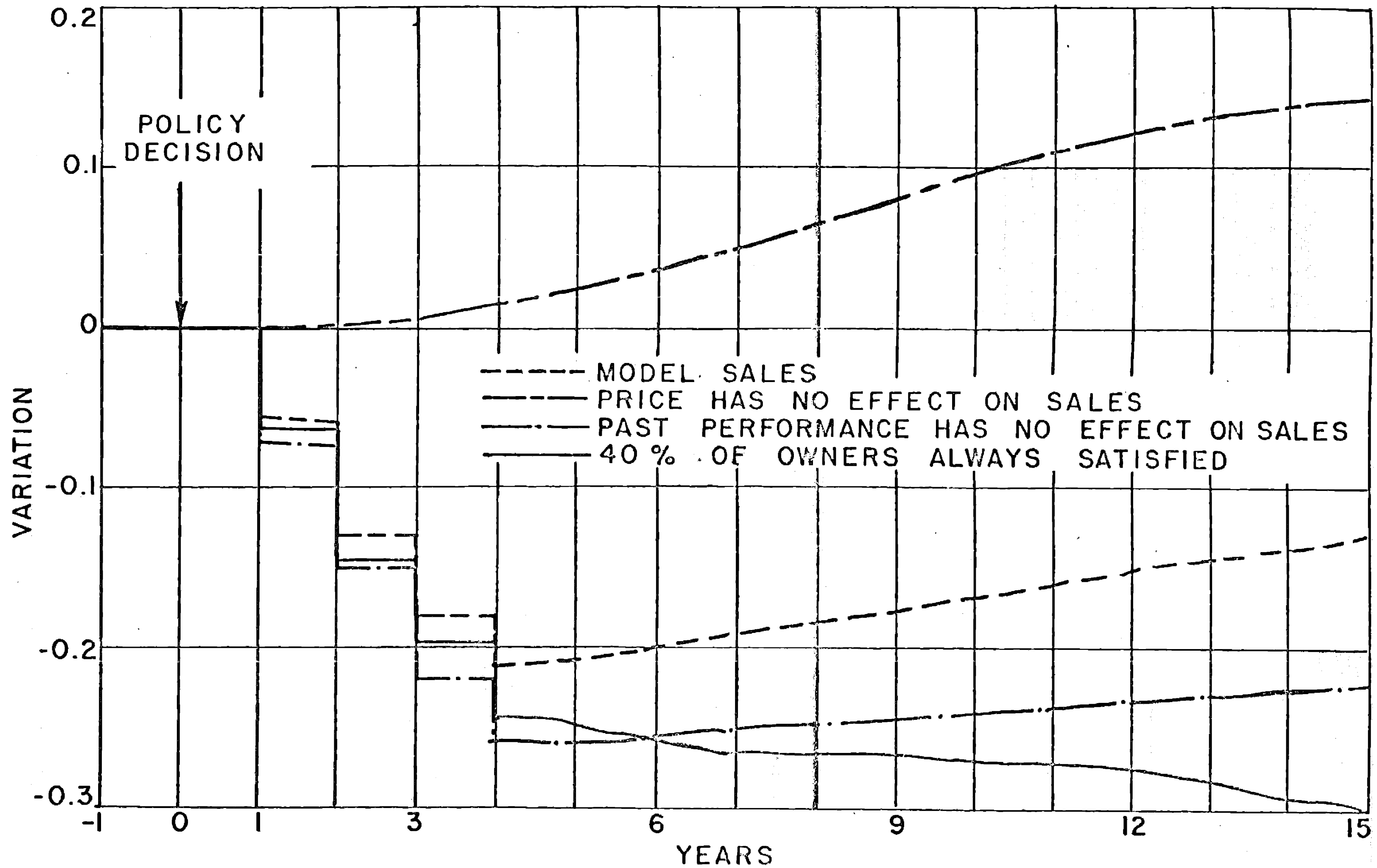
6.3 Analysis of Factors Affecting Sales

When the customer purchased a product in Section 6.2, he made his decision based on price, showroom appeal, past performance of the brand as compared to other brands, and ownership satisfaction. The following analysis was made to show the effect of each of these factors on the customer's decision.

Price Has No Effect on Sales

The customer purchases the product independent of its price.

When reliability is increased--Figure 18, there is no effect on sales until the increased reliability is experienced by owners. The greater reliability increases ownership satisfaction and company image by reducing service calls. Only after these increases do the sales



NOTE: MARKET SALES DO NOT VARY

FIG. 18. ANALYSIS OF FACTORS AFFECTING SALES
POLICY DECISION "DOUBLE RELIABILITY BUDGET"

increase. Reliability increase has a long-range effect.

When showroom appeal is increased, the effect is felt in the market immediately--Figure 19. The customer sees the product as more appealing than competition's and, since the price has no effect, buys it. Sales increase with the increase in showroom appeal.

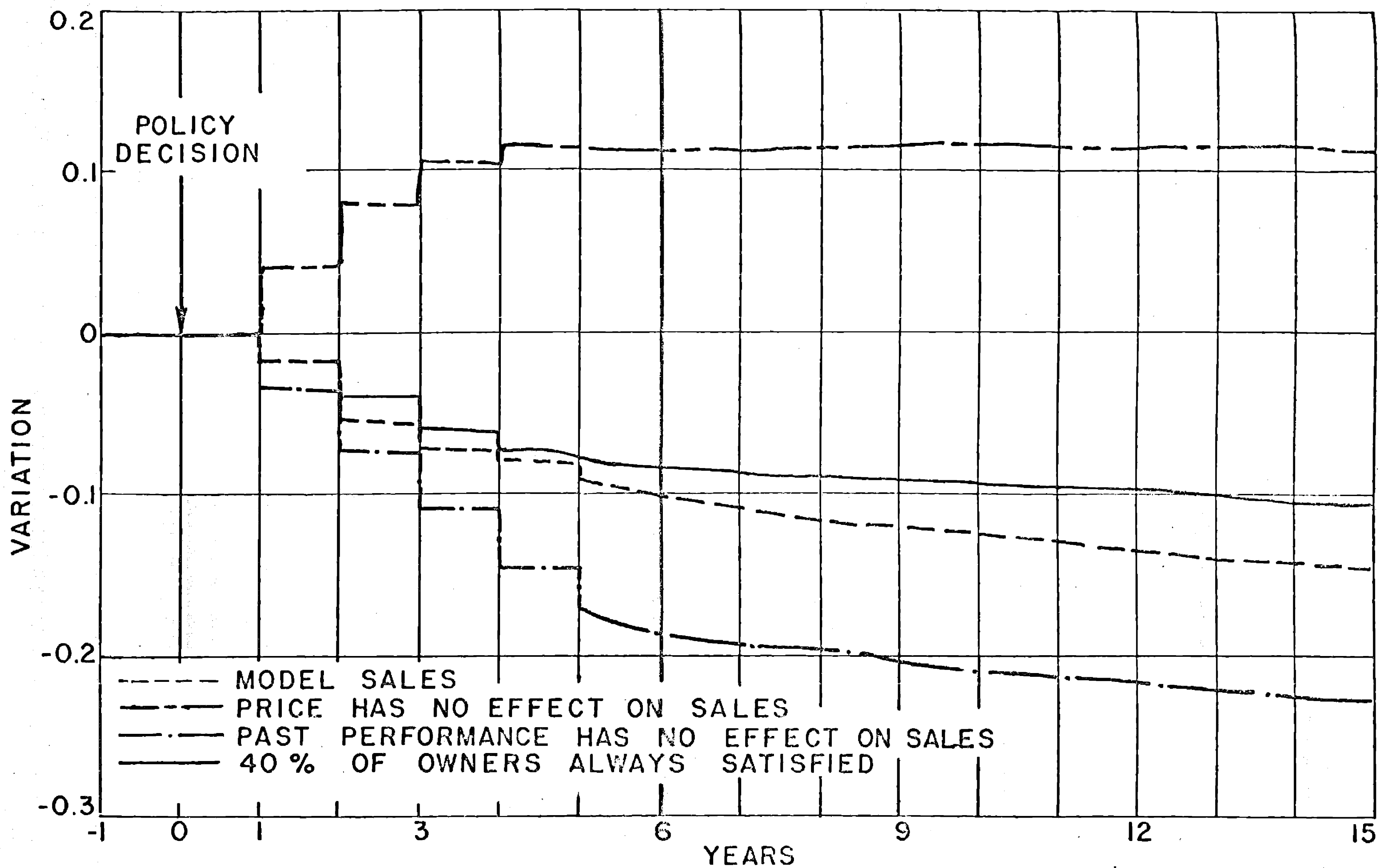
Past Performance Has No Effect on Sales

With an increase in reliability (Figure 18), and an increase in showroom appeal (Figure 19), the past performance has a beneficial effect on sales. As long as the company can remain superior to competition, past performance will have a beneficial effect. The curve depicting the condition of past performance having no effect on sales is of the same general shape as the model curve but divergent due to the increase in the effect of superior performance over time.

40 Per Cent of Owners Always Satisfied

In the model, ownership satisfaction varied with reliability. To establish the effect of this variation, ownership satisfaction was held constant at 0.4. No matter what changes were made in the product, 40 per cent of the owners would always be satisfied.

Where reliability was increased (Figure 18), the effect was detrimental to sales because it meant a decrease from the model's value of ownership satisfaction. The product now had the same showroom appeal as competition and the same percentage of owners were satisfied as competition, but the price was higher than competition, therefore the sales continue to decrease throughout the life of the model.



NOTE: MARKET SALES DO NOT VARY

FIG. 19. ANALYSIS OF FACTORS AFFECTING SALES
POLICY DECISION "DOUBLE SHOWROOM APPEAL BUDGET"

In the case of increased showroom appeal (Figure 19), this meant an increase from the model's value of ownership satisfaction. The sales rate, therefore, increased.

6.4 Reduce the Budget

The effect of reducing either the reliability budget or the showroom appeal budget is shown in Figure 20.

Price

The price is reduced after one year, and is reduced yearly for the first four years due to reduced cost. Then the decrease in sales causes the fixed cost per unit to increase and the price to start to increase.

Sales Rate

When the price is decreased, the sales rate increases for the product with reduced reliability. The product is competitive in showroom appeal and the customer can observe no reason for the reduced price. The reduced reliability eventually decreases ownership satisfaction and company image. This causes a reduction in the sales rate.

A reduction in showroom appeal is noticed immediately by customers, and the sales rate suffers as soon as the model is introduced. The reduction continues throughout the life of the model run.

Profit Rate

The profit rate increases as soon as the decision is made to decrease the budget. Sales and price are not reduced until the first

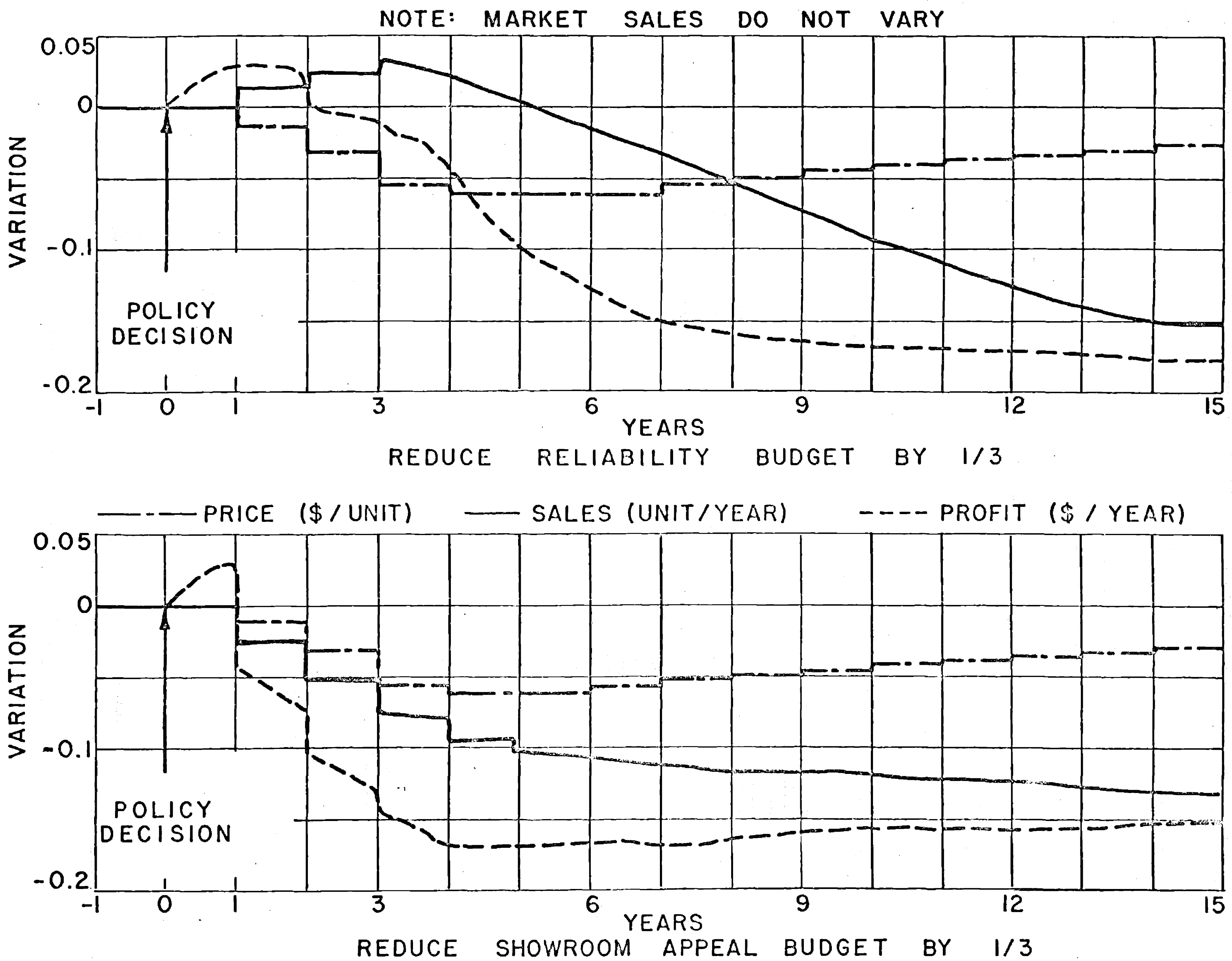


FIG. 20. POLICY DECISION "REDUCE THE BUDGET"

model that is affected by the decision is introduced. The profits decrease as the sales decrease.

6.5 Total Expenditure of All Budgets May Not Vary

The market has been shown to be very price sensitive. The policies shown in Figure 21 attempt to keep cost and price constant by removing the same amount from one budget that is added to the other budget.

Reduce Showroom Appeal and Increase Reliability

The price of the product remains constant, as expected, for only two years. It then increases due to the reduction in sales which causes the fixed cost per unit to increase. This increases the price.

The sales rate reduction is severe. The customer expected a reduction in price when the new model was introduced with decreased showroom appeal. When the price was held constant, many customers decided to purchase their product from competition, and when the price was increased, the proportion of customers who purchased from competition was increased.

The profit rate decreased due to the decreased sales rate and the poor estimate of expected sales used in setting price. (The expected sales is based on the level of sales over the past year which makes the estimate optimistic for declining sales.) As the sales rate began to level out, the estimated sales became more accurate, the price more nearly met the desired value, and profits began to increase.

