SIMULATION OF A PRODUCT LIFE CYCLE

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ABSTRACT

The purpose of this paper is to evaluate the characteristics of a Product Life Cycle (PLC) against various factors especially the effect of advertisement on it. The study took into consideration of the technology based products which are durable in nature and also changing their life styles and forms due to rapid technological change. The model assumes that consumer behavioral impact on life is negligible compared to other factors. This consumer behavioral factor acts quite randomly under constantly changing technological, social and political environment [16]. As the marketing system is very complex in nature having feedback causal relationships among the marketing factors considered, System Dynamics modeling methodology was utilized. Sensitivity analysis was done to see the behavior of PLC under varying factor conditions. The results obtained from the model was compared with actual data and other calculated values.

I. INTRODUCTION

The application of the theory of Product Life Cycle or PLC (Fig. 1) in marketing decision making has been accepted by marketing men. For instance, Wells [30] has shown how PLC concept can be successfully applied in the case of international trade and Cunningham [8] has stated its usefulness in corporate planning.

Every new product that is launched enters a product life cycle and due to rapid technological growth the products have been maturing more rapidly. Faced with the challenge of earlier maturity and shortening life cycle, few companies have seen the strength and opportunities lying in the life cycle management because the classifical life cycle concept holds that marketing decisions should be determined by the life cycle positions. Various concepts have been developed and the authors have suggested different strategies that have to be taken at different stages of life cycle in order to elongate the life span of the products.

This paper aims at investigating the behavior of the product life cycle against some marketing factors especially the effect of advertisement on it. The study was conducted on the basis of following assumptions:

- one to one substitution,
- two firms, two products,
- both products are technological in nature,
- promotional expenditure is induced for the new product from the commercial introduction until it captures 30% of the market share, and
- advertising expenditure is considered as a percentage of sales.

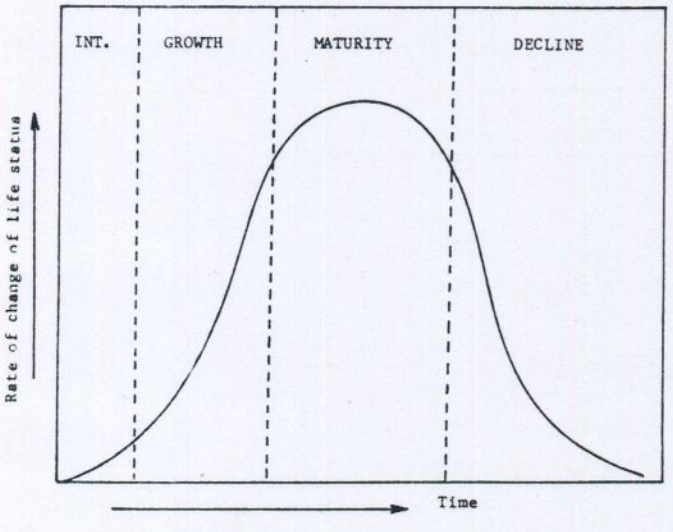


Figure 1. The Product Life Cycle Curve

II. FACTORS CONSIDERED IN FORMULATING THE MODEL

In formulating the PLC's causal model for determining market share of the product, many influencing factors were identified. The factors were broadly classified into two which were further subdivided according to their characteristics.

1. Producer Factors:
   a. Director Producer Factors
      - Advertising Expenditure
      - Quality of the Product
      - Word of Mouth Diffussion of Technology
      - Utility Adjusted Price Ratio
      - Price Perceived by the Respondents
   b. Consumer Behavioural Factors
      - Attitude Change due to Emotional Motives
      - Impact of Economic Motives
      - Attitude Towards Promotion
      - Impact due to Technological Motives
      - Attitude towards risk
      - Impact of Brand Loyalty
2. Market Factors :
   a. Direct Market Factors
      - Profitability associated with the installation of Innovation
      - Investment Size
      - Expansion of Economy
      - Stage of Perfection of Production Technology due to Time and Experience
   b. Durability and Obsolescence Factors
      - Effective life span of products and capital Equipment
   c. Factors Affecting Diffusion of Technology
      - Adopting Population
      - Potential Adopters

2.1 Advertising Expenditure

Advertising expenditure is considered as one of the major tools by which the firm directs persuasive communication to the target buyers. Advertising changes the price-value relationship of the product by providing a new and temporary reason for the consumer to buy it. Advertising has positive influence on the potential adopters which in turn has positive impact on life cycle. Fig. 2 [11] shows the hypothetical relationship between sales volume and advertising expenditure at different stages of life cycle. During the introductory stage, the basic objective is to inform, to diffuse the new ideas. The extra promotional drive must, in effect, "pioneer" acceptance of the new product. This promotional expenditure is maintained until the product captures 30% of the market share.

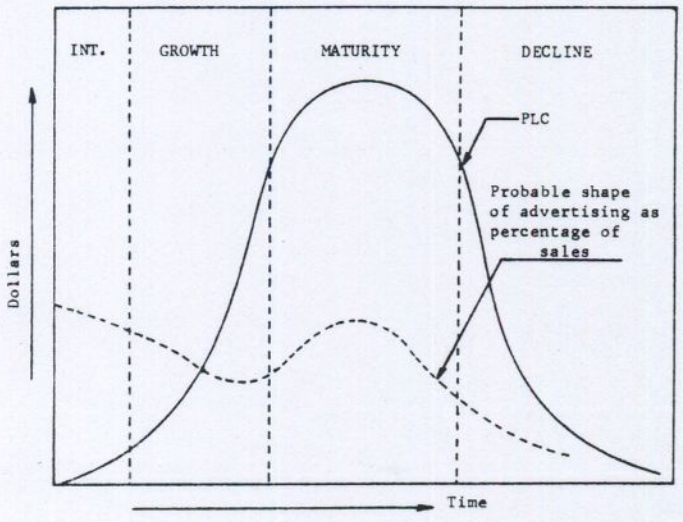


Figure 2. Probable Relationship of Advertising With PLC

2.2 Quality of the Product

The Quality of a product is very important but it is probably the most difficult of all image building features to define. The quality of a product is a weapon of competition. Quality affects a company's economics in two ways; effect on income and effect on cost. For inferior product market return is too low to compensate the production cost and the same thing happens if the quality is too high (Fig. 3). When a new product appears in the market, its quality should be at least equal that of the existing product for effective competition. The new product still remains at the refinement stage and its quality may be improved further with little cost due to improvement in production technology. But if the quality is improved beyond a certain limit, it may not have an increased value in the market in terms of service it renders and the consumers may not feel justified in paying for this increased quality.

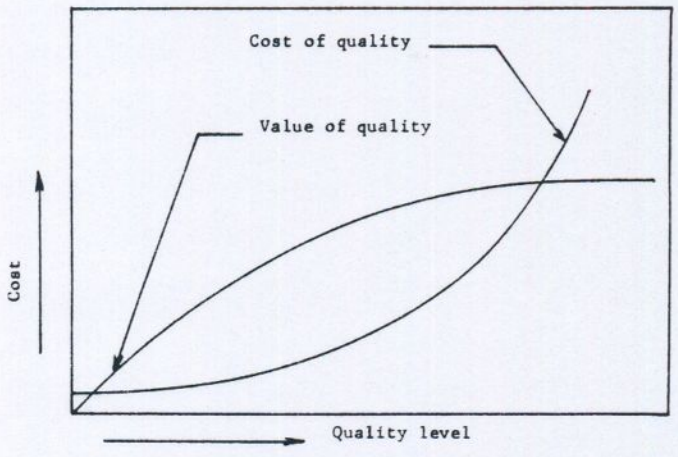


Figure 3. Economics of Quality

2.3 Word of Mouth Diffusion of Innovation

The most important source of information that creates

awareness of an innovation is impersonal (mass media). But personal source, though plays a minor role, plays a good part at least at the adaptation stage. Word of mouth has much greater impact than mass media communication on those who are exposed. According to Cook and Herniter [5], "at the time of next purchase, brand preference is modified by advertisement, word of mouth recommendation and authoritative view points".

2.4 Utility Adjusted Price Ratio

When a new product or technology competes and gradually replaces another, the new product or technology is never an exact equivalent of the old; hence, the unit price of the two are not directly comparable. The alternative technologies do not compete on the basis of price alone, but rather on the basis of maximum utility provided per dollar cost. When a new product appears, its price is considered to be higher, and then gradually deceases up to certain period due to production economics and gradual improvement in production technologies. Then its price rises due to the emergence of competition which dictates for higher technological quality which involves more cost. This paper assumes that price ratio tends to change rather smoothly over time and follows an exponential pattern.

2.5 Price Perceived by the Respondents

Price perception means 'the way people views and interpret price of different kinds'. There is growing evidence that consumers use price as one of the major yardsticks when purchasing goods [14]. This model assumes that the number of respondents who perceive the price of the product to be higher increases smoothly with the increase of price and follows the pattern as depicted in Fig. 4.

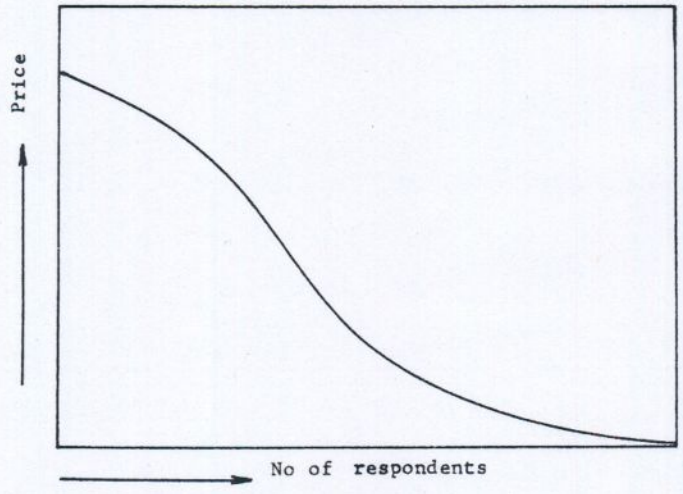


Figure 4. Price Perceived & Price By No. of Respondants

2.6 Attitude Change due to Emotional Motives

An important thing in marketing is to know that consumers have a need to be satisfied, and motives will help explain why they satisfy them and the way they do [16]. Motives can be arbitrarily classified "emotional and economic", It is very difficult to quantify the effect of emotional motive in quantified term. But it can be said that an increase in the emotional motives towards the product may affect the life span of the product. Advertisement plays a very important role in this respect.

2.7 Impact of Economic Motives

Economic motives are primarily concerned with making most effective use of the customers scarce resources and stimulated by limitless wants and needs. In case of technology based product, only an improvement in technological quality results in the performance of the function in an efficient and profitable manner, thereby satisfying the economic motive of the consumers. This may affect the life cycle of the product.

2.8 Attitude Towards Promotion

Promotion ranks with the advertising and selling as one of the most effective and persuasive of all elements of marketing mix [24, 25]. Promotion changes price-value relationship of a product by providing a new and temporary reason for consumers to buy it. This is because that most companies recognize that physical appearance in terms of packaging and display is very important for successful marketing. So it can be assumed that promotional campaign for the prospective customers will induce more people to buy it.

2.9 Impact Due to Technological Motive

While a consumer is purchasing a product he looks for certain technological quality features so that an efficient and reliable service could be obtained. It is considered that an increase in technological motive would have positive effect on the life cycle of the new product.

2.10 Attitude due to Risk Involvement

When a consumer purchases a new product which is unknown to him, there is some risk that the product may not perform in an acceptable manner. There is, moreover, some evidence that a person see (or perceive) greater risk in experimentation with the new brand than other. Pars and Summers [27] stated that the analysis of risk tolerance, subjects were found to be less willing to accept risk when one of the attribute values was unacceptable, so it may be particularly important to eliminate consumers doubt for effective acceptance of the market. Though the new product is technologically superior it will still be associated with some risk in the eye of the consumers as it has not been widely tested.

2.11 Impact of Brand Loyalty

Cunningham [8] who studied summary measures of brand purchase patterns reported by the consumers panel concluded that people exhibit both strong and operative brand loyalty. If the purchase history of an individual is known over some

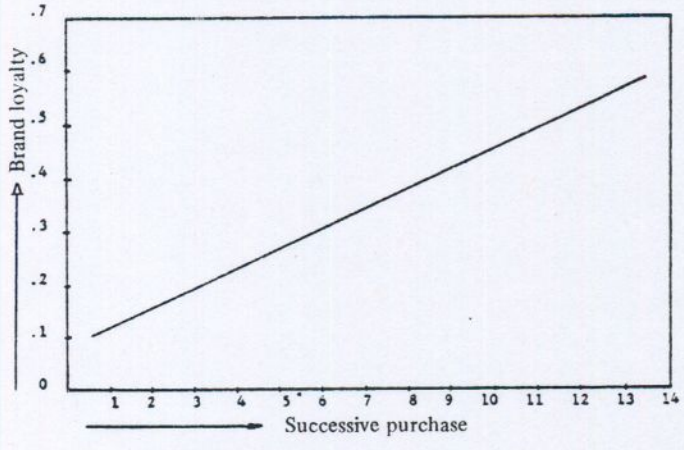


Figure 5. Successive Purchase vs Brand Loyalty

period of time, then the brand loyalty is the average length of run of purchase of the given product. There are several explanations for brand loyalty, that, in effect, imply that learning is the fundamental cause of such loyalty. There are two basic explanations for brand loyalty that rest on 'learning' foundation. The study considers probabilistic linear learning model (Fig. 5). For building this model it was also considered that the consumers are brand loyal to the older product whose amount decreases as the new product gets consumers' acceptance.

III. MATHEMATICAL MODEL FORMULATION

The causal diagram showing the cause-effect relationships among the various factors as discussed which may affect the life cycle is shown in Fig. 6. A mathematical model was formulated which includes all these factors considered. Mansfield [21, 22] who studied the innovation and rate of diffusion of technology stated that the probability of installing an innovation depends on the size of investment necessary for economic production, profitability and stage of perfection in production technology due to time and experience. He has

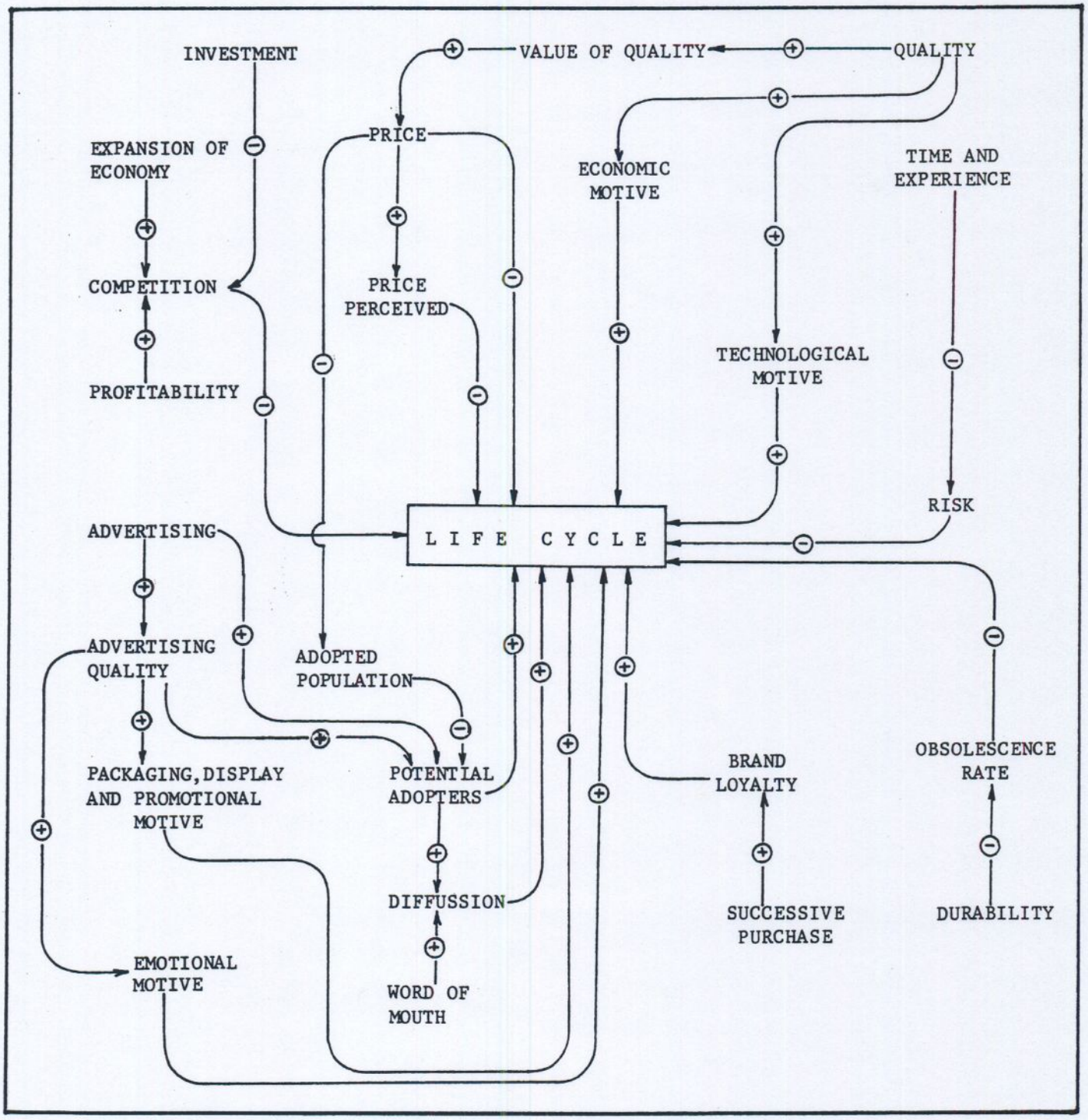


Figure 6. Causal Diagram

established the following relationship.