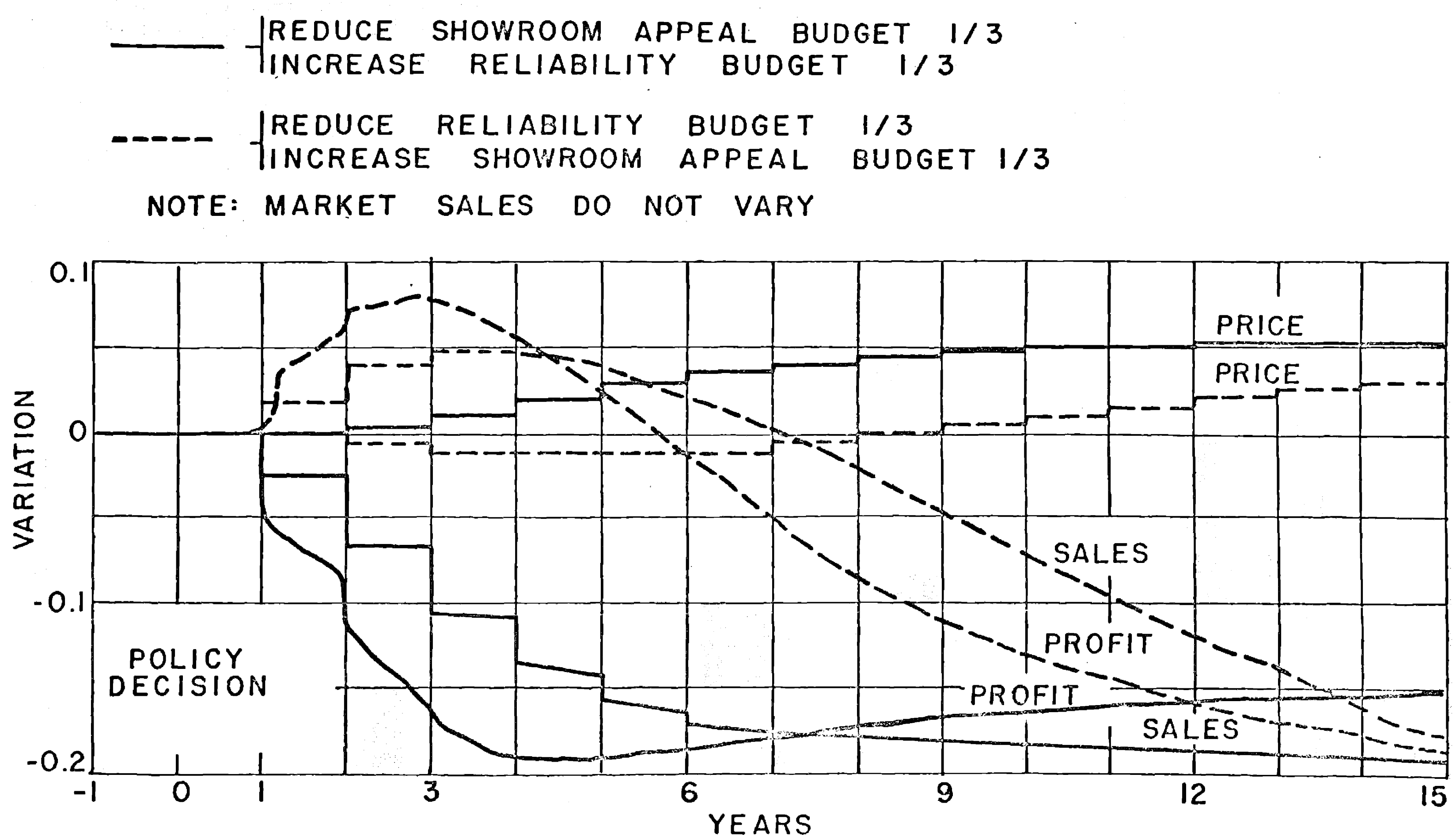


FIG. 21. POLICY DECISION
"TOTAL EXPENDITURE OF ALL BUDGETS MAY NOT VARY"

Reduce Reliability and Increase Showroom Appeal

The price began to decrease after two years due to increasing sales, but as sales began to decrease, the price began to increase.

The sales rate increased when the new model was introduced with increased showroom appeal at no increase in price. The product had more appeal than competition and the customer had no way of knowing that the product's reliability had been reduced.

Ownership satisfaction was reduced because of the increase in service calls on the new product model. This reduction caused the sales rate to decrease as dissatisfied customers entered the market.

The profit rate increased as sales increased, but began to decrease as the sales rate decreased.

6.6 Increase Company Efficiency

The company has been able to gain efficiencies which enable it to manufacture the identical product at reduced cost. Figure 22 compares the effect of three policies which could be enacted by the company.

1. No Change in Budgets

The company policy is to continue to budget the same amount to the design and development of reliability and showroom appeal. With the increased efficiency this would give the product greater reliability and more showroom appeal at about the same price.

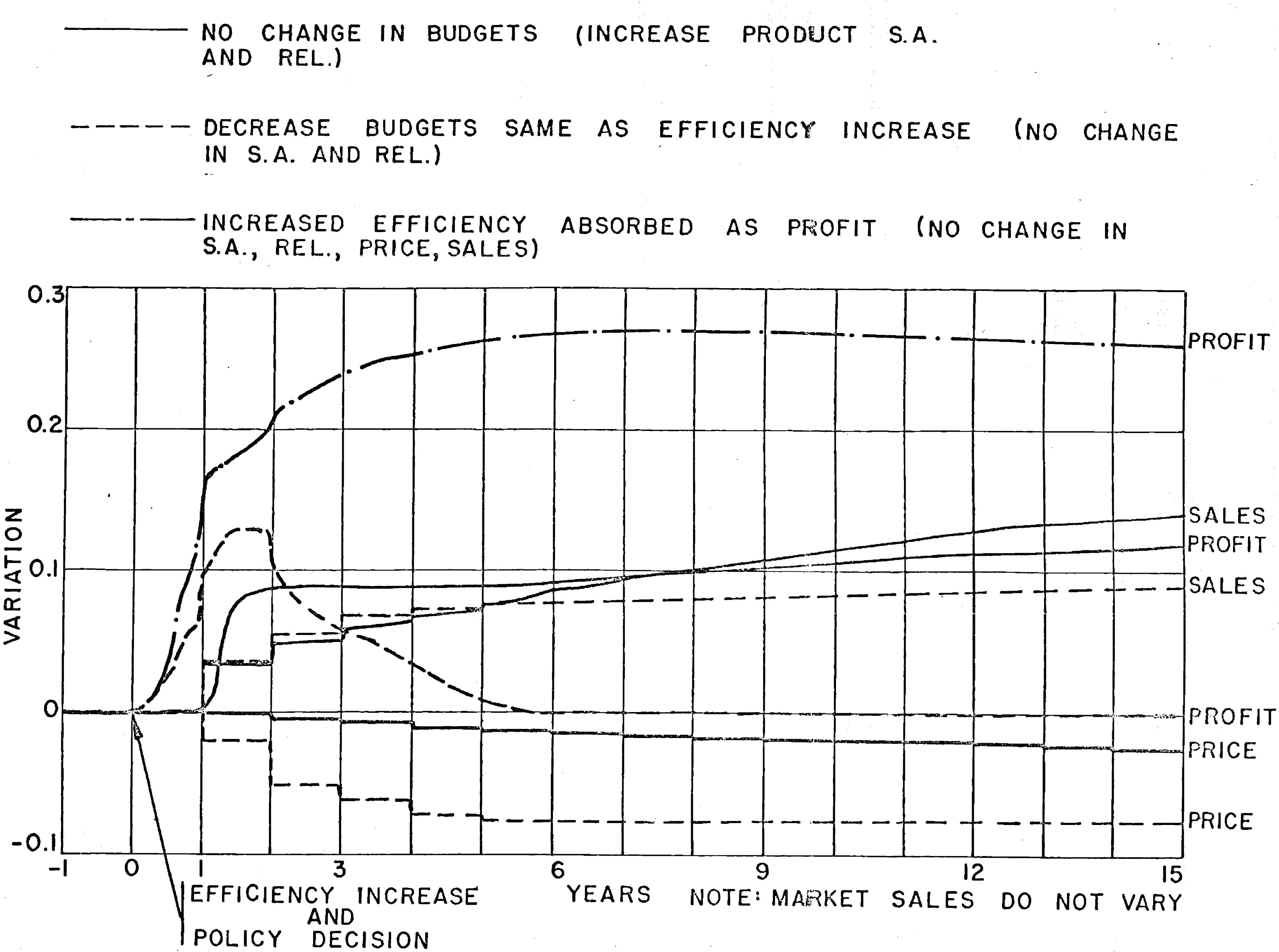


FIG. 22. INCREASED COMPANY EFFICIENCY
DESIGN AND DEVELOPMENT +20% MANUFACTURING + 10 % POLICY DECISION

The price remains relatively constant except for a slight decrease due to increased sales.

The sales rate increases immediately upon the introduction of a new model with more showroom appeal at no increase in price. As ownership satisfaction is increased due to increased reliability and company image, the sales rate continues to increase.

The profit rate increases with sales. The largest increase occurs during the first new model year when there is no decrease in price. In succeeding years the price decrease partially counteracts the sales increase and reduces the rate of increase.

2. Decrease Budgets Same as Efficiency Increase

The company policy is to pass the savings on to the customer. The company will continue to build a product comparable to competition at a reduced price.

The price of the product is reduced as the costs are reduced.

The sales rate increases due to the cost reduction with no reduction in reliability or showroom appeal. The sales rate does not increase as much as in Policy 1 stated above.

The profit rate increases due to the lag in reducing price with cost reductions. The rate decreases and levels at about the same rate as before the change in policy.

3. Increased Efficiency absorbed as Profit

The company policy is to continue to build a product with the same showroom appeal and reliability as competition and to sell it at the same price as competition.

The price is the same as competition and therefore does not change.

The sales rate does not change since the customer is getting the same product at the same price as competition.

The profit increases by the same amount as the costs are decreased due to the increased efficiency.

6.7 Effect of Market Delay Time on Sales

Economic conditions, price, and showroom appeal affect the time that the customer spends in the market deciding to buy. Figure 23 shows the effect on sales of a sinusodial variation in the delay time of customers in the market.

In general, as delay time increases sales decrease, and vice versa. But the shape of the sales curve does not simulate the shape of the delay time curve.

The market sales decrease as more customers remain in the market due to the increase in market delay time. As the delay time approaches its peak, its marginal increase is less than the actual increase in time that the customer spends in the market. There is,

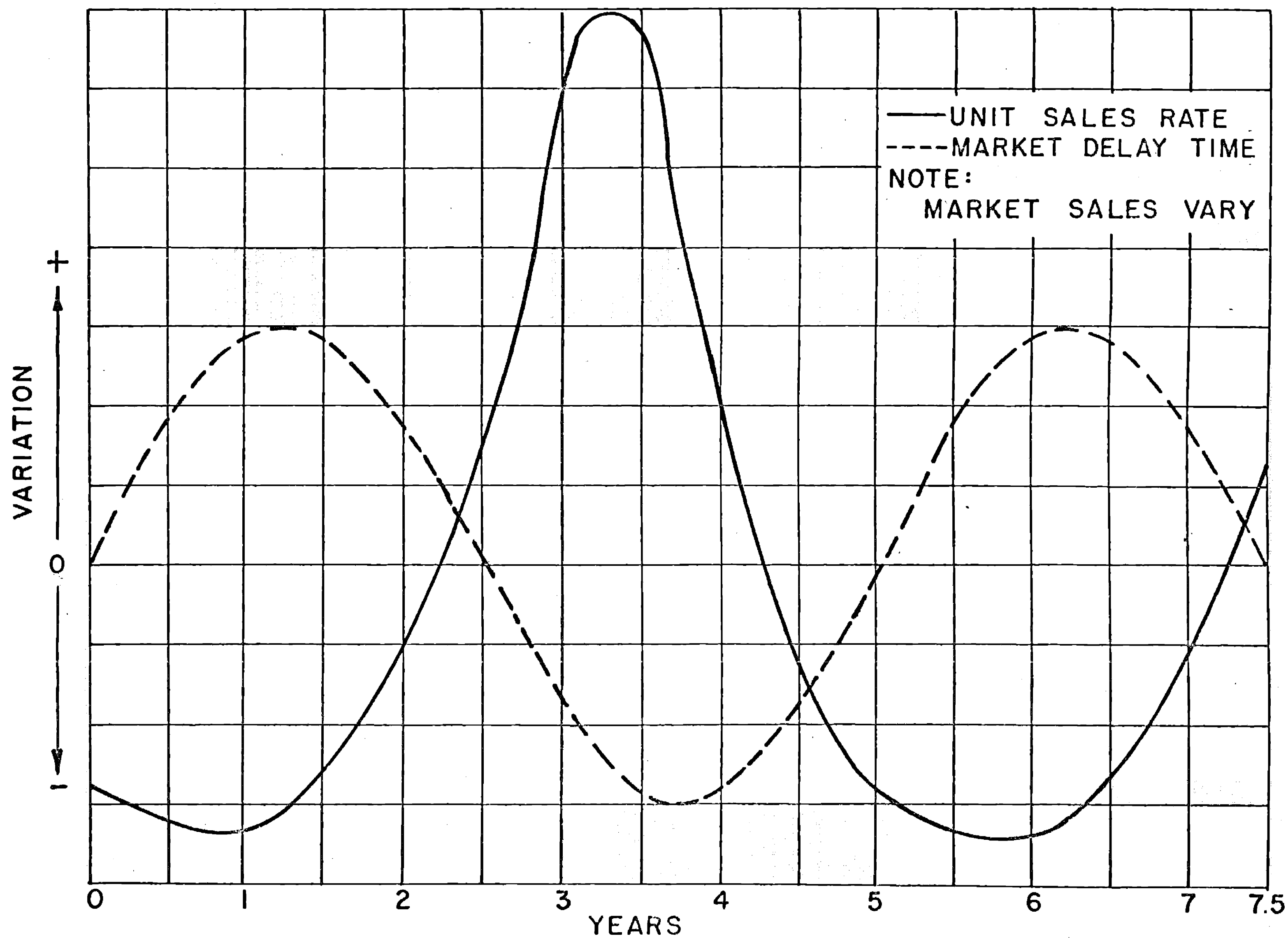


FIG. 23. MARKET ANALYSIS
MARKET DELAY TIME EFFECT

therefore, the slowly increasing sales rate before the market delay time reaches its peak.

After the peak, the sales rate increases rapidly, since the market delay time is decreasing while the actual time the customer spends in the market is increasing. Long-term customers buy immediately, since the delay time is decreased below the time that they have actually spent in the market. Other customers make their buying decisions sooner.

When the marginal decrease in delay time becomes less than the actual increase in time spent in the market, the sales rate peaks. This occurs before the minimum delay time is reached.

The sales rate decreases sharply as the delay time increases, since more customers remain in the market due to the marginal increase in delay time being greater than the increase in the time spent in the market.

The sales rate is below normal about one and one-half times as long as it is above normal. The sales rate curve shows a sharp sales peak with a long valley required to gain new customers to replace those who were persuaded to buy sooner than they originally expected. The sales rate increase above the mean is about twice as much as the decrease below the mean.

6.8 Company Delay Time

With a varying market, it is possible to have a policy which allows the budget to vary with one of the variables of the model. The variable chosen was expected sales.

Figure 24 shows the effect on showroom appeal when the desired budget varies as expected sales. Figure 25 shows the same effect when the budget is varied inversely as expected sales.

A minimum sales rate is experienced in the market at time A. The minimum is reflected in company forecasting of expected sales for the following year at time B. The forecast is less than the sales at A because sales have been increasing since A. It took the company from A to B to reach their minimum forecasted sales rate due to the leveling of the sales over the past year. (It should be noted that a rate curve tells the rate at a particular time and not the actual average rate for the year.)

After the expected sales have been determined, the desired budget is established at time C, which is the same time as B--no time delay between the company activities of forecasting and budgeting.

The actual budget used peaks at time D, and is less than the desired budget peak. Changes are continually being made in the desired budget and neither increases nor decreases can be realized with the speed that the desired budget changes. It takes time to add or remove projects.

After the budget is spent and the new product model is designed and developed, the effect of the design reaches the market at time E. The time between D and E was required to manufacture and distribute the product model. The model remains in the market for one year.

The total delay time from A to E very nearly matches the economic cycle of the model. The showroom appeal varies inversely with

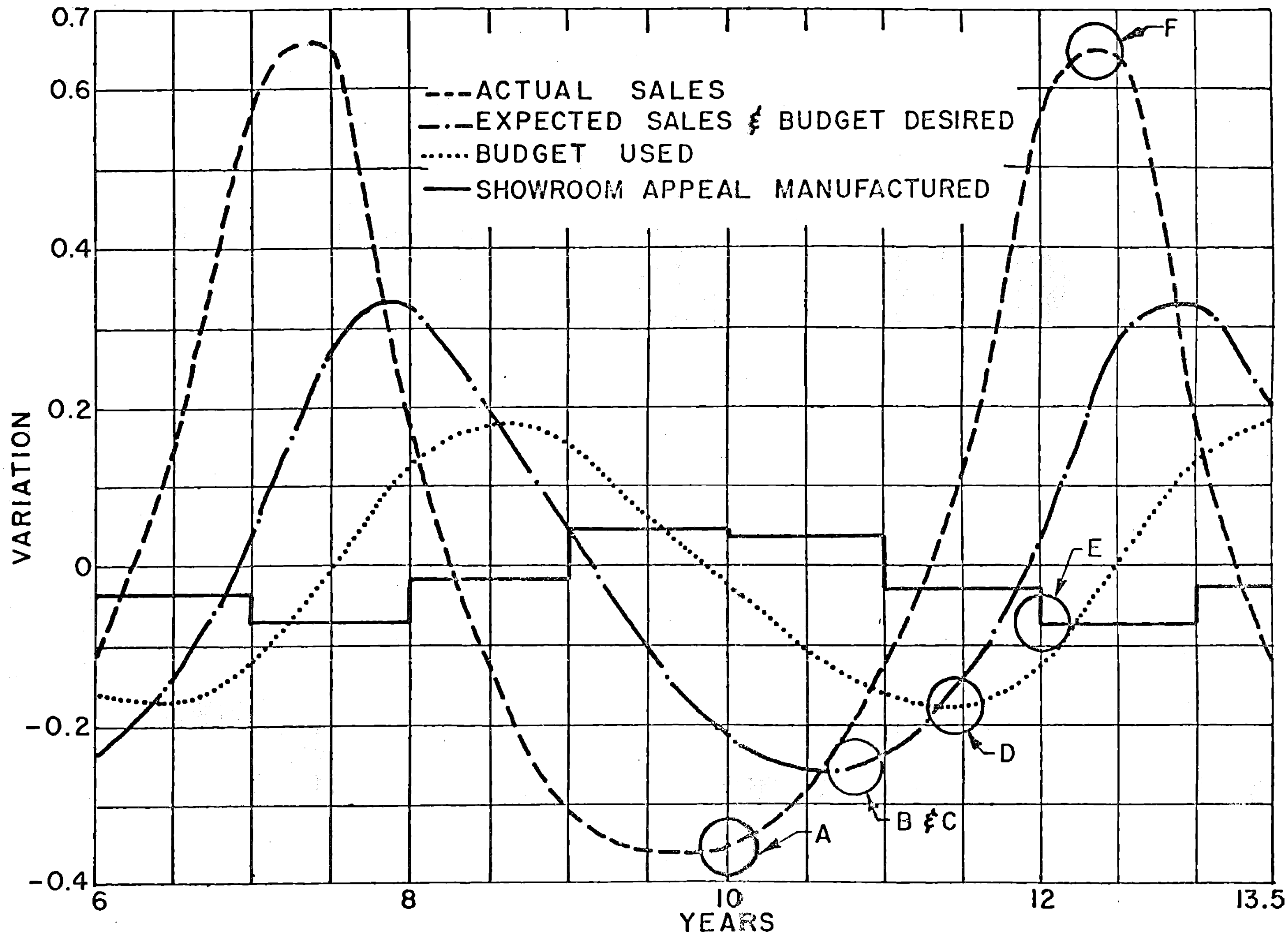


FIG. 24. COMPANY DELAY TIME
POLICY DECISION - "BUDGET VARIES DIRECTLY AS EXPECTED SALES"

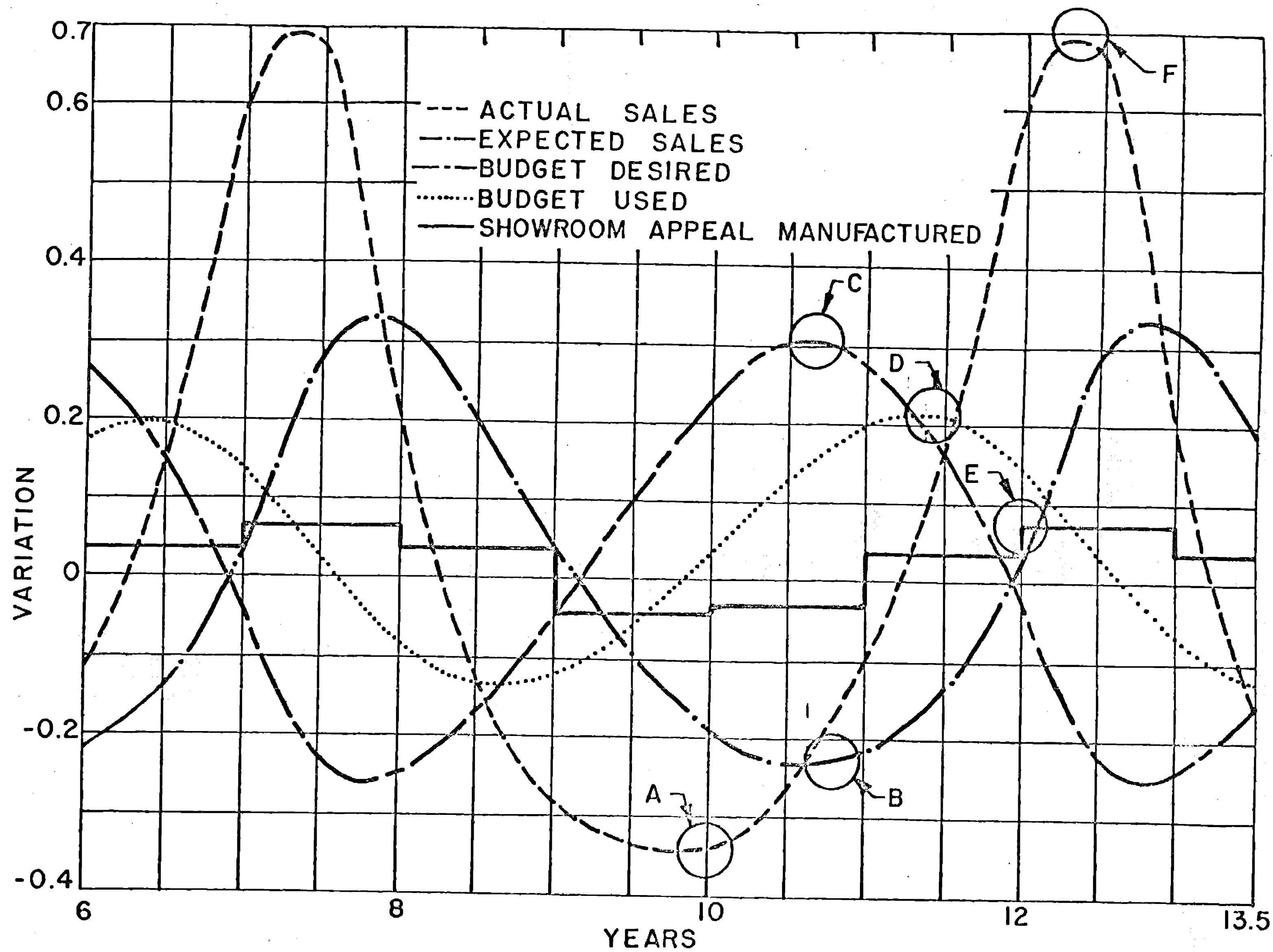


FIG. 25. COMPANY DELAY TIME POLICY DECISION - "BUDGET VARIES INVERSELY AS EXPECTED SALES"

actual sales (E and F, Figure 24) when the budget varies directly with sales. It varies directly with sales (E and F, Figure 25) when the budget varies inversely with sales.

The Effect of Showroom Appeal, Price, and Reliability on a Varying Market

An increase in showroom appeal affects the market in two ways. It causes more customers to want to buy the product and it reduces the customer's market delay time. The changing of the customer's decision on brand will have the greatest effect when the greatest number of customers are buying. Decreasing of customer delay time will have the greatest effect when the least number of customers are buying, i.e., when the delay time is the maximum.

Price has the inverse effect on the market as showroom appeal. Customers react favorably to low prices under the same conditions that they react favorably to high showroom appeal.

When all other things are equal, an increase in the showroom appeal demands an increase in price. These tend to cancel one another.

Reliability has a long-range effect (see Figure 16). A cyclic change in reliability, based on a five-year period, would have the same effect as a constant reliability of average value over the same period. Therefore, <u>minor cyclic changes</u> in reliability to balance changes in showroom appeal in order to keep the price fairly constant should give the best results in a varying market.

6.9 Policies Tried on the Varying Market

Figures 26 and 27 show the effect of various policies on the varying market.

The model was run with a policy of no budget variation to establish a base line for comparison of the effect of policy changes.

No policy change tried showed any really significant increase in the sales rate over a policy of no budget variation. The policies tried were:

Policy A: No budget variation.

Policy B: Showroom appeal and reliability budgets vary directly with expected sales.

Policy C: Showroom appeal and reliability budgets vary inversely with expected sales.

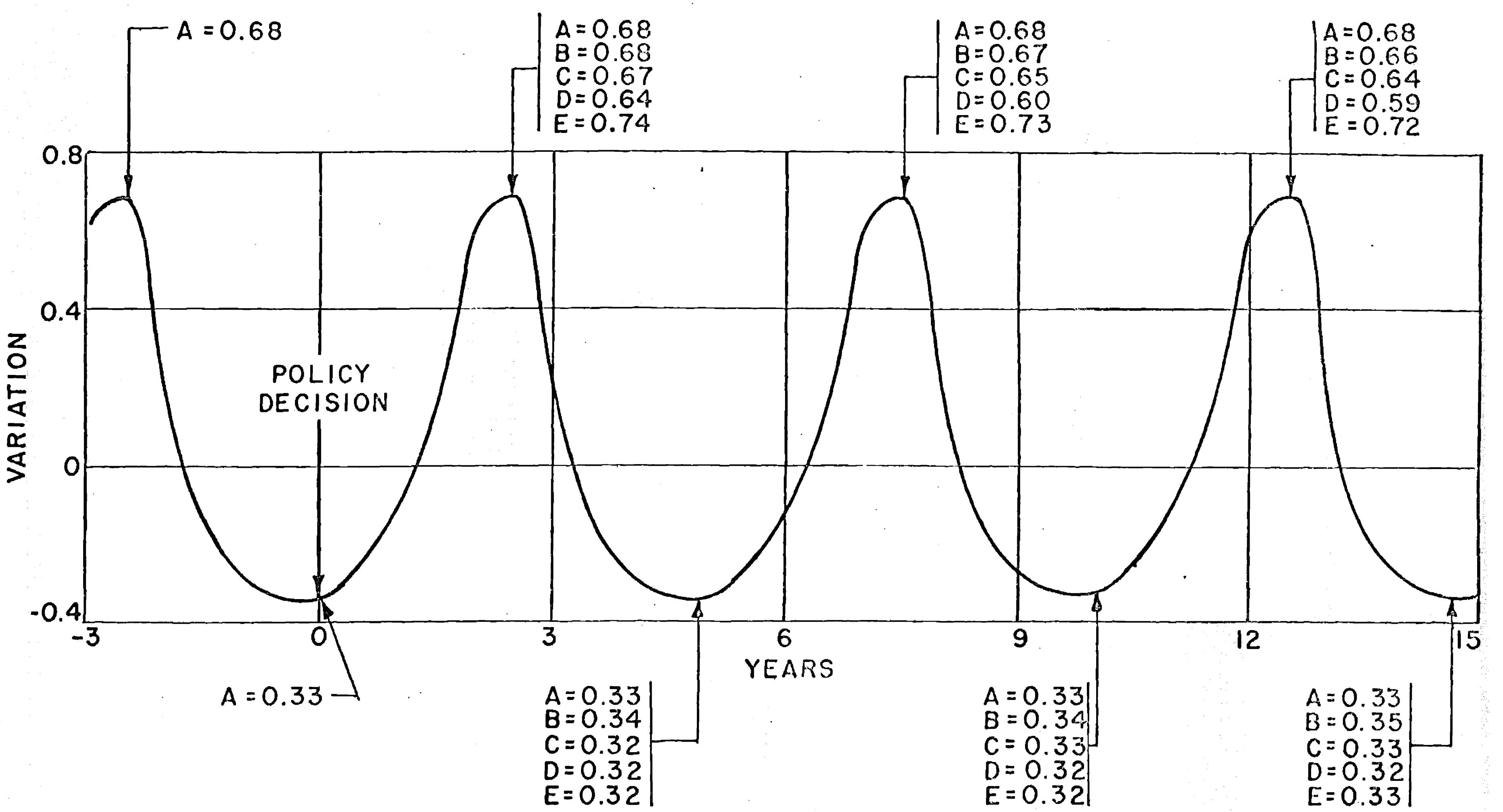
Policy D: Showroom appeal budget varies directly and reliability budget varies inversely with expected sales.

Policy E: Reliability budget varies directly and showroom appeal budget varies inversely with expected sales.

No dramatic variation from Policy A was found, but the trends are as follows:

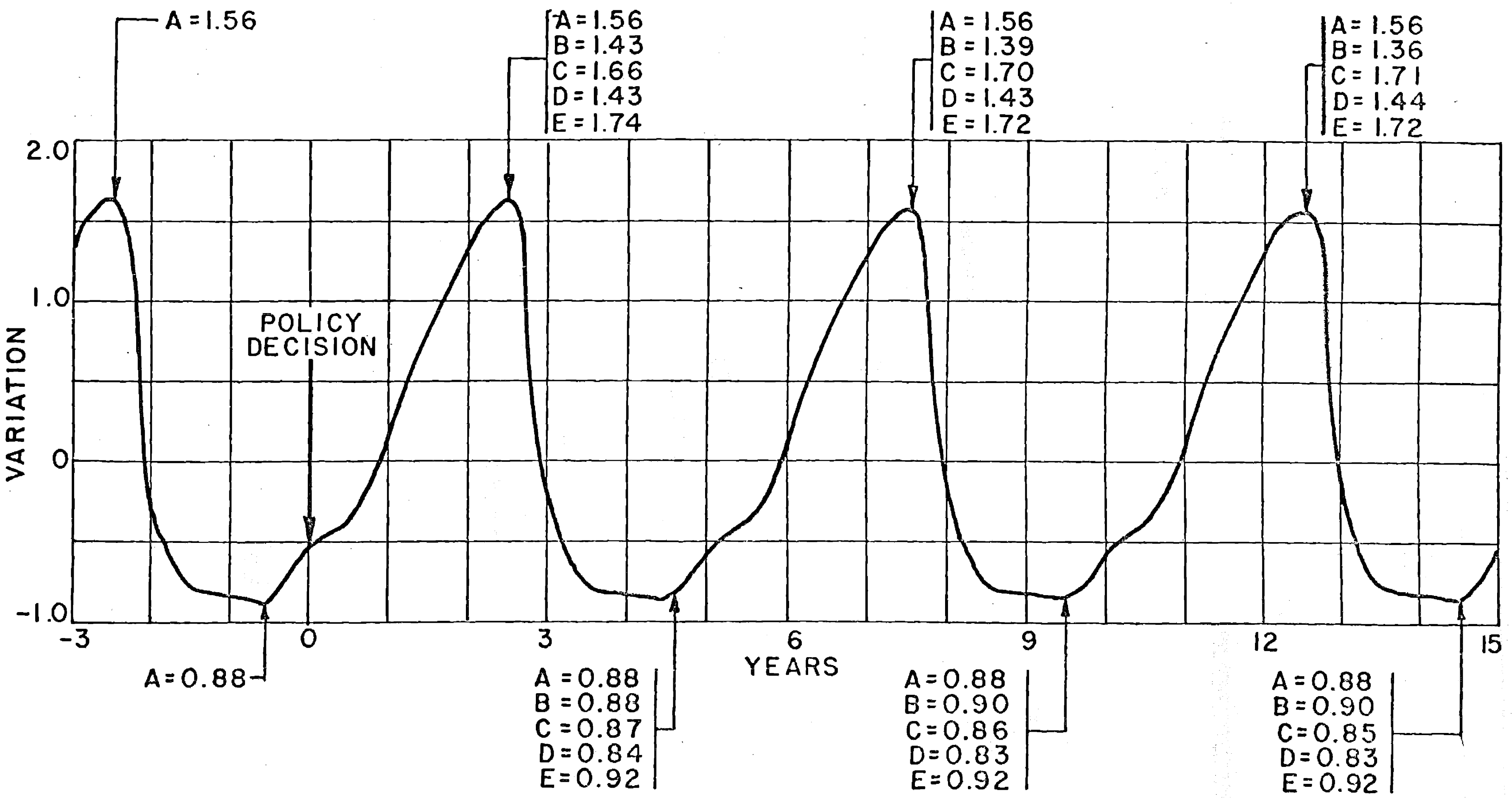
Policy B: The changes in sales rate are not significant. The profit decrease at peak profit was due to the decrease in price at maximum sales.