$$L_1 = a_1 + a_2 \ *P - a_3 \ *I + a_4 \ *T \qquad \text{Eqn. 1}$$

Where

L_1 = A parameter which governs the life cycle

P = Profitability in installing an innovation relative to an alternative investment

I = Investment size

T = Number of years elapsed before an innovation

a_1 = Constant for a given industry

a_2 ,a_3 , a_4 = Constants

The profitability and investment index as defined by Mansfield [21] is

$$P = \frac{\text{Rate of return associated with innovation}}{\text{Minimum rate of return required for investment}} \qquad \text{Eqn. 2}$$

$$I = \frac{\text{Average initial investment}}{\text{Average total asset of the firm}} \qquad \text{Eqn. 3}$$

These relationships are also been adopted by Blackman [3] and Nielsen and Fienh [24].

Mansfield [22] and Nielsen [23] also studied the factors of growth of industrial production (expansion of economy) which has bearings upon the substitution rate of the technology. They theorized that

$$L_2 = a_5 * G \qquad \text{Eqn. 4}$$

where:

L_2 = A parameter which governs the life cycle

G = Annual rate of growth of industrial production

a_5 = constant

The durability and obsolescence factor are very much linked with the factors concerning the adopting population and potential adopters. This model considered the formulation developed by Webber [29] which takes care of the above factors,

$$L_3 = a_6 * D + c^2 K \ (N - K) \ (N - 2K) \qquad \text{Eqn. 5}$$

where

L_3 = A parameter which governs the substitution rate

i.e., life cycle of product

c , a_6 = Constants

D = Obsolescence effect multiplier

K = Adopters of technology

N = Total market size

The useful life of the product and capital equipment are considered as a fraction of its total life and its utility is considered to be 100 and becoming zero at the end of life cycle. Using the sum of years method in calculating the utility depreciation (Fig. 7) and considering that the user of the older product may go for the new product when the old product has 10% of the remaining utility, we get that the older product has a useful life of 29% of the estimated life span. Since adoption follows a normal distribution, it can be said that the age of the distribution of the product and capital equipments are also normally distributed. In case of normal distribution, 99.73% of the total population falls within $\mu + 3\sigma$ limit [17]. From the normal distribution table we get that 10.38 of the older product still has service life of 29% of the total estimated life i.e., 10.38 of the total user of the older product may opt for substitution.

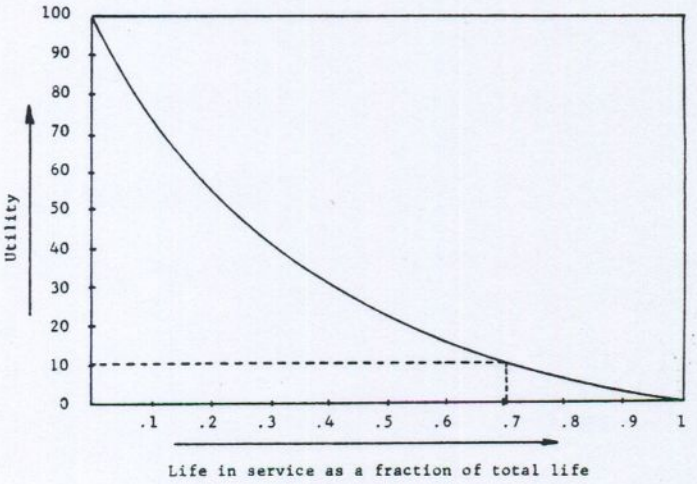


Figure 7. Utility Depreciation Curve

Webber [29] suggested that the diffusion process depends on the number who adopt the innovation (dK) in a period (dt) depends not only the number who already know K, but also the number who have not yet known the product (N - K), where N is the total population.

Then we get,

$$dK = cK \ (N-K) \ dt \qquad \text{Eqn. 6}$$

Integrating the above equation,

$$K = \frac{N \ e^{Nct}}{N-1+e^{Nct}} \quad \text{(if K=1 at t=0)} \qquad \text{Eqn. 7}$$

The second derivative of the Eqn. 6 (i.e., the rate of acceleration of the number of knowers) is,

$$\frac{d^2 K}{dt^2} = c^2 \ f \ (1-f) \ (1-2f) \qquad \text{Eqn. 8}$$

where

f = K/N = Total market share

Based on the above factors we get the product market factors

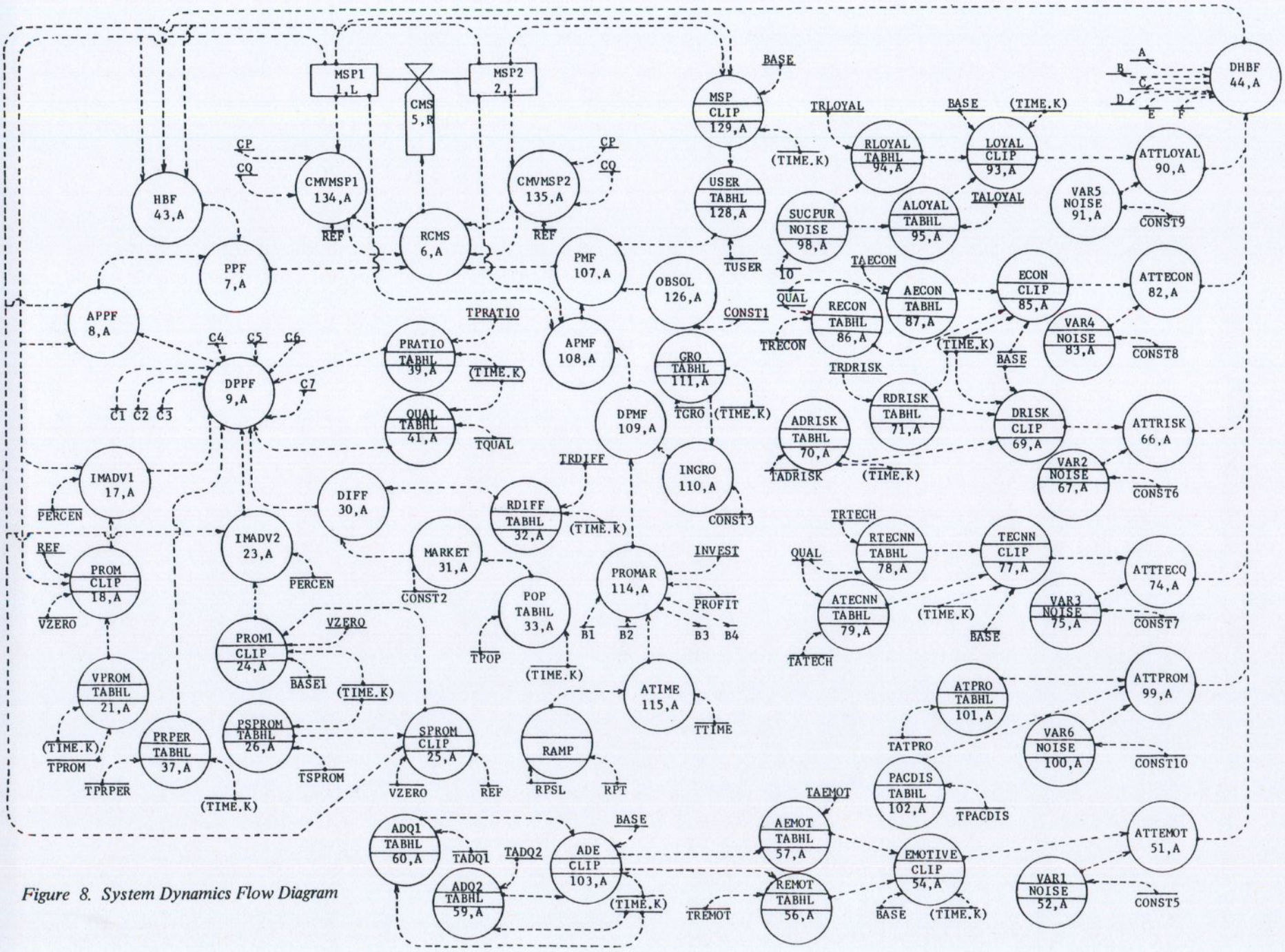


Figure 8. System Dynamics Flow Diagram

as

$$L_4 = L_1 - L_2 + L_3 \qquad \text{Eqn. 9}$$

A simple market share model developed by Dhalla and Yuspeh [9] was considered which took into account a few factors that have impact on the producer of technology, this model puts emphasis on the advertisement of the product in question and also the competing products. After rearranging the formulation we get the market share which may affect the life cycle of the product:

$$L_5 = C_1 + C_2 * IMADV_1 + C_3 * DIFF - C_4 * PRPER - C_5 * PRATIO - C_6 * IMADV_2 + C_7 * QUAL \qquad \text{Eqn.10}$$

where

L_5 = A parameter which governs the life cycle

$IMADV_I$ = Advertising expenditure of the product in question

DIFF = Word of mouth diffusion of technology

PRPER = Price perception (percentage of respondents who regard the product as high priced)

$IMADV_2$ = Advertising expenditure of the competing product

QUAL = Quality ratio

PRATIO = Utility adjusted price ratio

Formulation for utility adjusted price ratio [17]

$$P = \frac{P_a}{P_b} \qquad \text{Eqn. 11}$$

For building this model socio-psychological aspects of consumer behavior were considered. There are so many of these factors which may affect the life cycle and marketing research study of this nature is very complex. But their overall effect may be considered negligible compared to other factors. The model considered that consumer purchasing behavior is stochastic in nature and the help of random number was taken to solve this complexity. In order to analyze the impact of consumer behavior the following expression was considered.

$$L_6 = A*ATTEMOT - B*ATTRISK + C*ATTTECQ + D*ATTECON - E*ATTLOYAL + F*ATTPROM \qquad \text{Eqn.12}$$

where

L_6 = A parameter which governs the life cycle

A, B, C, D, E, F = Unity constants

ATTEMOT = Attitude towards the new product due to emotional motive

ATTRISK = Attitude due to risk involvement in new product

ATTTECQ = Attitude towards the new product due to technological quality

ATTECON = Attitude towards the new product due to economic motive

ATTLOYAL = Attitude towards the old product due to brand loyalty

ATTPROM = Attitude towards the new product due to promotional quality

The producer factors which affect the life cycle is

$$L_7 = L_5 + L_6 \qquad \text{Eqn. 13}$$

Thus the overall mathematical model is

$$L = L_4 * L_7 \qquad \text{Eqn. 14}$$

Where: L = A parameter which governs the life cycle.

A System Dynamics diagram of the above model is given in Fig. 8 and the equations are given in APPENDIX-A.

IV DISCUSSION OF MODEL BEHAVIOR

This study incorporated so many factors those have effect on life cycle. As it was very difficult to get the values of the constants and the table functions, the values were taken from the available studies and universal behavior of the different factors.

The general behavior of the product life cycle was obtained by considering the five factors incorporated into this model is shown in Fig. 9. It was considered in the model that in 1968 another new product which is technologically advanced was introduced in the market which replaces the product introduced in 1947. Fig. 10 shows the change in pattern of the advertising expenditure at different stages of product life cycle which conforms the probable shape as (advertising expenditure as percentage of sales) suggested by Forrester [11]. Fig. 11 shows the impact of percentage of sales as advertising expenditure on the life cycle. A number of runs were given with different values (4, 5, 6 & 8) and observed that the more is the advertising expenditure as percentage of sales among the competing products, the lesser is the life cycle.

The study shows that promotional expenditure at the initial stage of the life cycle has profound effect on PLC as shown in Fig.12. For this model, promotional expenditure was first increased and then decreased until the product captures 30% of the market share. Several runs were given by changing different table values and analysis of the figure reveals that the more the promotional expenditure, the more quickly the new product substitutes the older product and the life span is also increased. From Fig.12 it can be seen that without promotion the new product failed to substitute the older product as the new product could not diffuse into the market without promotion.

Fig.13 shows the impact of diffusion on the life cycle of the product which was considered to follow an exponential pattern. Three alternative runs were given considering different table functions which states that the more the diffusion, the more is the rate of substitution and the more is the life span of the new product.

Three alternative runs were given in order to evaluate the impact of utility adjusted price ratio on the life cycle. It was considered in the model that the utility adjusted price ratio would first increase due to sophistication of production technology and production economics and then decrease

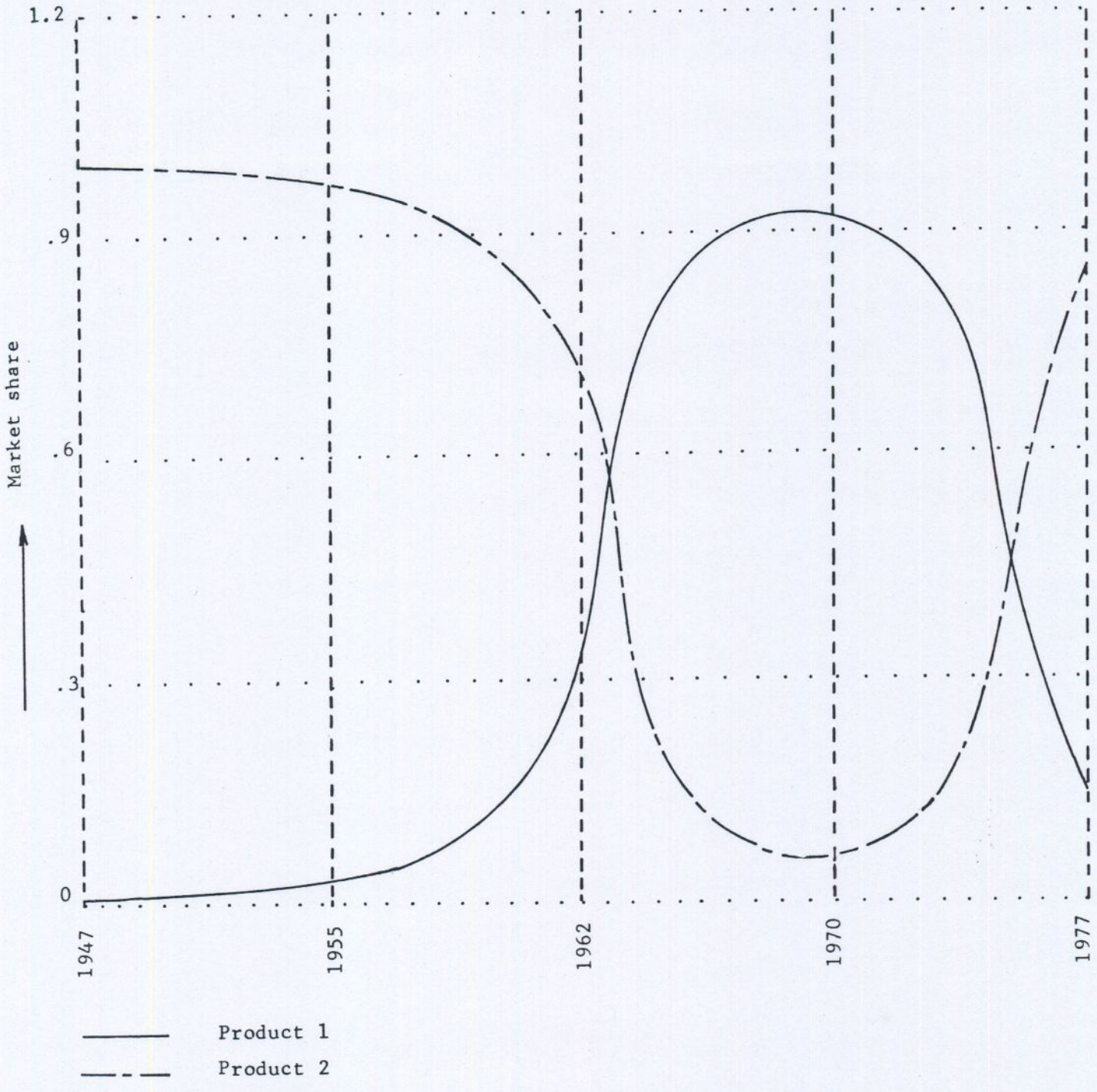


Figure 9. Life Cycle of Product One and Two

following an exponential pattern. It can be seen from the Fig.14 that the utility adjusted price ratio has substantial effect on life cycle.