Policy C: The trend to decreasing peak sales is caused by the high price at peak sales. This high price, however, yielded a high profit. The customers with products of high reliability, i.e., high ownership satisfaction, rebuy at any part of the cycle. The reliability



A = NO BUDGET VARIATION
B = S.A. AND REL. DIRECTLY
C = S.A. AND REL. INVERSELY
D = S.A. DIRECTLY, REL. INVERSELY
E = REL. DIRECTLY, S.A. INVERSELY
NOTE: MARKET SALES VARY

FIG. 26. UNIT SALES RATE VARIATION
BUDGET VARIES WITH RESPECT TO EXPECTED SALES



A = NO BUDGET VARIATION
B = S.A. AND REL. DIRECTLY
C = S.A. AND REL. INVERSELY
D = S.A. DIRECTLY, REL. INVERSELY
E = REL. DIRECTLY, S.A. INVERSELY
NOTE: MARKET SALES VARY

FIG. 27. COMPANY PROFIT RATE VARIATION
BUDGET VARIES WITH RESPECT TO EXPECTED SALES

effect, being long run, tends to react as an average value over the complete cycle.

Policy D: This policy was the worst. The models with the best showroom appeal were introduced during poor sales years. Price remained relatively constant because the increase in one budget was balanced by a decrease in the other. The increase in showroom appeal did not significantly affect the customer's delay time in the market. Profits varied with sales.

Policy E: This policy was the best. The showroom appeal, which has an immediate effect on customers, was highest when most customers were buying. The price remained relatively constant, causing an additional boost to sales. The profits were high on account of the high sales rate.

For all the policies, A through E, the company image remained relatively constant and at approximately the same value. The average value of showroom appeal and reliability was approximately the same for all policies. Company image is determined from average values of reliability and showroom appeal established over three and four years, respectively. The five-year economic cycle was too close to the average time to allow the company image to vary appreciably.

CHAPTER VII

CONCLUSIONS

7.1 Conclusions Drawn from Results

Definite conclusions can be drawn from the experimental results analyzed in Chapter VI.

1. Any change in product reliability has a long-run effect. The effects of the change in reliability are realized when owners enter the market to buy their next product. Increases in sales due to the reduced price made possible by the reduction in reliability are short lived.

2. Any change in showroom appeal has an immediate effect on sales. This change can be observed and customers react immediately.

3. The market is price sensitive and any change that has an associated price change, i.e., increase a product characteristic and increase price or vice versa, has a detrimental effect on sales.

4. No method of manipulation of the budgets showed any major effect on sales, because of the long life of the established product and the saturated market in which the product was sold. One could, however, make some gains by taking advantage of the immediate effect of increased showroom appeal on sales. This was accomplished in Policy E, Section 6.9, of Chapter VI. The showroom appeal varied as sales causing the cost and price of the product to remain competitive. A larger proportion of customers were captured from competition when the total market sales were a maximum, due to increased showroom

appeal. When showroom appeal was below competition, causing a decrease in the proportion of captured customers, the total market sales were at a minimum. The increased proportion being of a larger number of market sales than the decreased proportion, the absolute increase in sales was greater than the absolute decrease over the cycle. The reliability change being less than 10 per cent averaged out over the cycle, causing little effect. The company, therefore, gained its position in the market and increased its profits over the cycle.

7.2 Conclusions Implied by Results

The results imply that:

1. The major reason for minimal effect of changes in policy is the saturated market. Every customer has had experience with the product. Many customers are loyal to the brand that they now own. The company should make an effort to make the market act as a growth market.

The company should not make a major effort to increase showroom appeal and reliability above competition, but should develop new products and/or features which would attract new customers. The company should have something that competition does not have rather than just a better product than competition.

2. The system model did not take marketing into account. The results imply that changes in the product alone will not make major changes in sales expected. The way that the product is marketed will probably be more effective than any results shown in this thesis.

7.3 Comments

The results discussed in Chapter VI and VII are the reactions of the system model to policy changes. This satisfies the objective of the thesis, i.e., to design a policy best suited to the system described.

Management's responsibilities do not stop after the policy is designed; it must also control the operations of the enterprise. For effective control, management must keep its "finger on the pulse" of the system. The system model helps to determine where the pulses are located.

By experimenting with the system model, management can determine the sensitivity of the system to changes in each of its parts, and/or changes in the relationship between the parts. The most sensitive parts and relationships are the "pulses" of the system. Accurate data on these parts would be effective aids in controlling operations and anticipating the future. The model, therefore, can be effectively used in determining which data should be collected from the real world.

* * *

Industrial dynamics will play an important role in the process of changing management from an art to a science.

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BIBLIOGRAPHY

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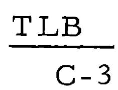
APPENDIX

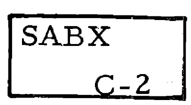
APPENDIX

This appendix includes the model diagram and its associated formulas used to describe the thesis problem.

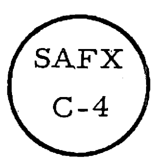
The symbols used in the model to indicate constants, levels, auxiliaries, rates, delays, information flow, and customer flow are as follows:



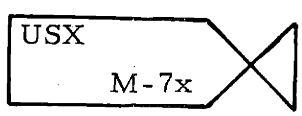
A constant quantity is underlined. It will not change during the model run time. The equation number is under the line.



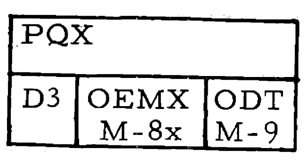
Levels are indicated by rectangles. The quantity name and equation number are indicated as shown.



Auxiliaries are indicated by circles with the quantity name and equation number included.



Rates are indicated as shown with the quantity name and equation number as shown.



Delays are indicated by a rectangle divided to show the level that is being delayed across the top and information about the delay across the bottom.

Information flow is indicated by a dashed line.

Customer flow is indicated by a solid line.

The method used in describing the equations is as follows:

6N ABC=IABC X-2

The information on the left, "6N," is the dynamo equation form number which is required by the computer program.

The information in the center, "ABC=IABC," is the equation describing the quantity.

The information on the right, "X-2," is the model equation number which will locate the equation in Figures 28, 29, 30, and/or 31.

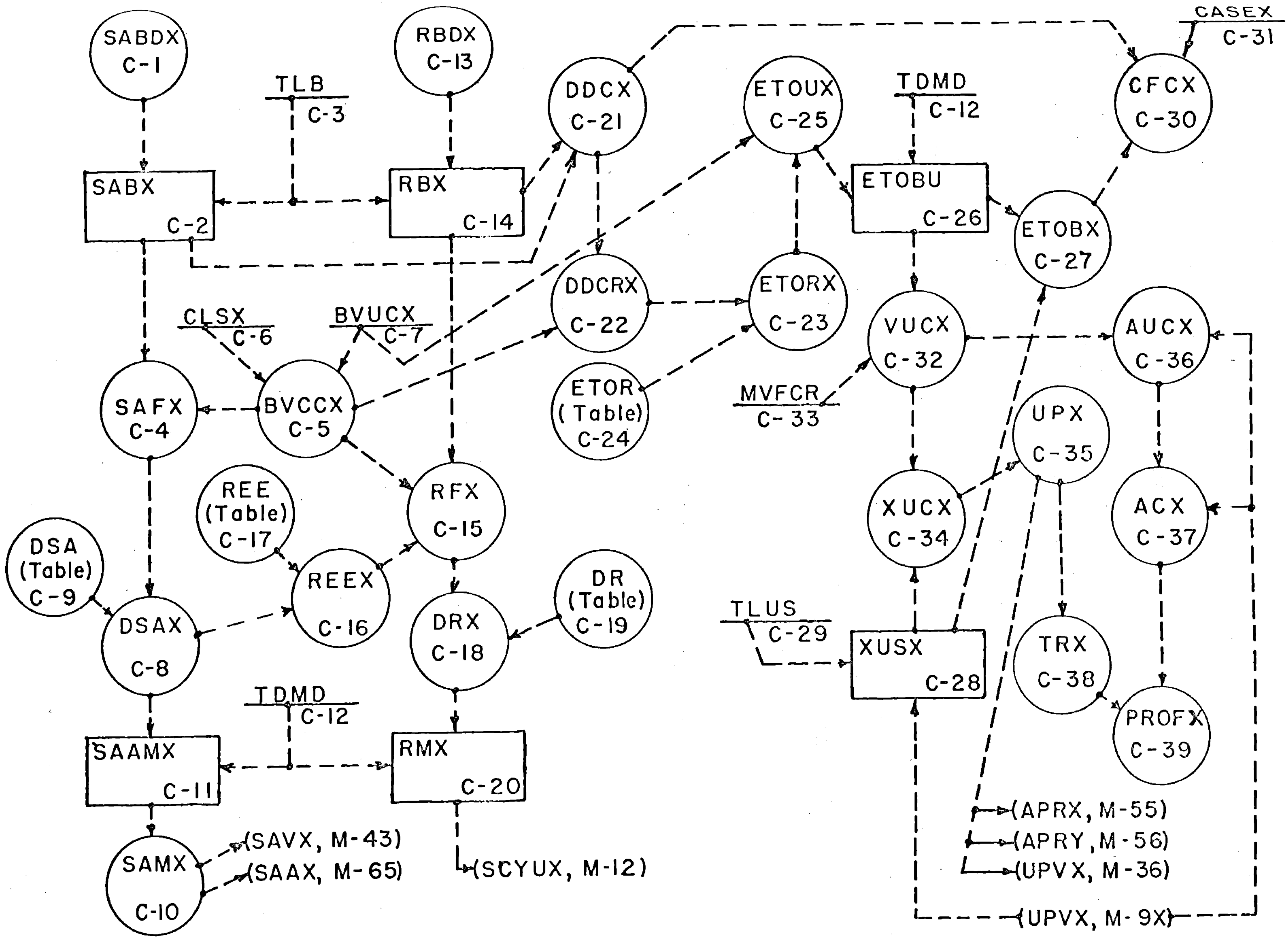


FIG. 28 COMPANY SECTOR

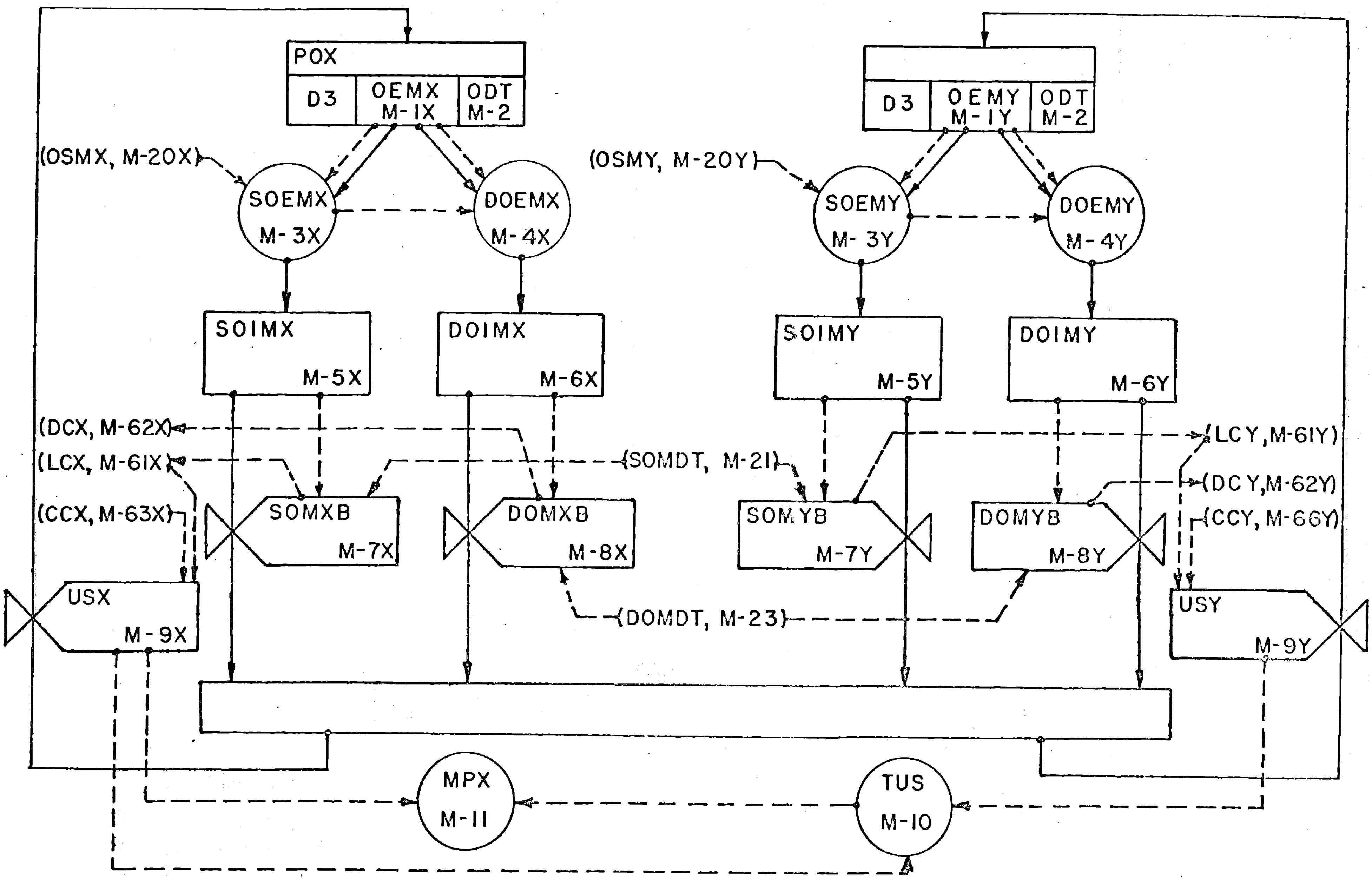


FIG. 29. MARKET SECTOR —"CUSTOMER FLOW"

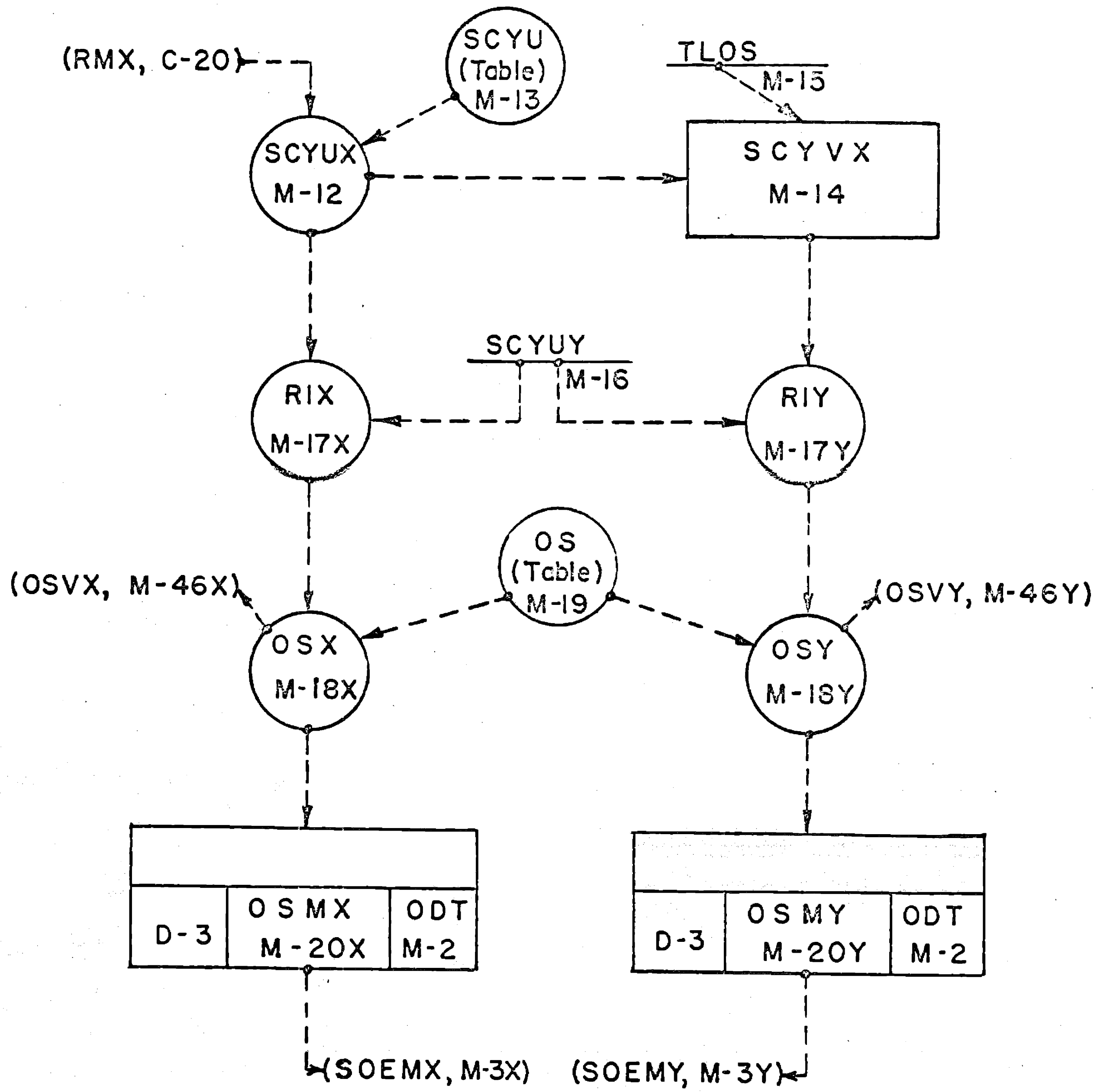


FIG. 30
MARKET SECTOR
CUSTOMER "OWNERSHIP SATISFACTION" DECISION

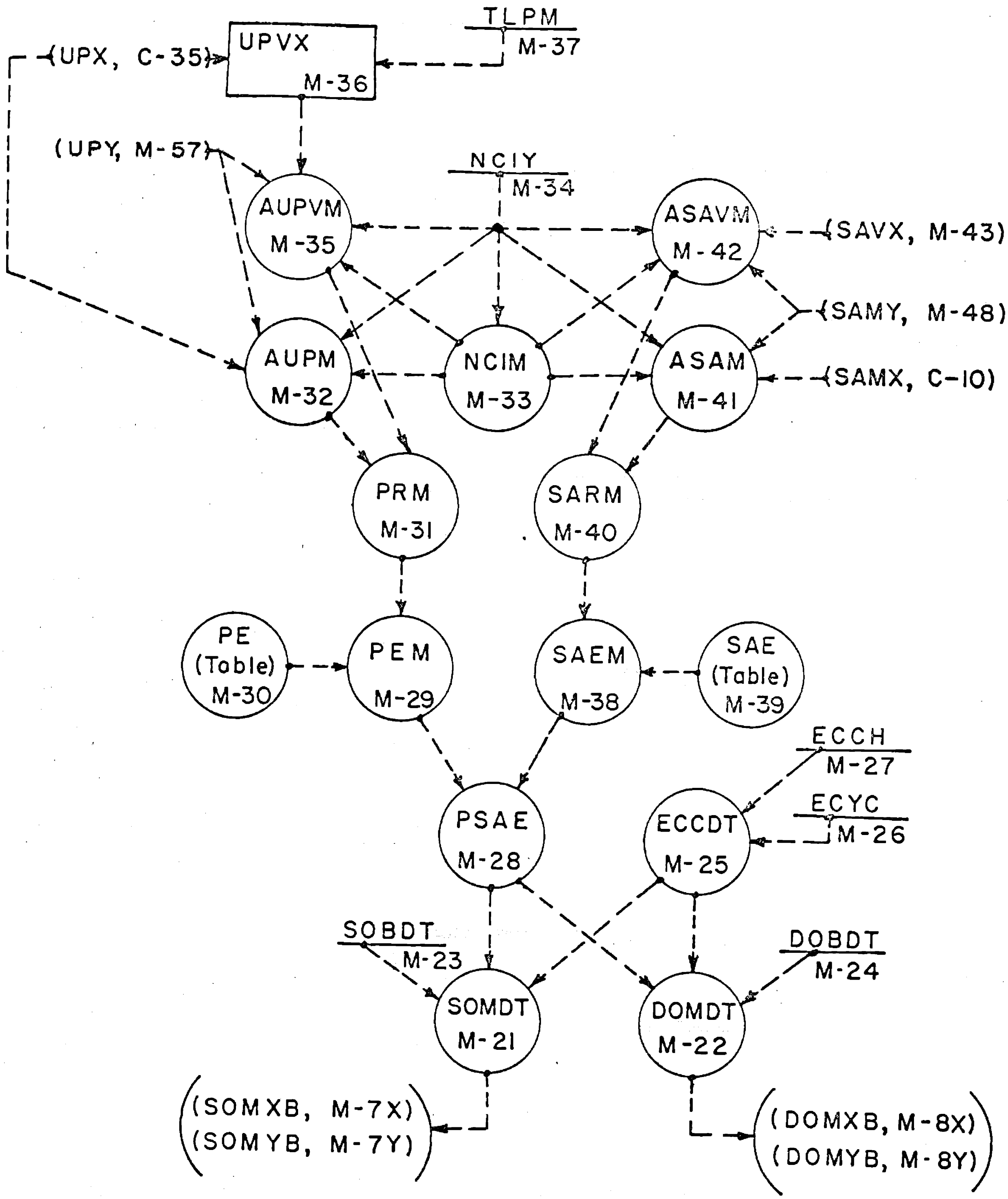


FIG. 31. MARKET SECTOR
-CUSTOMER "WHEN TO BUY" DECISION-

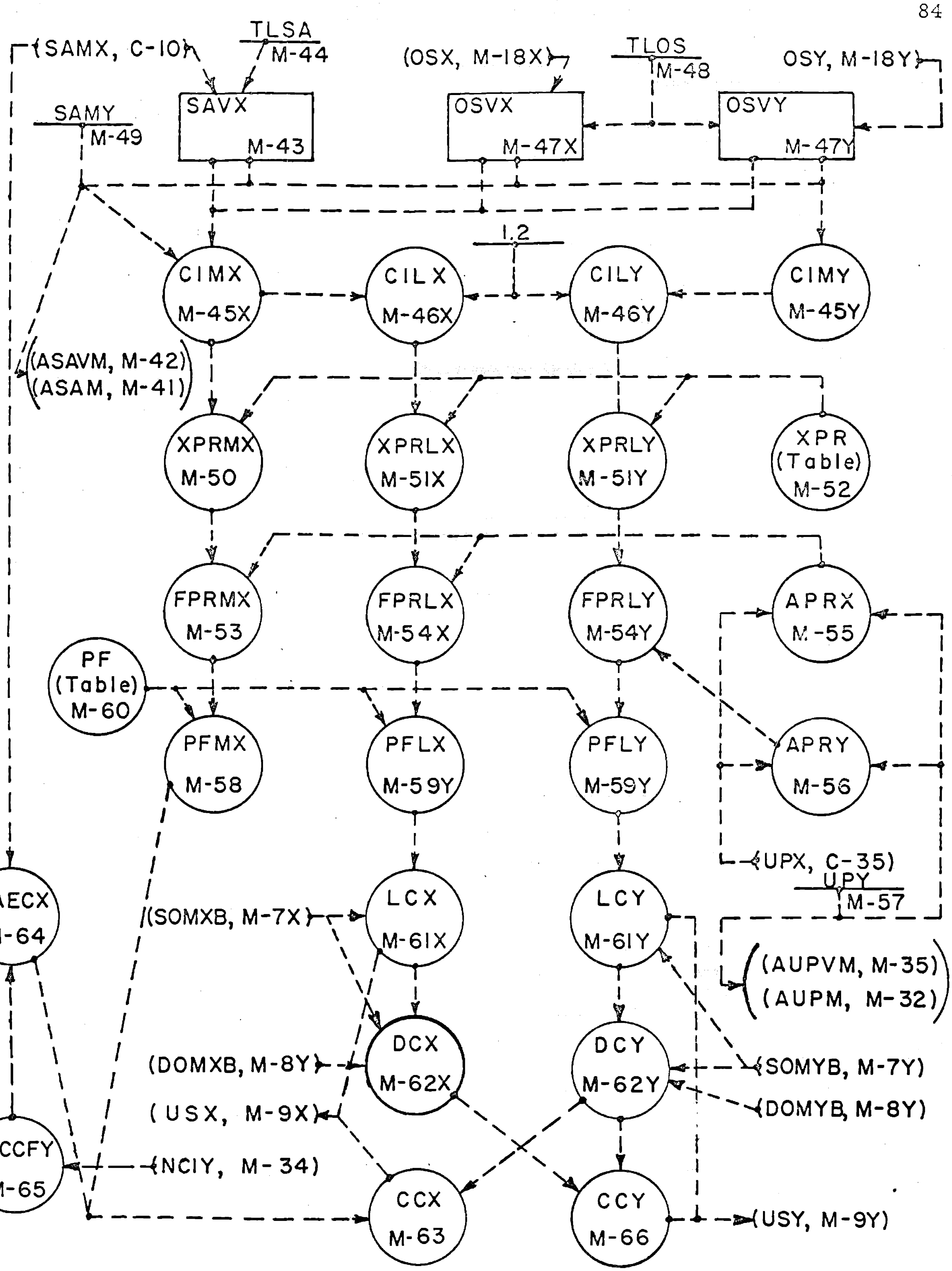


FIG. 32. MARKET SECTOR
CUSTOMER "BRAND OF PRODUCT" DECISION

A.1 COMPANY SECTOR EQUATIONS

(See Figure 28)

C ISAB=2.75E6 Dollars/year C-1, A

6N SABDX=ISABD C-1, B

SABDX = Showroom Appeal Budget Desired by company X ($/yr)

ISABD = Initial Showroom Appeal Budget Desired ($/yr)

This establishes the desired budget at the time the calculations are started.

— — — —

The following are Company X policies pertaining to the Showroom Appeal Budget:

6A SABDX.K=5.5E6 Dollars/year C-1, C

SABDX = Showroom Appeal Budget Desired by company X ($/yr)

This equation indicates that the budget has been changed but will be held constant at the new value. The change indicated here is to $5.5 million. Any budget value can be used.

— — — —

44A SABDX.K=(XUSX.K)(ISABD)/IXUSX C-1, D

SABDX= Showroom Appeal Budget Desired by company X ($/yr)

XUSX = eXpected Unit Sales by company X (Units/yr)

ISABD = Initial Showroom Appeal Budget Desired ($/yr)

IXUSX = Initial eXpected Unit Sales by company X (Units/yr)

The company policy on the showroom appeal budget is to vary the budget as the expected sales vary. This is based on initial values of both sales and budget.

\-　　　　-　　　　-　　　　-

44A　SABDX.K=(IXUSX)(ISABD)/XUSX.K　　C-1, E

SABDX =	Showroom Appeal Budget Desired by co. X	($/yr)
IXUSX =	Initial eXpected Unit Sales by co. X	(Units/yr)
ISABD =	Initial Showroom Appeal Budget Desired	($/yr)
XUSX =	eXpected Unit Sales by co. X	(Units/yr)

The company policy is to vary the showroom appeal budget inversely with expected sales.

*　　　　*　　　　*　　　　*

6N　SABX=ISABD　　C-2, A

SABX =	Showroom Appeal Budget co. X	($/yr)
ISABD =	Initial Showroom Appeal Budget Desired	($/yr)

At the beginning of the problem the showroom appeal budget is the same as the desired showroom appeal budget. (It is also the same as the showroom appeal budget of Company Y.) The system is in a state of equilibrium and will remain so until a change is made. This budget is for the design and development of showroom appeal.

\-　　　　-　　　　-　　　　-

3L　SABX.K=SABX.J+(DT)(1/TLB)(SABDX.J-SABX.J)　　C-2, B

SABX =	Showroom Appeal Budget co. X	($/yr)
DT =	Delta Time	(yr)
TLB =	Time to Level Budget	(yr)
SABDX =	Showroom Appeal Budget Desired by co. X	($/yr)

When management policy requires a change in the level of the budget the effect of this change is not felt immediately. Time is required to change the facilities in order to effectively use the budget. The time required to make the complete budget effective is TLB.

* * * *

DT=0.01 years (yr)

DT=Delta Time

Delta Time is the time between calcuations. It is the time between J and K (the past to the present) or between K and L (the present to the future). The time interval used was 0.01 years.

* * * *

C-3

C TLB=1 year (yr)

TLB=Time to Level Budget

It requires one year to level the budget from the actual to the desired.

* * * *

C-4

20A SAFX.K=SABX.K/BVCCX (Dimensionless)

SAFX = Showroom Appeal Factor co. X ($/yr)

SABX = Showroom Appeal Budget co. X ($/yr)

BVCCX = Basic Variable Class Cost co. X

The effectiveness of the budget is dependent on the size of the budget, the basic product cost, and size of the company. The showroom appeal factor equates these quantities in order to establish a unit of measurement for the effectiveness of the showroom appeal budget.

* * * *

12N BVCCX=(CLSX)(BVPCX) C-5

BVCCX = Basic Variable Class Cost co. X ($/yr)
CLSX = CLaSs of co. X (Units/yr)
BVPCX = Basic Variable Product Cost co. X ($/product)

The basic variable class cost is the cost of the basic variable cost at class production schedule.

* * * *

C CLSX=1E6 Units/year C-6

CLSX = CLaSs of co. X (Units/yr)

Company X is established as a company in the one million units per year class.

* * * *

C BVPCX=50 Dollars/Unit C-7

BVPCX = Basic Variable Product Cost co. X ($/unit)

The product is established as one that requires a minimum of $50 material and labor.

* * * *

C IDSAX=0.55 C-8, A

6N DSAX=IDSAX C-8, B

IDSAX = Initial Designed Showroom Appeal co. X (Dimensionless)
DSAX = Designed Showroom Appeal co. X (Dimensionless)

Based on the initial budget for showroom appeal, the designed showroom appeal is 0.55.

\- \- \- \-

59A DSAX.K=TABLE(DSA,SAFX.K,0,0.4,0.02) C-8, C

DSAX = Designed Showroom Appeal co. X (Dimensionless)
DSA = Designed Showroom Appeal (Table)
SAFX = Showroom Appeal Factor co. X (Dimensionless)

The designed showroom appeal is based on the designed showroom appeal table. The table equates the showroom appeal factor to designed showroom appeal. The table may be entered with showroom appeal factors between zero and 0.4. The values are given at intervals of 0.02. Any value between the given values is interpolated as a straight line variation.