In order to evaluate the price perception by the consumer, two runs were given. The analysis of the Fig.15 indicates that the lesser the price perception by the consumers the more is the life span of the product.

Fig.16 shows how the product quality is affecting the life cycle. For the basic run it was considered that quality ratio increases at the beginning and then decreases subsequently. Two alternative runs were given considering quality ratio to be one and increasing exponentially. Though the study reveals that quality has lesser impact on the life cycle, it is considered as one of the decisive factors for market penetration.

For the basic run, the market growth was considered to follow a business cycle (changes over time and season). Two alternative runs were given considering no growth and exponential growth (3.3% per year). The study shows that market growth rate has very little impact on the life cycle as shown in Fig.17.

In order to study the behavior of the life cycle under different profitability index four runs were given (P= .41, .51, 1 and

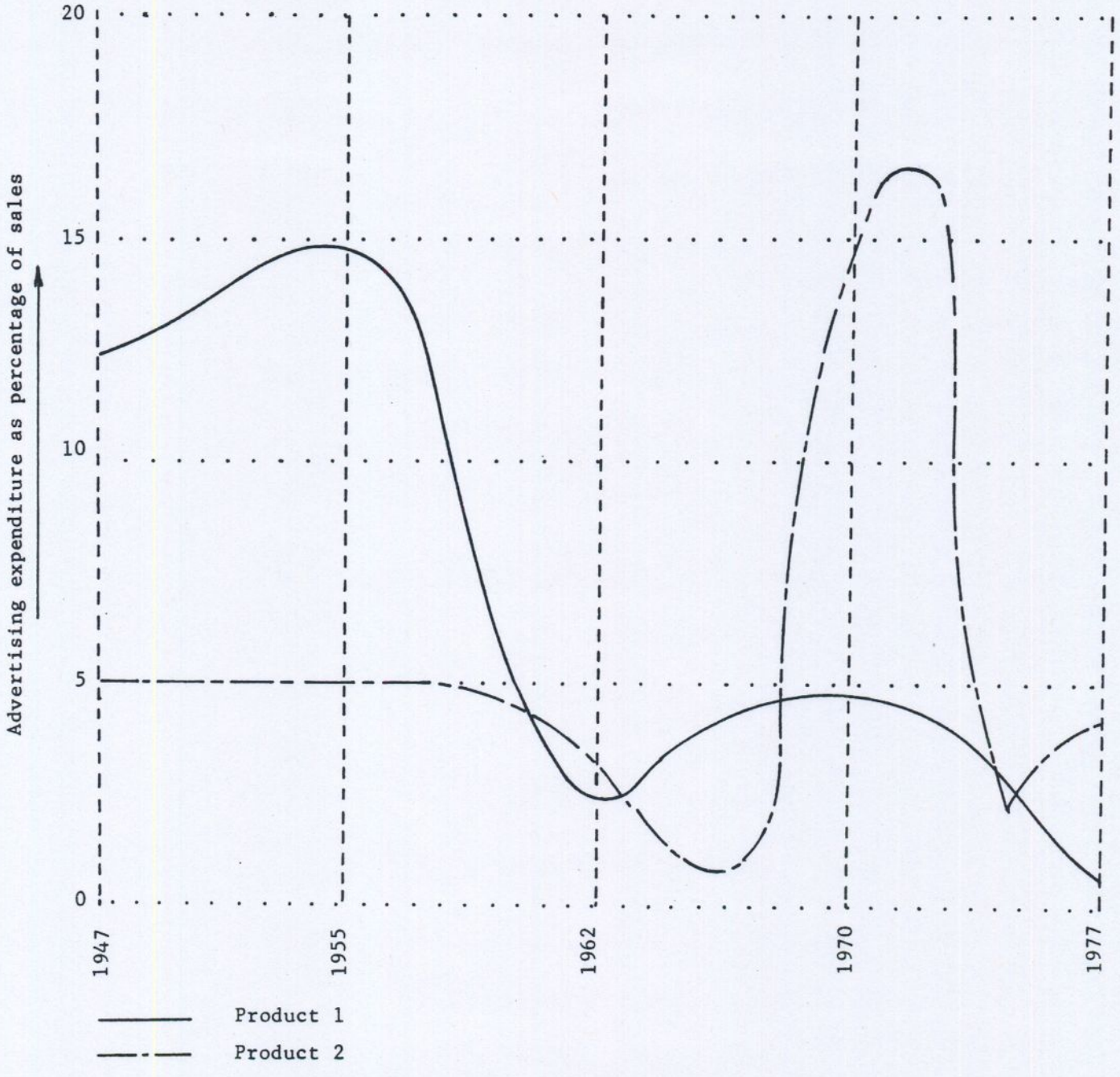


Figure 10. Advertising Expenditure of Product One and Two

2.5) as shown in Fig.18. Evaluation of the figure indicates that the more profitable the investment is, the lesser is the life span of the product. The figure also indicates that if the investment is unprofitable, fewer firms are interested to enter into the market and this eventually increases the life span of the existing product.

Three alternative runs were given for investment size to be .005, 1 and 1.5 considering profitability on investment to be constant. Analysis of the Fig.19 shows that the product life cycle is directly related with the size of investment.

From Fig.20 the effect of time and experience on life cycle, for which two alternative runs were given considering time and experience to be zero and 7 years. It can be seen that though it has a very negligible effect, more time and experience about the market elongates the life span to some extent.

Six other factors which were included in the consumer behavioural factors were considered for sensitivity analysis. It was mentioned earlier that most of these factors have very negligible effect on PLC than the other factors considered. But it is generally agreed that brand loyalty plays a very important part in the case of the technology-based product among all the behavioural factors [14, 16].

V MODEL APPLICATION

Life cycle of the filter and non-filter cigarette was considered in order to study the validity of the model [26]. The model considered that there were 100 millions of people over 20 years of age and advertising index to be one and on that basis advertising expenditure of both the forms of cigarette were

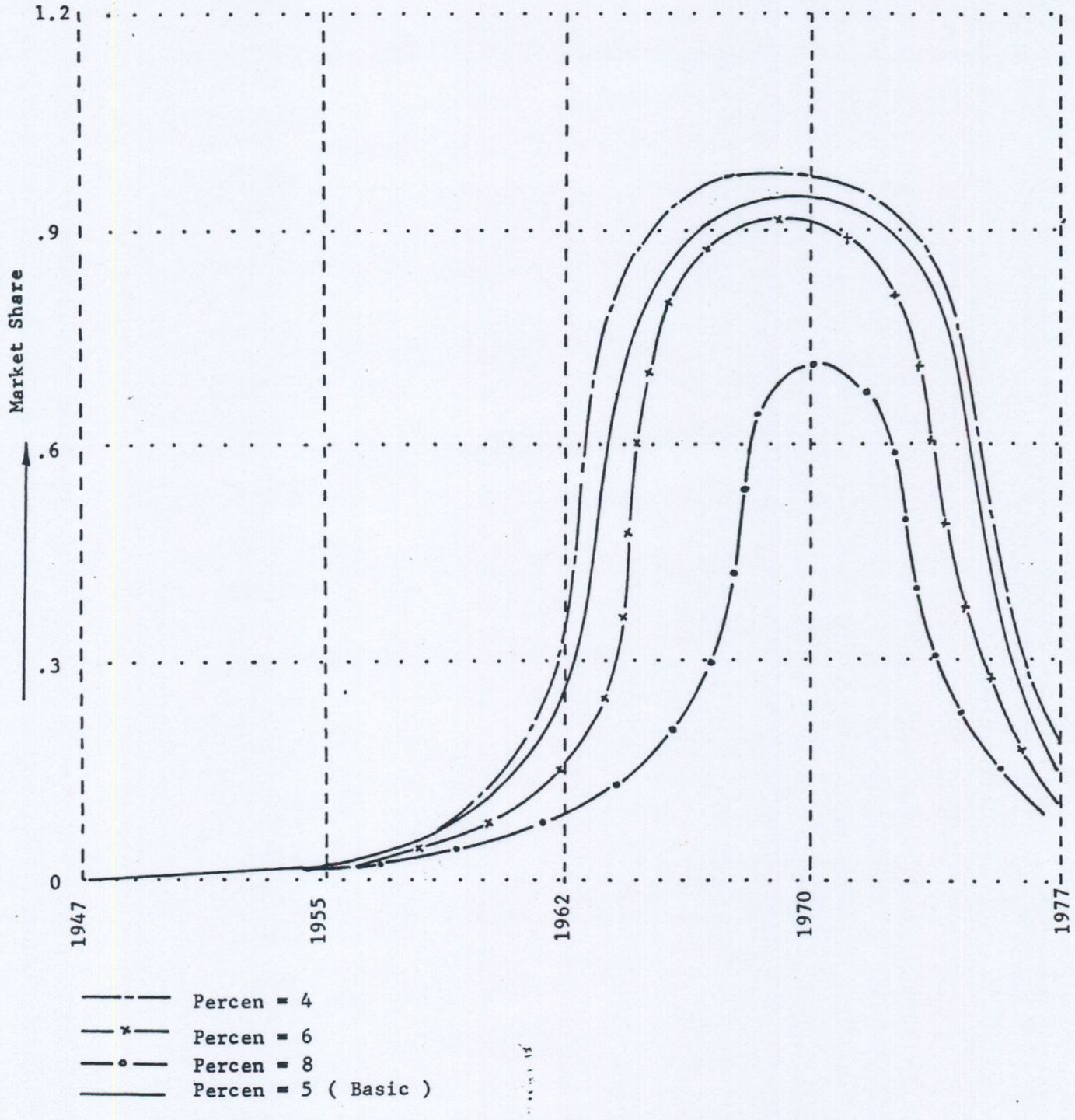


Figure 11. Impact of PERCEN (percentage of sales as advertising expenditure) on Life Cycle of Product One

calculated. As it was very difficult to get the actual values of the constants and the table functions, only the values of the table function of price perception and utility adjusted price ratio were changed. The model considered that there are equal number of filter and non-filter smokers so the price perception was changed from 0-50 with the corresponding change in price ratio from 100-125. The result obtained as per the model is shown in the Fig.21 and was compared with the historical data. Theoretical values were also calculated considering exponential growth and the three sets of values are shown in Table 1.

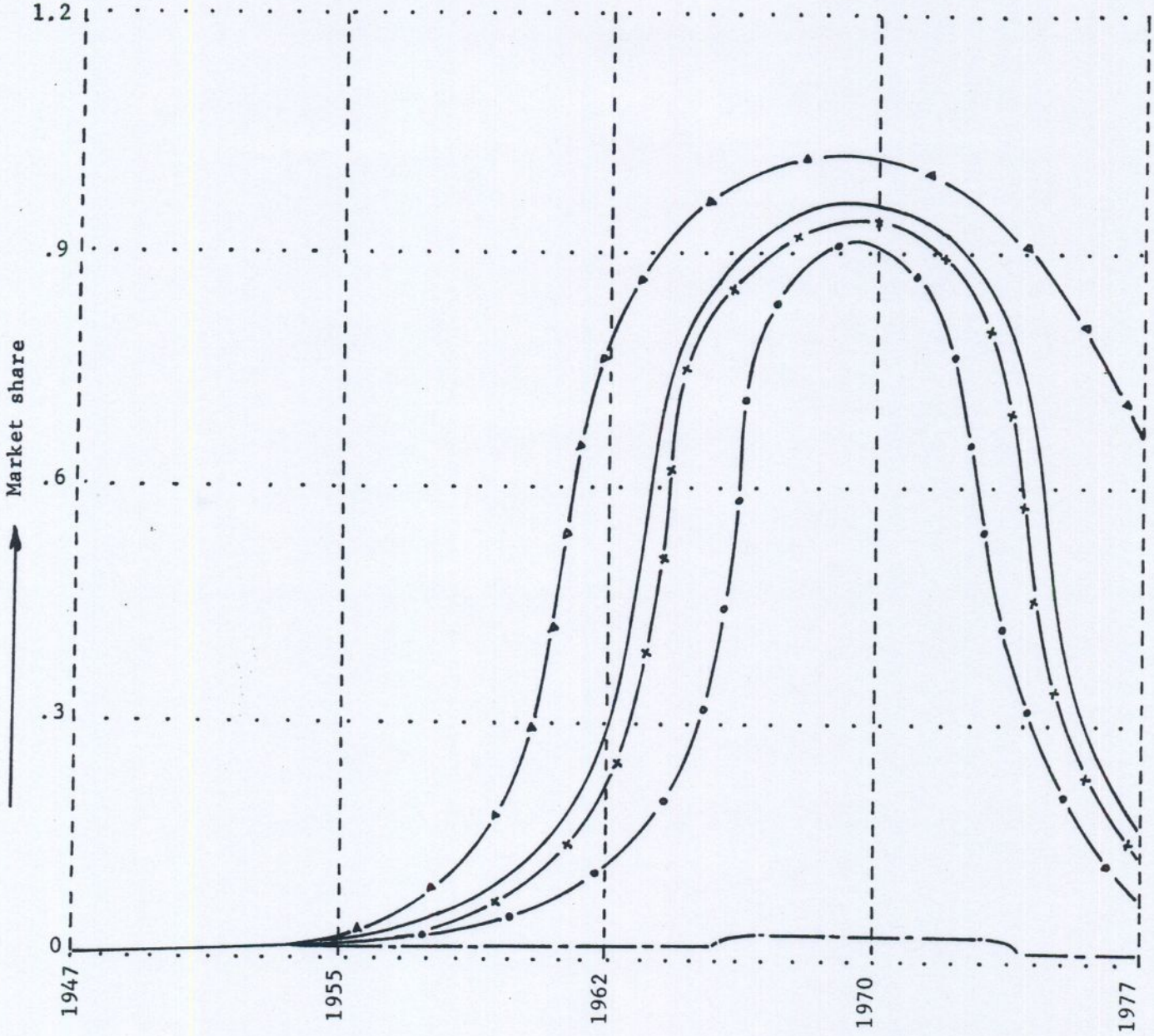


Figure 12. Impact of Promotional Expenditure of Product One (TPROM) on Life Cycle of Product One

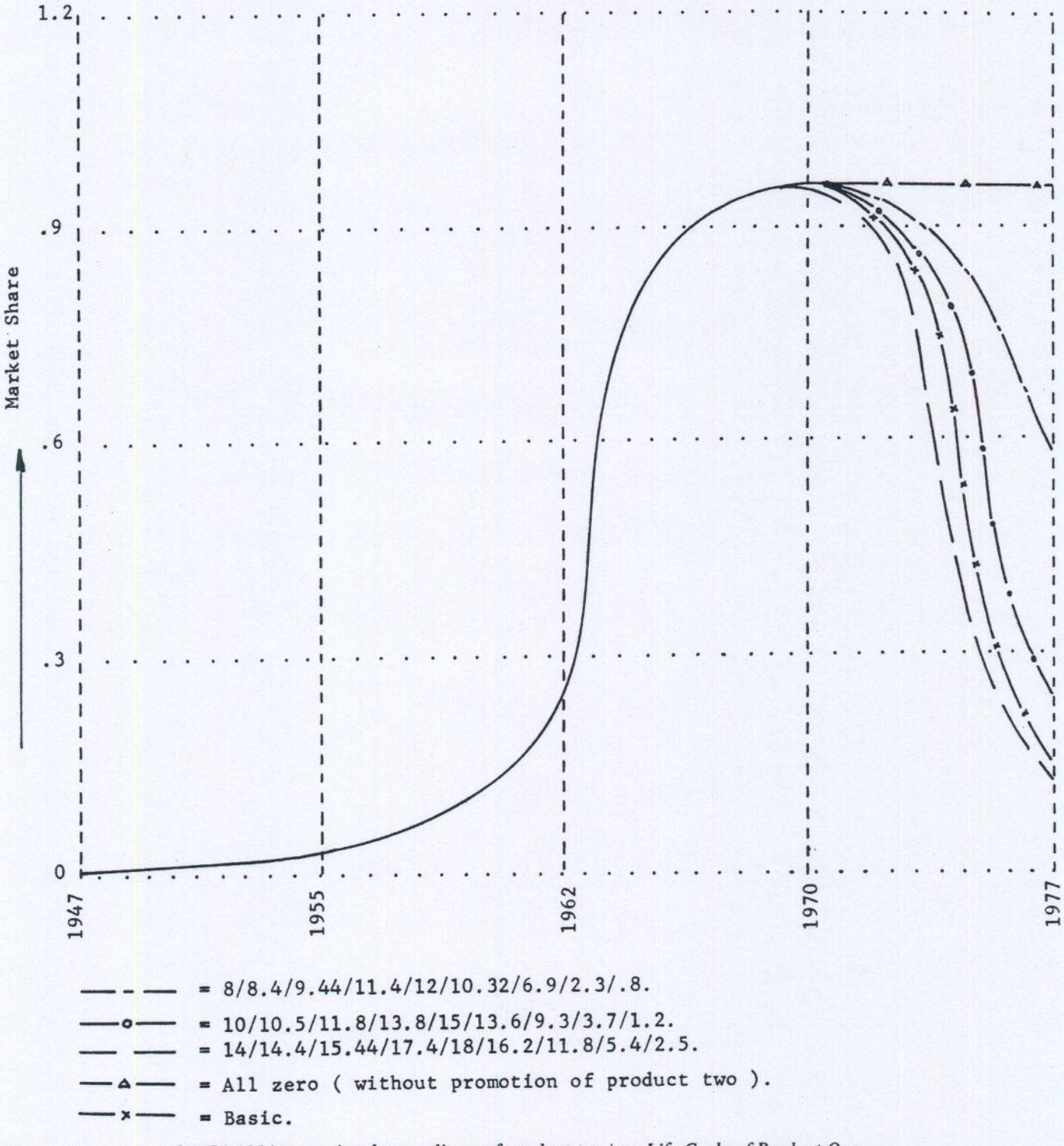


Figure 12. Impact of TSPROM (promotional expenditure of product two) on Life Cycle of Product One