- - - -

59A DSAX.K=TABLE(DSA, SAFX.K, 0, 0.32, 0.016) C-8, D

This formula was used for the reduction in showroom appeal costs.

* * * *

C DSA*=0.0/0.28/0.46/0.58/0.66/0.72/0.75/0.78/
0.80/0.82/0.83/0.84/0.84/0.84/0.85/0.85/
0.85/0.85/0.85/0.85/0.85 C-9

DSA = Designed Showroom Appeal (Table)

The designed showroom appeal table used in equation C-8.

* * * *

6N SAMX=IDSAX

SAMX = Showroom Appeal Manufactured by co. X (Dimensionless)
IDSAX = Initial Designed Showroom Appeal co. X (Dimensionless)

The initial showroom appeal manufactured is equal to the initial designed showroom appeal because of equilibrium at the start of calculations.

- - - -

43A SAMX.K=SAMPLE(SAAMX.K, 1) C-10

SAMX = Showroom Appeal Manufactured by co. X (Dimensionless)
SAAMX = Showroom Appeal Available for Manufacture by co. X (Dimensionless)

Each year a new model is put on the market. The showroom appeal of this model is the level of showroom appeal that is available for manufacture at the end of the preceding year. This value of showroom appeal is held constant throughout the year.

* * * *

6N SAAMX=ISAMX C-11, A

SAAMX = Showroom Appeal Available for Manufacture by co. X (Dimensionless)

ISAMX = Initial Showroom Appeal Manufactured by co. X (Dimensionless)

Since the model is initially in a state of equilibrium, the showroom appeal available for manufacture is equal to the showroom appeal being manufactured.

\- - - -

3L SAAMX.K=SAAMX.J+(DT)(1/TDMD)(DSAX.J-SAAMX.J) C-11, B

SAAMX = Showroom Appeal Available for Manufacture by co. X (Dimensionless)

DT = Delta Time (yr)

TDMD = Time Delay for Manufacture and Distribution (yr)

DSAX = Designed Showroom Appeal co. X (Dimensionless)

New model designs are supplied to the manufacturer yearly while design refinements are supplied when available. The level of showroom appeal available is based on the TDMD time required to bring the design from the Engineering Department to the customer.

* * * *

C TDMD=1 year C-12

TDMD = Time Delay for Manufacture and Distribution

It requires one year to manufacture and distribute the new model.

* * * *

C IRBDX=2.85E6 Dollars/year C-13, A

6N RBDX=IRBDX C-13, B

IRBDX = Initial Reliability Budget Desired by co. X ($/yr)
RBDX = Reliability Budget Desired by co. X ($/yr)

This establishes the desired reliability budget at the start of calculations.

\- - - -

The following are Company X policies pertaining to the Reliability Budget:

6A RBDX.K=5.7E6 Dollars/ year C-13, C

RBDX = Reliability Budget Desired by co. X ($/yr)

The budget is changed to a new value and held constant for the complete run. The change may be to any value. In this case it was to 5.7 million dollars.

\- - - -

44A RBDX.K=(XUSX.K)(IRBDX)/IXUSX C-13, D

RBDX = Reliability Budget Desired by co. X ($/yr)
XUSX = eXpected Units Sold co. X (Units/yr)
IRBDX = Initial Reliability Budget Desired by co. X ($/yr)
IXUSX = Initial eXpected Units Sold by co. X (Units/yr)

The company policy on the reliability budget is to vary the budget as the expected sales vary. This is based on the initial values of both sales and budget.

\- - - -

44A RBDX.K=(IXUSX)(IRBDX)/XUSX.K C-13, E

RBDX = Reliability Budget Desired by co. X ($/yr)
IXUSX = Initial eXpected Units Sales by co. X (Units/yr)

IRBDX = Initial Reliability Budget Desired by co. X ($/yr)
XUSX = eXpected Units Sales by co. X (Units/yr)

The company policy is to vary the reliability budget inversely as sales.

* * * *

6N RBX=IRBDX C-14, A

RBX = Reliability Budget co. X ($/yr)
IRBDX = Initial Reliability Budget Desired by co. X ($/yr)

Since the system is in equilibrium at the start, the reliability budget is equal to the desired reliability budget. This budget is for the design and development of reliability in the product.

3L RBX.K=RBX.J+(DT)(1/TLB)(RBDX.J-RBX.J) C-14, B

RBX = Reliability Budget co. X ($/yr)
DT = Delta Time (yr)
TLB = Time to Level Budget (yr)
RBDX = Reliability Budget Desired by co. X ($/yr)

When management desires a change in the level of the budget, the effect of the change is not felt immediately. As in C-2, the level is increased over TLB time.

* * * *

44A RFX.K=(REEX.K)(RBX.K)/BVCCX.K C-15

RFX = Reliability Factor co. X (Dimensionless)
REEX = Reliability Effort Effectiveness co. X (Dimensionless)
RBX = Reliability Budget co. X ($/yr)
BVCCX = Basic Variable Class Cost co. X ($/yr)

The effectiveness of the reliability budget is dependent on the showroom appeal of the product, the size of the budget, the basic product cost, and the size of the company. This reliability factor equates these quantities to establish a unit of measurement for the effectiveness of the reliability budget.

* * * *

59A REEX.K=TABLE(REE, DSAX.K, 0, 1, 0.1) C-16

REEX = Reliability Effort Effectiveness co. X (Dimensionless)
REE = Reliability Effort Effectiveness (Table)
DSAX = Designed Showroom Appeal co. X (Dimensionless)

The reliability effort effectiveness is based on the reliability effort effectiveness table. The table equates the designed showroom appeal to the reliability effort effectiveness. The table is entered with showroom appeal values between zero and one. The values are given in 0.1 intervals. Values between the given values are interpolated as a straight line variation.

* * * *

C REE*=1.0/1.0/0.99/0.97/0.95/0.93/0.90/0.86/
0.81/0.76/0.70 C-17

REE = Reliability Effort Effectiveness (Table)

As the showroom appeal of a product increases, more effort is required to maintain the same reliability. The reliability effort effectiveness represents the effectiveness of the reliability budget for various values of showroom appeal.

* * * *

C IDRX=0.5 C-18, A

6N DRX=IDRX C-18, B

IDRX = Initial Designed Reliability co. X (Dimensionless)
DRX = Designed Reliability co. X (Dimensionless)

Based on the initial reliability budget, the initial designed reliability is 0.5.

59A DRX.K=TABLE(DR,RFX.K,0.02,0.4,0.02) C-18, C

DRX = Designed Reliability co. X (Dimensionless)
DR = Designed Reliability (Table)
RFX = Reliability Factor co. X (Dimensionless)

The designed reliability is based on the designed reliability table. This table is entered with the reliability factor from 0.02 to 0.4. The designed reliability values are given in intervals of 0.02 of reliability factor and are interpolated as a straight line variation for values not given.

\- - - -

59A DRX.K=TABLE(DR,RFX.K,0.016,0.32,0.016) C-18, D

This formula was used for reduced cost of showroom appeal.

* * * *

C DR*=0.25/0.45/0.53/0.58/0.64/0.68/0.72/0.76/0.80/
0.82/0.84/0.85/0.86/0.87/0.87/0.87/0.88/0.88/
0.88/0.88 C-19

DR = Designed Reliability (Table)

The designed reliability table used in C-18 is indicated here.

* * * *

6N RMX=IDRX C-20, A

RMX = Reliability Manufactured by co. X (Dimensionless)
IDRX = Initial Designed Reliability by co. X (Dimensionless)

The reliability manufactured initially is equal to the initial designed reliability due to equilibrium at the start of calculations.

3L RMX.K=RMX.J+(DT)(1/TDMD)(DRX.J-RMX.J) C-20, B

RMX	= Reliability Manufactured by co. X	(Dimensionless)
DT	= Delta Time	(yr)
TDMD	= Time Delay for Manufacture and Distribution	(yr)
DRX	= Designed Reliability co. X	(Dimensionless)

A change in designed reliability requires TDMD time to be manufactured and distributed to customers. The level of reliability of the manufactured product is varied by the design being manufactured. This change requires TDMD time to take full effect.

* * * *

7A DDCX.K=SABX.K+RBX.K C-21

DDCX	= Design and Development Cost co. X	($/yr)
SABX	= Showroom Appeal Budget co. X	($/yr)
RBX	= Reliability Budget co. X	($/yr)

The design and development cost is made up of the showroom appeal budget and the reliability budget.

* * * *

20A DDCRX.K=DDCX.K/BVCCX.K C-22

DDCRX	= Design and Development Cost Ratio co. X	(Dimensionless)
DDCX	= Design and Development Cost co. X	($/yr)
BVCCX	= Basic Variable Class Cost co. X	($/yr)

The design and development cost ratio is the unit of measurement used to determine the equipment, tools, and overhead expenses that could be expected when manufacturing the product.

* * * *

59A ETORX.K=TABLE(ETOR,DDCRX.K,0,0.6,0.6) C-23

ETORX = Equipment, Tool, and Operating expense Ratio, co. X (Dimensionless)

ETOR = Equipment, Tool, and Operating expense Ratio (Table)

DDCRX = Design and Development Cost Ratio co. X (Dimensionless)

The equipment, tool, and operating expense ratio is the ratio of equipment, tool, and operating expense to the basic variable unit cost. This ratio is established by the equipment, tool, and operating expense table. This table is entered using the design and development cost ratio.

* * * *

C ETOR*=0.5/2.0 C-24

ETOR = Equipment, Tool, and Operating expense Ratio (Table)

This table establishes the ratio of equipment, tool, and operating expenses to the basic variable unit cost.

* * * *

12A ETOUX.K=(BVUCX)(ETORX.K) C-25

ETOUX = Equipment, Tool, and Operating expenses per Unit co. X ($/unit)

BVUCX = Basic Variable Unit Cost co. X ($/unit)

ETORX = Equipment, Tool and Operating expenses Ratio co. X (Dimensionless)

This establishes the amount of equipment, tool, and operating expenses expected per unit built.

* * * *

C IETOU=39 Dollars C-26, A

6N ETOBU=IETOU C-26, B

The equipment, tool, and operating expense budget is $39.00 per unit based on the initial design and development budgets.

3L ETOBU.K=ETOBU.J+(DT)(1/TDMD)(ETOUX.J-ETOBU.J) C-26, C

ETOBU	= Equipment, Tool, and Operating expense Budget per Unit	($/yr)
DT	= Delta Time	(yr)
TDMD	= Time Delay for Manufacture and Distribution	(yr)
ETOUX	= Equipment, Tool, and Operating expense per Unit co. X	($/unit)

The expenses that are required by design must be leveled over the time required for manufacture and distribution. As the new model is being tooled for manufacture, the expenses of the new model are being accrued. The expenses are not paid immediately upon the issue of the design to manufacturing but are paid during the tooling period.

* * * *

12A ETOBX.K=(ETOBU.K)(XUSX.K) C-27

ETOBX	= Equipment, Tool, and Overhead expense Budget co. X	($/yr)
ETOBU	= Equipment, Tool, and Overhead expense Budget per Unit	($/unit)
XUSX	= eXpected Unit Sales co. X	(Units/yr)

The company sets its budget for equipment, tools, and operating expense by determining the cost per unit and the amount of units that the company expects to sell.

* * * *

C IXUSX=1E6 units/year C-28, A

6N XUSX=IXUSX C-28, B

IXUSX	= Initial eXpected Unit Sales co. X	(Units/yr)
XUSX	= eXpected Unit Sales co. X	(Units/yr)

At the start of calculations the expected sales is equal to the company class of one million units per year.

3L XUSX.K=XUSX.J+(DT)(1/TLUS)(USX.J-XUSX.J) C-28, C

XUSX	= eXpected Unit Sales co. X	(Units/yr)
DT	= Delta Time	(yr)
TLUS	= Time to Level Unit Sales	(yr)
USX	= Unit Sales co. X	(Units/yr)

The expected sales is based on present sales leveled over a period of time equal to TLUS. The company, therefore, is pessimistic during rising sales and optimistic during falling sales.

* * * *

C TLUS=1 year C-29

TLUS	= Time to Level Unit Sales	(yr)

Expected sales is leveled over a one-year period.

* * * *

8A CFCX.K=DDCX.K+ETOBX.K+CASEX C-30

CFCX	= Company Fixed Costs co. X	($/yr)
DDCX	= Design and Development Cost co. X	($/yr)
ETOBX	= Equipment, Tool, and Operating expense Budget co. X	($/yr)
CASEX	= Company Administrative and Selling Expense co. X	($/yr)

Company fixed cost is the addition of all costs that do not vary or that vary a minimum amount with changes in sales.

* * * *

C CASEX=25E6 Dollars/year C-31

CASEX	= Company Administrative and Selling Expense co. X	($/yr)

The selling and administrative expense is considered constant for this thesis.

* * * *

12A VUCX.K=(MVFCR)(ETOBU.K) C-32

VUCX	= Variable Unit Cost co. X	($/unit)
MVFCR	= Manufacturing Variable to Fixed Cost Ratio	(Dimensionless)
ETOBU	= Equipment, Tool, and Operating expense Budget per Unit	($/unit)

The ratio of fixed and variable manufacturing costs is constant (MVFCR) for this thesis.

* * * *

C MVFCR=2 C-33

MVFCR	= Manufacturing Variable to Fixed Cost Ratio	(Dimensionless)

Manufacturing variable costs are twice manufacturing fixed costs.

* * * *

27A XUCX.K=(CFCX.K/XUSX.K)+ VUCX.K C-34

XUCX	= eXpected Unit Cost co. X	($/unit)
CFCX	= Company Fixed Cost co. X	($/yr)
XUSX	= eXpected Unit Sales co. X	(Units/yr)
VUCX	= Variable Unit Cost co. X	($/unit)

The expected unit cost is the sum of the fixed cost per unit based on expected sales the the variable unit cost.

* * * *

The company used three unit price policies in this thesis as follows: (1) Match competition's price, (2) price is a given percentage of the expected costs, and (3) price is a given percentage of expected cost not to exceed a given percentage of competition's price.

The price is changed once per year.

C IUPX=184.50 Dollars C-35, A

6N UPX=IUPX C-35, B

IUPX = Initial Unit Price co. X ($/unit)
UPX = Unit Price co. X. ($/unit)

The initial unit price is based on 125% of initial costs. This is the same price as competition.

6A UPX.K=UPY C-35, C

UPX = Unit Price co. X ($/unit)
UPY = Unit Price co. Y ($/unit)

Company policy is that Company X will match competition's price.

43A UPX.K=SAMPLE(DUPX.K, 1) C-35, D

UPX = Unit Price co. X ($/unit)
DUPX = Desired Unit Price co. X ($/unit)

The unit price is the desired price at the beginning of the model year. This price remains constant for the year.

54A DUPX.K=MIN(XUPX.K, MUPX) C-35, E

DUPX = Desired Unit Price co. X ($/unit)
XUPX = eXpected Unit Price co. X ($/unit)
MUPX = Maximum Unit Price co. X ($/unit)

Company policy is that the desired unit price is XUPX if XUPX is below MUPX. No price will be above MUPX.

12A XUPX.K=(XUCX.K)(CPP) C-35, F

XUPX = eXpected Unit Price co. X ($/unit)
XUCX = eXpected Unit Cost co. X ($/unit)
CPP = Company Price Policy (Dimensionless)

The expected price is based on a company policy which sets the percentage of profit expected.

C CPP=1.25 C-35, G

CPP = Company Price Policy (Dimensionless)

The price is set at 125% of costs.

12N MUPX=(MPR)(UPY) C-35, H

MUPX = Maximum Unit Price co. X ($/unit)
MPR = Maximum Price Ratio (Dimensionless)
UPY = Unit Price co. Y ($/unit)

The maximum price is based on a percentage of competition's price.