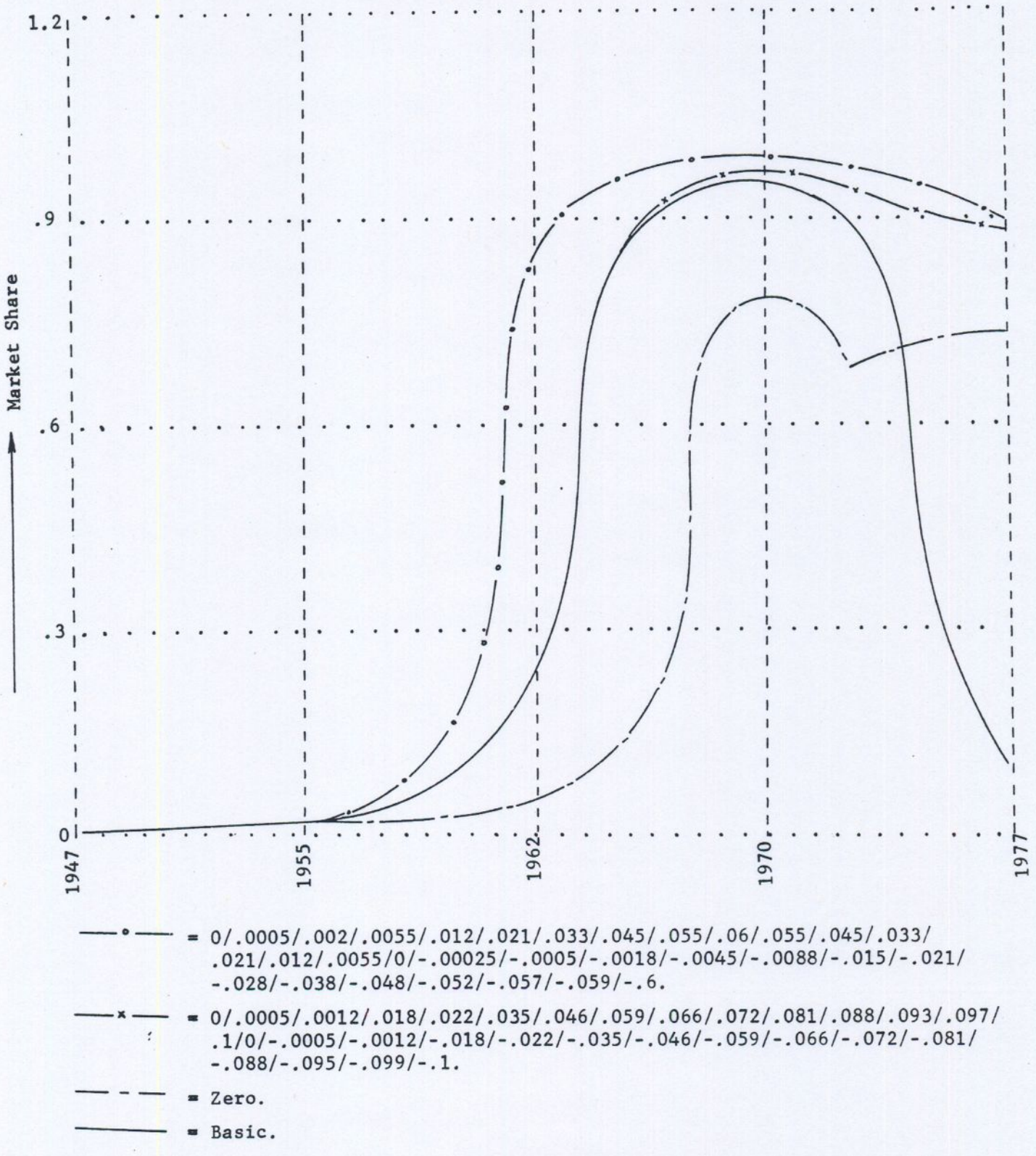
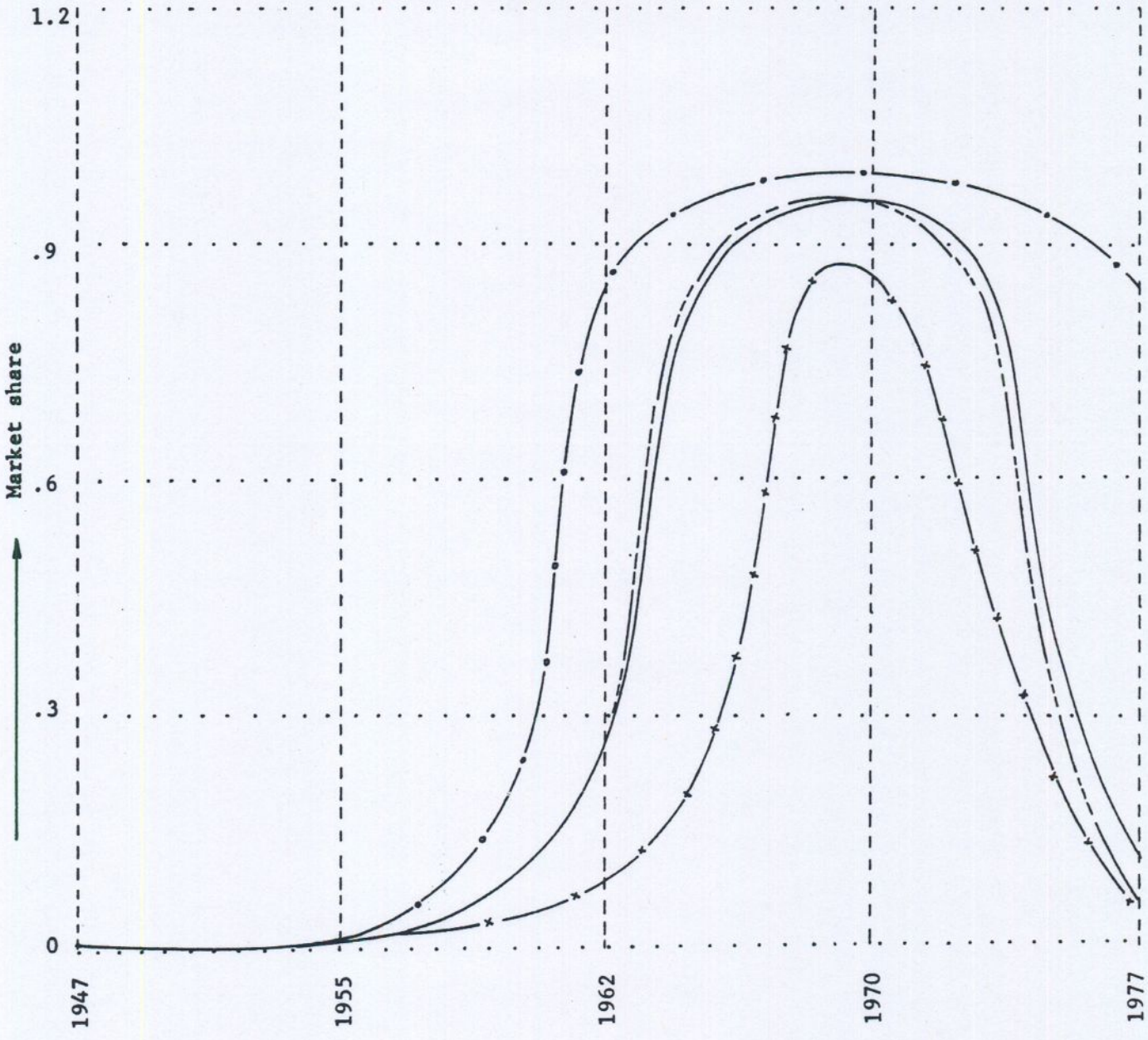


Figure 13. Impact of RDIFF (diffussion of technology) on Life Cycle of Product One



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—---— = 110/110.75/111.5/113/114.5/116/118/120/121.25/123.5/124/124.75/125/124/123/120.5/117/115.2/112.4/109.5/106.8/103.5/102/101.2/100.5/99.6/99.2/98.8/98.4/98.1/98.