C MPR=1.2 C-35, I

MPR = Maximum Price Ratio (Dimensionless)

The unit price cannot be more than 120% of competition's price. This percentage can vary and can be made high enough to make MUPX ineffective and, therefore, have no maximum price.

* * * *

27A AUCX.K=(CFCX.K/USX.K)+VUCX.K C-36

AUCX = Actual Unit Cost co. X ($/unit)
CFCX = Company Fixed Cost co. X ($/yr)
USX = Units Sold by co. X (Units/yr)
VUCX = Variable Unit Cost co. X ($/unit)

The actual unit cost is the sum of the unit fixed cost based on actual units sold and the variable unit cost.

* * * *

12A ACX.K=(AUCX.K)(USX.K) C-37

ACX = Actual Costs co. X ($/yr)
AUCX = Actual Unit Cost co. X ($/unit)
USX = Units Sold by co. X (Units/yr)

The actual cost is the product of the unit cost and the units sold.

* * * *

12A	TRX.K=(UPX.K)(USX.K)	C-38
	TRX = Total Revenue co. X	($/yr)
	UPX = Unit Price co. X	($/unit)
	USX = Units Sold by co. X	(Units/yr)

The total revenue is the product of the unit price and the units sold.

* * * *

7A	PROFX.K=TRX.K-ACX.K	C-39
	PROFX = PROFit co. X	($/yr)
	TRX = Total Revenue co. X	($/yr)
	ACX = Actual Cost co. X	($/yr)

The profit is the difference between the total revenue and the actual costs.

A.2 MARKET SECTOR

Customer Flow Equations
(See Figure 29)

39R OEMX.KL=DELAY3(USX.JK,ODT) M-1X

39R OEMY.KL=DELAY3(USY.JK,ODT) M-1Y

OEMX	= Owners Entering Market brand X	(Units/yr)
OEMY	= Owners Entering Market brand Y	(Units/yr)
USX	= Units Sold brand X	(Units/yr)
USY	= Units Sold brand Y	(Units/yr)
ODT	= Owner Delay Time	(yr)

The owners of the product own the product an average of ODT years before they enter the market and become prospective customers. They are delayed between buying and reentering the market to rebuy by a third order delay which allows some owners to reenter the market almost immediately while others remain out of the market longer than the average "ODT."

* * * *

C ODT=3 years M-2

ODT = Owner Delay Time

Owners remain out of the market for a new product an average of three years.

* * * *

12A SOEMX.K=(OSMX.JK)(OEMX.JK) M-3X

12A SOEMY.K=(OSMY.JK)(OEMY.JK) M-3Y

SOEMX	= Satisfied Owners Entering Market brand X	(Units/yr)
SOEMY	= Satisfied Owners Entering Market brand Y	(Units/yr)
OSMX	= Ownership Satisfaction to Market brand X	(Dimensionless)
OSMY	= Ownership Satisfaction to Market brand Y	(Dimensionless)

OEMX = Owners Entering Market brand X (Units/yr)
OEMY = Owners Entering Market brand Y (Units/yr)

The proportion of owners who enter the market as satisfied owners is based on the ownership satisfaction of the owners who enter the market. If the owner enters the market as a satisfied owner he will remain a satisfied owner until he buys a new product.

* * * *

7A DOEMX.K=OEMX.JK-SOEMX.K M-4X

7A DOEMY.K=OEMY.JK-SOEMY.K M-4Y

DOEMX = Dissatisfied Owners Entering Market brand X (Units/yr)
DOEMY = Dissatisfied Owners Entering Market brand Y (Units/yr)
OEMX = Owners Entering Market brand X (Units/yr)
OEMY = Owners Entering Market brand Y (Units/yr)
SOEMX = Satisfied Owners Entering Market brand X (Units/yr)
SOEMY = Satisfied Owners Entering Market brand Y (Units/yr)

Owners who are not satisfied are dissatisfied.

* * * *

1L SOIMX.K=SOIMX.J+(DT)(SOEMX.J-SOMXB.JK) M-5X

1L SOIMY.K=SOIMY.J+(DT)(SOEMY.J-SOMYB.JK) M-5Y

1L DOIMX.K=DOIMX.J+(DT)(DOEMX.J-DOMXB.JK) M-6X

1L DOIMY.K=DOIMY.J+(DT)(DOEMY.J-DOMYB.JK) M-6Y

SOIMX = Satisfied Owners In Market brand X (units)
SOIMY = Satisfied Owners In Market brand Y (units)
DT = Delta Time (yr)
SOEMX = Satisfied Owners Entering Market brand X (Units/yr)
SOEMY = Satisfied Owners Entering Market brand Y (Units/yr)
SOMXB = Satisfied Owners in Market brand X Buying (Units/yr)
SOMYB = Satisfied Owners in Market brand Y Buying (Units/yr)

DOIMX = Dissatisfied Owners In Market brand X (Units)
DOIMY = Dissatisfied Owners In Market brand Y (Units)
DOEMX = Dissatisfied Owners Entering Market brand X (Units/yr)
DOEMY = Dissatisfied Owners Entering Market brand Y (Units/yr)
DOMXB = Dissatisfied Owners in Market brand X Buying (Units/yr)
DOMYB = Dissatisfied Owners in Market brand Y Buying (Units/yr)

The level of customers in the market varies by the difference between the amount of customers entering and amount of customer leaving. If more customers leave the market, by buying a new product, than enter, the level will decrease.

* * * *

20R SOMXB.KL=SOIMX.K/SOMDT.K M-7X

20R SOMYB.KL=SOIMY.K/SOMDT.K M-7Y

20R DOMXB.KL=DOIMX.K/DOMDT.K M-8X

20R DOMYB.KL=DOIMY.K/DOMDT.K M-8Y

SOMXB = Satisfied Owners in Market brand X Buying (Units/yr)
SOMYB = Satisfied Owners in Market brand Y Buying (Units/yr)
SOIMX = Satisfied Owners In Market brand X (Units)
SOIMY = Satisfied Owners In Market brand Y (Units)
SOMDT = Satisfied Owners Market Delay Time (yr)
DOMXB = Dissatisfied Owners in Market brand X Buying (Units/yr)
DOMYB = Dissatisfied Owners in Market brand Y Buying (Units/yr)
DOIMX = Dissatisfied Owners In Market brand X (Units)
DOIMY = Dissatisfied Owners In Market brand Y (Units)
DOMDT = Dissatisfied Owners in Market Delay Time (yr)

The length of time that a prospective customer remains in the market deciding to buy is dependent on many factors. These factors are incorporated in SOMDT which determines the delay time for those satisfied with the product they now own and DOMDT which determines the delay time for those dissatisfied. The amount of buyers is dependent on the number of prospective customers and their delay time in the market.

* * * *

7R USX.KL=LCX.K+CCX.K M-9X

7R USY.KL=LCY.K+CCY.K M-9Y

USX = Units Sold co. X (Units/yr)
USY = Units Sold co. Y (Units/yr)
LCX = Loyal Customers brand X (Units/yr)
LCY = Loyal Customers brand Y (Units/yr)
CCX = Captured Customers co. X (Units/yr)
CCY = Captured Customers co. Y (Units/yr)

The customers who determine the units sold are either loyal customers, who rebuy the same brand, or captured customers, who previously owned a different brand.

* * * *

7A TUS.K=USX.JK+USY.JK M-10

TUS = Total Units Sold (Units/yr)
USX = Units Sold co. X. (Units/yr)
USY = Units Sold co. Y (Units/yr)

The sum of the units sold by all companies is the total units sold.

* * * *

20A MPX.K=USX.K/TUS.K M-11

MPX = Market Percentage co. X (Dimensionless)

USX = Units Sold co. X		(Units/yr)
TUX = Total Units Sold		(Units/yr)

This equation determines the market percentage of Company X.

* * * *

It is assumed that one million units per year are sold by each of the four competing companies. Therefore, Company Y would sell three million units. The initial values required for the above equations are:

SOIMX = 0.8E6	units/yr	M-5X
SOIMY = 2.4E6	units/yr	M-5Y
DOIMX = 0.6E6	units/yr	M-6X
DOIMY = 1.8E6	units/yr	M-6Y
SOMXB = 0.4E6	units/yr	M-7X
SOMYB = 1.2E6	units/yr	M-7Y
DOMXB = 0.6E6	units/yr	M-8X
DOMYB = 1.8E6	units/yr	M-8Y
USX = 1.0E6	units/yr	M-9X
USY = 3.0E6	units/yr	M-9Y

* * * *

A. 3 MARKET SECTOR

Customer "Ownership Satisfaction" Decision Equations
(See Figure 30)

59A SCYUX.K=TABLE(SCYU,RMX.K,0,1,0.1) M-12

SCYUX	= Service Calls per Year per Unit brand X	(Dimensionless)
SCYU	= Service Calls per Year per Unit	(Table)
RMX	= Reliability Manufactured co. X	(Dimensionless)

The service calls per year are dependent upon the reliability that is manufactured into the product. This relationship between service calls and reliability is established by the Service Calls per Year per Unit Table.

* * * *

C SCYU*=10/4.6/2.5/1.8/1.4/1.0/0.75/0.6/0.4/0.2/0 M-13

SCYU	= Service Calls per Year per Unit	(Table)

This table establishes the relationship between reliability and service calls per year.

* * * *

3L SCYVX.K=SCYVX.J+(DT)(1/TLOS)(SCYUX.J-SCYVX.J) M-14

SCYVX	= Service Calls per Year leVel brand X	(Dimensionless)
DT	= Delta Time	(yr)
TLOS	= Time to Level Ownership Satisfaction	(yr)
SCYUX	= Service Calls per Year per Unit brand X	(Dimensionless)

Owners of brand Y establish the service calls that they believe are required by brand X by the level of service calls over TLOS time. Brand Y owners know of brand X service calls by hearsay from all owners of brand X.

* * * *

C TLOS=4 years M-15

TLOS = Time to Level Ownership Satisfaction (yr)

* * * *

C SCYUY=1 Service call/year M-16

SCYUY = Service Calls per Year per Unit brand Y (Dimensionless)

Competition's products require one service call per year consistently. The service call per year level is, therefore, the same as the service calls per unit.

* * * *

20A RIX.K=SCYUY/SCYUX.K M-17X

20A RIY.K=SCYVX.K/SCYUY M-17Y

RIX	= Reliability Image brand X	(Dimensionless)
RIY	= Reliability Image brand Y	(Dimensionless)
SCYUY	= Service Calls per Year per Unit co. Y	(Dimensionless)
SCYUX	= Service Calls per Year per Unit brand X	(Dimensionless)
SCYVX	= Service Calls per Year leVel brand X	(Dimensionless)

The owner's reliability image is the ratio of competition's service call level to the service calls he experiences on his product.

* * * *

59A OSX.K=TABLE(OS,RIX.K,0,5.2,0.4) M-18X, A

59A OSY.K=TABLE(OS,RIY.K,0,5.2,0.4) M-18Y, A

OSX	= Ownership Satisfaction brand X	(Dimensionless)
OSY	= Ownership Satisfaction brand Y	(Dimensionless)
OS	= Ownership Satisfaction	(Table)
RIX	= Reliability Image brand X	(Dimensionless)
RIY	= Reliability Image brand Y	(Dimensionless)

Ownership satisfaction is determined by the reliability image of the brand owned. The Ownership Satisfaction Table establishes the relationship of these two.

\- \- \- \-

C OS*=0/0.28/0.36/0.43/0.49/0.55/0.60/0.65/0.69/ 0.72/0.75/0.78/0.81/0.82 M-19

OS = Ownership Satisfaction (Table)

This table establishes the relationship between reliability image and ownership satisfaction.

* * * *

39R OSMX.KL=DELAY3(OSX.K,ODT) M-20X

39R OSMY.KL=DELAY3(OSY.K,ODT) M-20Y

OSMX	= Ownership Satisfaction to Market brand X	(Dimensionless)
OSMY	= Ownership Satisfaction to Market brand Y	(Dimensionless)
OSX	= Ownership Satisfaction brand X	(Dimensionless)
OSY	= Ownership Satisfaction brand Y	(Dimensionless)
ODT	= Owner Delay Time	(yr)

These equations delay ownership satisfaction the same amount as the owners who are experiencing the satisfaction (see M-1X, M-1Y). When the owners enter the market, their satisfaction enters with them.

* * * *

All companies start the problem experiencing the same ownership satisfaction. Based on the initial budget conditions, the initial values required are:

SCYUX	= 1	M-12
SCYVX	= 1	M-14
OSX	= 0.4	M-18X
OSY	= 0.4	M-18Y

* * * *

A.4 MARKET SECTOR

Customer "When to Buy" Decision Equations
(See Figure 31)

18A SOMDT.K=(PSAE.K)(SOBDT+ECCDT.K) M-21, A

18A DOMDT.K=(PSAE.K)(DOBDT+ECCDT.K) M-22, A

SOMDT	= Satisfied Owners Market Delay Time	(yr)
DOMDT	= Dissatisfied Owners Market Delay Time	(yr)
PSAE	= Price and Showroom Appeal Effect	(Dimensionless)
SOBDT	= Satisfied Owner Basic Delay Time	(yr)
DOBDT	= Dissatisfied Owner Basic Delay Time	(yr)
ECCDT	= Economic Conditions Change in Delay Time	(yr)

The time spent in the market is affected by economic conditions, satisfaction of the owner, price, and showroom appeal. Economic conditions increase or decrease the basic delay time by adding or subtracting time. Customers may be swayed from this new delay time by price and showroom appeal.

\- \- \- \-

6A SOMDT.K=SOBDT M-21, B

6A DOMDT.K=DOBDT M-22, B

SOMDT	= Satisfied Owner Market Delay Time	(yr)
SOBDT	= Satisfied Owner Basic Delay Time	(yr)
DOMDT	= Dissatisfied Owner Market Delay Time	(yr)
DOBDT	= Dissatisfied Owner Basic Delay Time	(yr)

This equation is used when the market delay time is not affected by economic conditions, price, and showroom appeal.

* * * *

C SOBDT=2 years M-23

C DOBDT=1 year M-24

SOBDT	= Satisfied Owner Basic Delay Time	(yr)
DOBDT	= Dissatisfied Owner Basic Delay Time	(yr)

These equations establish the basic delay time in the market. Satisfied owners remain in the market longer than dissatisfied owners.

* * * *

31A ECCDT.K=(ECCH)SIN((2PI)(TIME.K)/ECYC) M-25, A

ECCDT	= Economic Conditions Change in Delay Time	(yr)
ECCH	= Economic Conditions Change Height	(yr)
SIN	= SINe trignometric function	(Dimensionless)
PI	= π	
TIME	= TIME	(yr)
ECYC	= Economic Conditions Yearly Cycle	(yr)

The economic conditions cause the basic delay time to vary a maximum of plus or minus ECCH. The variation is sinusoidal over an ECYC period.

\- - - -

6A ECCDT.K=0 M-25, B

ECCDT = Economic Conditions Change in Delay Time (yr)

This equation is used when the basic delay time is not affected by economic conditions.

* * * *

C ECYC=5 years M-26

ECYC = Economic Conditions Yearly Cycle (yr)

The economic cycle varies over a five-year period.

* * * *

C ECCH=0.75 years M-27

ECCH = Economic Conditions Change Height (yr)

The maximum variation in basic delay time due to economic conditions is plus or minus nine months.

* * * *

30A PSAE.K=(1)SQRT(APSAE.K) M-28, A

12A APSAE.K=(PEM.K)(SAEM.K) M-28, B

PSAE = Price and Showroom Appeal Effect (Dimensionless)
SQRT = SQare RooT
APSAE = Auxiliary Price and Showroom Appeal Effect (Dimensionless)
PEM = Price Effect on the Market (Dimensionless)
SAEM = Showroom Appeal Effect on the Market (Dimensionless)

The auxiliary quantity (APSAE) is required because DYNAMO cannot calculate the square root of the product of two quantities.

The effect of price and showroom appeal is the square root of the product of the effect of price and the effect of showroom appeal. The square root was used instead of the average because it weights the result towards the lower value.

\- - - -

6A PSAE.K=1 M-28, C

PSAE = Price and Showroom Appeal Effect (Dimensionless)

The equation is used if price and showroom appeal have no effect on the market.

* * * *

59A PEM.K=TABLE(PE,PRM.K,0.7,1.3,0.1) M-29, A

PEM = Price Effect on the Market (Dimensionless)
PE = Price Effect (Table)
PRM = Price Ratio in the Market (Dimensionless)

The price effect on the market is determined by the price ratio of present and recent market prices. The Price Effect Table establishes the relationship.

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6A PEM.K=1 M-29, B

This equation is used if price is to have no effect on the market.

* * * *

C PE*=0.5/0.58/0.75/1/1.2/1.35/1.4 M-30

PE = Price Effect (Table)

This table establishes the effect that price has on the delay time in the market. The values below 1 indicate a reduction and the values above 1 an increase.

* * * *

20A PRM.K=AUPM.K/AUPVM.K M-31

PRM	= Price Ratio in the Market	(Dimensionless)
AUPM	= Average Unit Price in the Market	($/unit)
AUPVM	= Average Unit Price leVel in the Market	($/unit)

The price ratio in the market is the ratio of the average price being paid today to the average price level over a period of time.

* * * *

22A AUPM.K=(1/NCIM)((UPX.K)(1)+(NCIY)(UPY)) M-32

AUPM	= Average Unit Price in the Market	($/unit)
NCIM	= Number of Companies In the Market	(Dimensionless)
UPX	= Unit Price brand X	($/unit)
NCIY	= Number of Companies In co. Y	(Dimensionless)
UPY	= Unit Price brand Y	($/unit)

The average price in the market is the average of the price of each brand. Since there is one brand by

Company X and more than one brand by Company Y, the price of Y must be weighted by the number of companies (brands) in Company Y.

The average unit price is the average of the prices being paid today.

* * * *

7N NCIM=NCIY+1 M-33

NCIM = Number of Companies In the Market (Dimensionless)
NCIY = Number of Companies In co. Y (Dimensionless)

The number of companies in the market is the sum of the companies in Y and Company X.

* * * *

C NCIY=3 M-34

NCIY = Number of Companies In co. Y (Dimensionless)

* * * *

22A AUPVM.K=(1/NCIM)((UPVX.K)(1)+(NCIY)(UPY)) M-35

AUPVM = Average Unit Price leVel in the Market ($/unit)
NCIM = Number of Companies In the Market (Dimensionless)
UPVX = Unit Price leVel brand X ($/unit)
NCIY = Number of Companies In co. Y (Dimensionless)
UPY = Unit Price brand Y ($/unit)

The average of the level of brand prices over a period of time. The price of Brand Y does not vary and, therefore, the price level is equal to the unit price.

* * * *

3L UPVX.K=UPVX.J+(DT)(1/TLPM)(UPX.J-UPVX.J) M-36

UPVX = Unit Price leVel brand X ($/unit)
DT = Delta Time (yr)
TLPM = Time to Level Price in Market (yr)
UPX = Unit Price brand X ($ unit)

The price in the market is leveled over TLPM time.

* * * *

C TLPM=1 year M-37

TLPM = Time to Level Prices in the Market (yr)

Customers remember prices an average of one year.

* * * *

The description for the equations describing the effect of showroom appeal on the market parallels the description of the equations describing the effect of price on the market. No description will be given for the showroom appeal equations. (See M-29, M-30, M-31, M-32, M-33, M-34, M-35).

59A SAEM.K=TABLE(SAE,SARM.K,0.5,1.5,0.1) M-38,A

6A SAEM.K=1 (When showroom appeal has no effect on the market) M-38,B

C SAE*=1.4/1.37/1.27/1.12/1.02/1/0.98/0.85/0.7/0.62/0.6 M-39

20A SARM.K=ASAM.K/ASAVM.K M-40

22A ASAM.K=(1/NCIM)((SAMX.K)(1)+(NCIY)(SAMY)) M-41

22A ASAVM.K=(1/NCIM)((SAVX.K)(1)+(NCIY)(SAMY)) M-42

SAEM	= Showroom Appeal Effect on the Market	(Dimensionless)
SAE	= Showroom Appeal Effect	(Table)
SARM	= Showroom Appeal Ratio in the Market	(Dimensionless)
ASAM	= Average Showroom Appeal in the Market	(Dimensionless)
ASAVM	= Average Showroom Appeal leVel in the Market	(Dimensionless)
NCIM	= Number of Companies In the Market	(Dimensionless)
SAMX	= Showroom Appeal Manufactured co. X	(Dimensionless)
SAMY	= Showroom Appeal Manufactured co. Y	(Dimensionless)
SAVX	= Showroom Appeal leVel co. X	(Dimensionless)
NCIY	= Number of Companies In Y	(Dimensionless)

* * * *

A.5 MARKET SECTOR

Customer "Brand of Product" Decision Equations
(See Figure 32)

3L SAVX.K=SAVX.J+(DT)(1/TLSA)(SAMX.J-SAVX.J) M-43

SAVX	= Showroom Appeal leVel brand X	(Dimensionless)
DT	= Delta Time	(yr)
TLSA	= Time to Level Showroom Appeal	(yr)
SAMX	= Showroom Appeal Manufactured co. X	(Dimensionless)

The level of showroom appeal that is expected of Brand X is the level established over TLSA time.

* * * *

C TLSA=2 years M-44

TLSA	= Time to Level Showroom Appeal	(yr)

Customers remember showroom appeal an average of two years.

* * * *

30A CIMX.K=(1)SQRT(ACIMX.K) M-45X, A

46A ACIMX.K=(SAVX.K)(OSVX.K)(1)/((SAMY)(OSVY.K)(1)) M-45X, B

30A CIMY.K=(1)SQRT(ACIMY.K) M-45Y, A

46A ACIMY.K=(SAMY)(OSVY.K)(1)/((SAVX.K)(OSVX.K)(1)) M-45Y, B

CIMX	= Company Image in the Market co. X	(Dimensionless)
ACIMX	= Auxiliary Company Image in the Market co. X	(Dimensionless)
SAVX	= Showroom Appeal leVel brand X	(Dimensionless)
OSVX	= Ownership Satisfaction leVel brand X	(Dimensionless)
SAMY	= Showroom Appeal Manufactured co. Y	(Dimensionless)
OSVY	= Ownership Satisfaction leVel brand Y	(Dimensionless)
CIMY	= Company Image in the Market co. Y	(Dimensionless)
ACIMY	= Auxiliary Company Image in the Market co. Y	(Dimensionless)
SQRT	= SQuare RooT	(Dimensionless)

The auxiliary quantities are required because DYNAMO can only calculate the square root of a single quantity.

Company image in the market is the square root of the product of the ratios of the showroom appeal levels and the ownership satisfaction levels. The square root is used instead of the average to weight the result to the lower ratio. This compares the company's past performance with competition's past performance.

*　　*　　*　　*

12A	CILX.K=(1.2)(CIMX.K)	M-46X, A
12A	CILY.K=(1.2)(CIMY.K)	M-46Y, A

CILX = Company Image of Loyal customers of co. X (Dimensionless)
CILY = Company Image of Loyal customers of co. Y (Dimensionless)
CIMX = Company Image in the Market co. X (Dimensionless)
CIMY = Company Image in the Market co. Y (Dimensionless)

The company image of loyal customers is 20 per cent higher than the company image in the market place.

*　　*　　*　　*

6A	CIMX.K=1	M-45X, B
6A	CIMY.K=1	M-45Y, B
6A	CILX.K=1	M-46X, B
6A	CILY.K=1	M-46Y, B

The above equations for company image are used when past performance has no effect on the market.

*　　*　　*　　*

3L	OSVX.K=OSVX.J+(DT)(1/TLOS)(OSX.J-OSVX.J)	M-47X
3L	OSVY.K=OSVY.J+(DT)(1/TLOS)(OSY.J-OSVY.J)	M-47Y
C	TLOS=4 years	M-48

OSVX	= Ownership Satisfaction leVel brand X	(Dimensionless)
TLOS	= Time to Level Ownership Satisfaction	(yr)
DT	= Delta Time	(yr)
OSX	= Ownership Satisfaction brand X	(Dimensionless)
OSVY	= Ownership Satisfaction leVel brand Y	(Dimensionless)
OSY	= Ownership Satisfaction brand Y	(Dimensionless)

Ownership satisfaction is leveled over an average of four years, the average life of the product.

*   *   *   *

C   SAMY=0.55   M-49

SAMY = Showroom Appeal Manufactured co. Y   (Dimensionless)

Fifty-five per cent of the customers in the market like the showroom appeal of brand Y consistently.

*   *   *   *

59A   XPRMX.K=TABLE(XPR,CIMX.K,0.2,3,0.4)   M-50
59A   XPRLX.K=TABLE(XPR,CILX.K,0.2,3,0.4)   M-51X
59A   XPRLY.K=TABLE(XPR,CILY.K,0.2,3,0.4)   M-51Y

XPRMX	= eXpected Price Ratio in the Market co. X	(Dimensionless)
XPRLX	= eXpected Price Ratio by Loyal customers co. X	(Dimensionless)
XPRLY	= eXpected Price Ratio by Loyal customers co. Y	(Dimensionless)
XPR	= eXpected Price Ratio	(Table)
CIMX	= Company Image in the Market co. X	(Dimensionless)
CILX	= Company Image of Loyal customers co. X	(Dimensionless)
CILY	= Company Image of Loyal customers co. Y	(Dimensionless)

The expected price ratio is the ratio of what the customer expects to pay to the price of a competitive brand. The customer establishes this ratio from the image that he has of the company.

*   *   *   *

C	XPR*=0.3/0.75/1/1.08/1.15/1.2/1.23/1.25	M-52

XPR = eXpected Price Ratio (Table)

This table equates company image to the expected price ratio.

* * * *

20A	FPRMX.K=APRX.K/XPRMX.K	M-53
20A	FPRLX.K=APRX.K/XPRLX.K	M-54X
20A	FPRLY.K=APRY.K/XPRLY.K	M-54Y

FPRMX = eFfective Price Ratio in the Market co. X (Dimensionless)
FPRLX = eFfective Price Ratio for Loyal customers co. X (Dimensionless)
FPRLY = eFfective Price Ratio for Loyal customers co. Y (Dimensionless)

The expected price ratio may vary from the actual price ratio. This variation has an effect on the decision on what brand to buy. The ratio of the actual to the expected determines the variation between the actual and expected prices.

* * * *

20A	APRX.K=UPX.K/UPY	M-55
20A	APRY.K=UPY/UPX.K	M-56

APRX = Actual Price Ratio co. X (Dimensionless)
APRY = Actual Price Ratio co. Y (Dimensionless)
UPX = Unit Price brand X ($/unit)
UPY = Unit Price brand Y ($/unit)

The actual price ratio is the ratio of the price of the interested brand to the price of competition.

* * * *

C	UPY=184.50 Dollars	M-57

UPY = Unit Price of brand Y ($/unit)

* * * *

59A	PFMX.K=TABLE(PF,FPRMX.K,0,2.75,0.25)	M-58, A
59A	PFLX.K=TABLE(PF,FPRLX.K,0,2.75,0.25)	M-59X, A
59A	PFLY.K=TABLE(PF,FPRLY.K,0,2.75,0.25)	M-59Y, A

PFMX	= Price eFfectiveness on the Market co. X	(Dimensionless)
PFLX	= Price eFfectiveness on Loyal customers company X	(Dimensionless)
PFLY	= Price eFfectiveness on Loyal customers company Y	(Dimensionless)
PF	= Price eFfectiveness	(Table)
FPRMX	= eFfective Price Ratio in the Market co. X	(Dimensionless)
FPRLX	= eFfective Price Ratio for Loyal customers co. X	(Dimensionless)
FPRLY	= eFfective Price Ratio for Loyal customers co. Y	(Dimensionless)

The effect of price on the customer's decision to buy is based on how the actual price relates to the expected price. The price effectiveness is, therefore, determined by the effective price ratio. The Price Effectiveness Table equates effective price ratio to price effectiveness.

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6A	PFMX.K=1	M-58, B
6A	PFLX.K=1	M-59X, B
6A	PFLY.K=1	M-59Y, B

The above equations are used when price has no effect on customers' buying decisions.

* * * *

C	PF*=2/1.35/1.22/1.13/1/0.7/0.3/0.1/0.04/0.02/0.01/0	M-60

PF = Price eFfectiveness (Table)

This table equates the effective price ratio to price effectiveness.

* * * *

12A LCX.K=(SOMXB.JK)(PFLX.K) M-61X

12A LCY.K=(SOMYB.JK)(PFLY.K) M-61Y

LCX	= Loyal Customers brand X	(Units/yr)
LCY	= Loyal Customers brand Y	(Units/yr)
SOMXB	= Satisfied Owners in Market brand X Buying	(Units/yr)
SOMYB	= Satisfied Owners in Market brand Y Buying	(Units/yr)
PFLX	= Price eFfectiveness Loyal customers co. X	(Dimensionless)
PFLY	= Price eFfectiveness Loyal customers co. Y	(Dimensionless)

Satisfied owners would buy the brand they now own if the price is right. The customers who rebuy are loyal customers.

* * * *

8A DCX.K=DOMXB.JK+SOMXB.JK-LCX.K M-62X

8A DCY.K=DOMYB.JK+SOMYB.JK-LCY.K M-62Y

DCX	= Disloyal Customers brand X	(Units/yr)
DCY	= Disloyal Customers brand Y	(Units/yr)
DOMXB	= Dissatisfied Owners in Market brand X Buying	(Units/yr)
DOMYB	= Dissatisfied Owners in Market brand Y Buying	(Units/yr)
SOMXB	= Satisfied Owners in Market brand X Buying	(Units/yr)
SOMYB	= Satisfied Owners in Market brand Y Buying	(Units/yr)
LCX	= Loyal Customers brand X	(Units/yr)
LCY	= Loyal Customers brand Y	(Units/yr)

The customers who are buying and are not loyal are disloyal.

* * * *

13A CCX.K=(DCY.K)(SAECX.K)(PFMX.K) M-63

CCX	= Captured Customers by co. X	(Units/yr)
DCY	= Disloyal Customers brand Y	(Units/yr)

SAECX = Showroom Appeal Effect Customers co. X (Dimensionless)

PFMX = Price eFfectiveness in Market co. X (Dimensionless)

Company X can capture disloyal customers from Company Y. The number of customers captured is dependent on the showroom appeal effect and the price effect.

* * * *

20A SAECX.K=SAMX.K/SSACC.K M-64, A

14A SSACC.K=SAMX.K+(NCCFY)(SAMY) M-64, B

7N NCCFY=NCIY-1 M-65

SAECX = Showroom Appeal Effect Customers co. X (Dimensionless)

SAMX = Showroom Appeal Manufactured co. X (Dimensionless)

SSACC = Sum of Showroom Appeals of Competing Companies (Dimensionless)

SAMY = Showroom Appeal Manufactured co. Y (Dimensionless)

NCCFY = Number of Companies Competing From co. Y (Dimensionless)

NCIY = Number of Companies In co. Y (Dimensionless)

There are three companies competing for the disloyal customers of Company Y--Company X and the two companies in Company Y whose product was not owned by the disloyal customer. The proportion of the disloyal customers captured by Company X is that proportion of the sum of the showroom appeal of the competing companies which is the showroom appeal of Company X.

* * * *

8A CCY.K=DCX.K+DCY.K-CCX.K M-66

CCY = Captured Customers co. Y (Units/yr)

DCX = Disloyal Customers co. X (Units/yr)

DCY = Disloyal Customers co. Y (Units/yr)
CCX = Captured Customers co. X (Units/yr)

The disloyal customers of both Brand X and Brand Y who are not captured by Company X are captured by Company Y.

* * * *

The initial values required for the "Brand of Product" decision section are as follows:

SAVX=0.55 M-43
OSVX=0.4 M-47X
OSVY=0.4 M-47Y

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