——— = Basic.

Figure 14. Impact of PRATIO (Utility adjusted price ratio) on Life Cycle of Product One

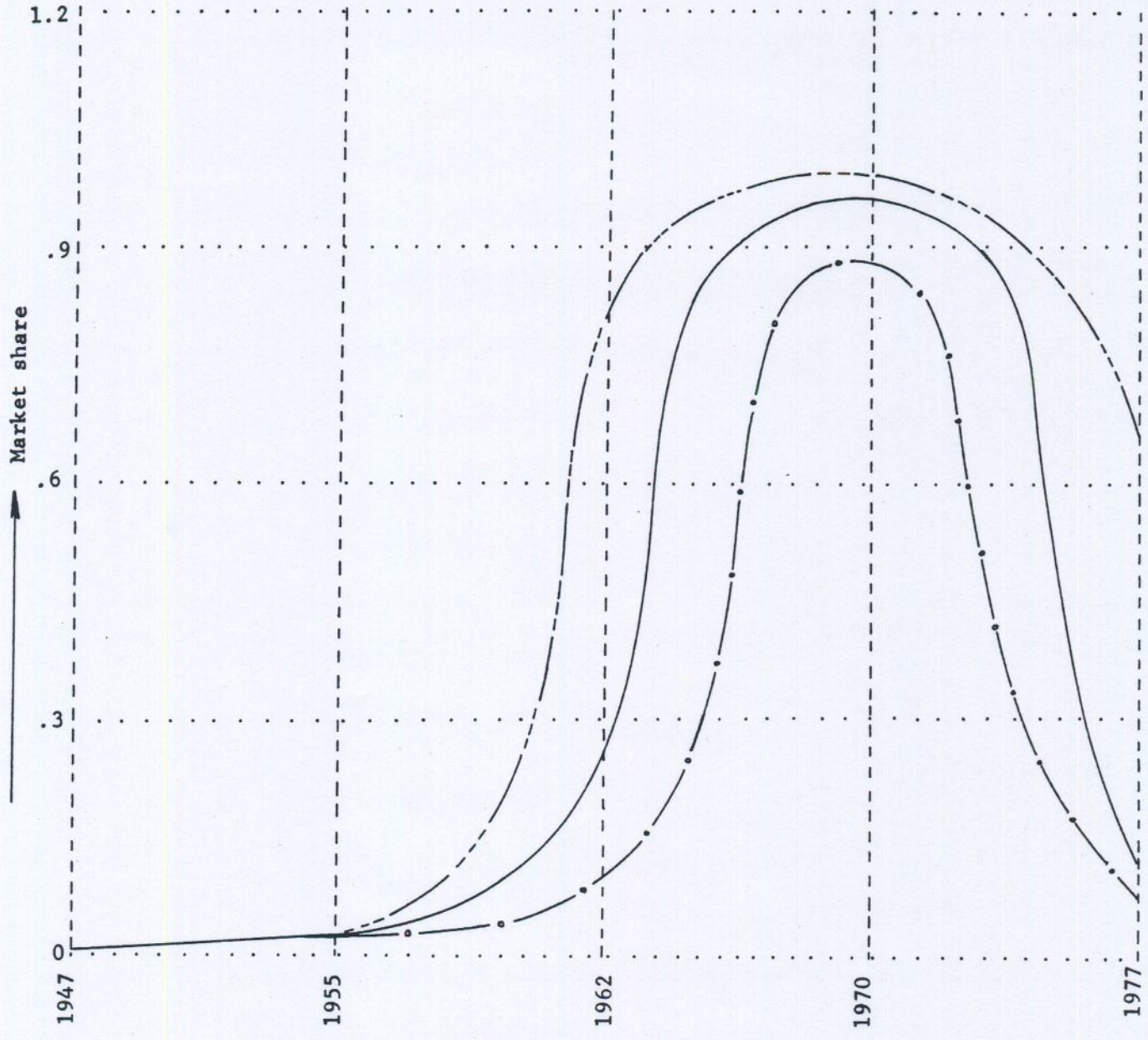

Figure 15. Impact of PRPER (Price perception by consumer) on Life Cycle of Product One

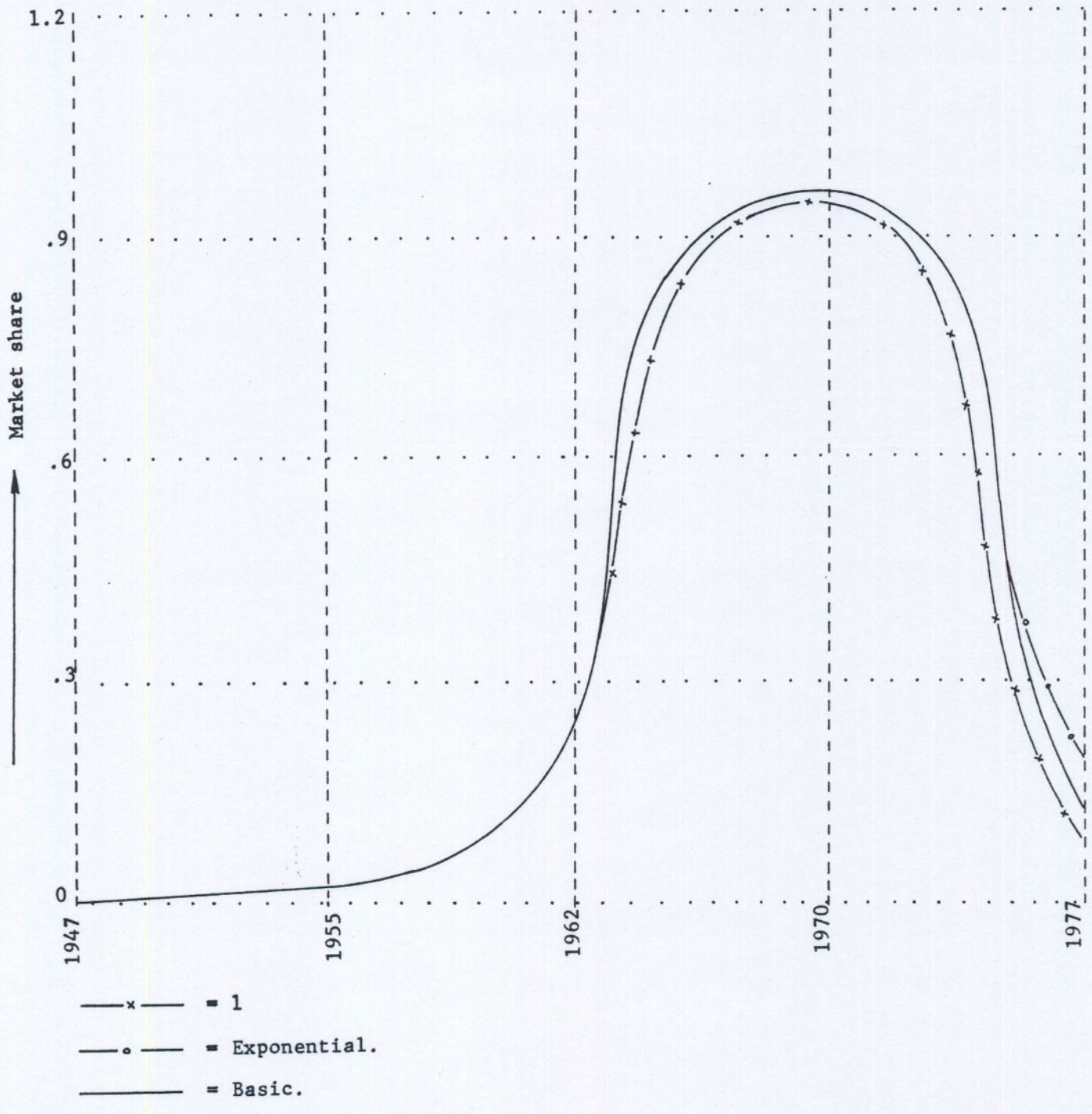

Figure 16. Impact of QUAL (Quality ratio) on Life Cycle of Product One

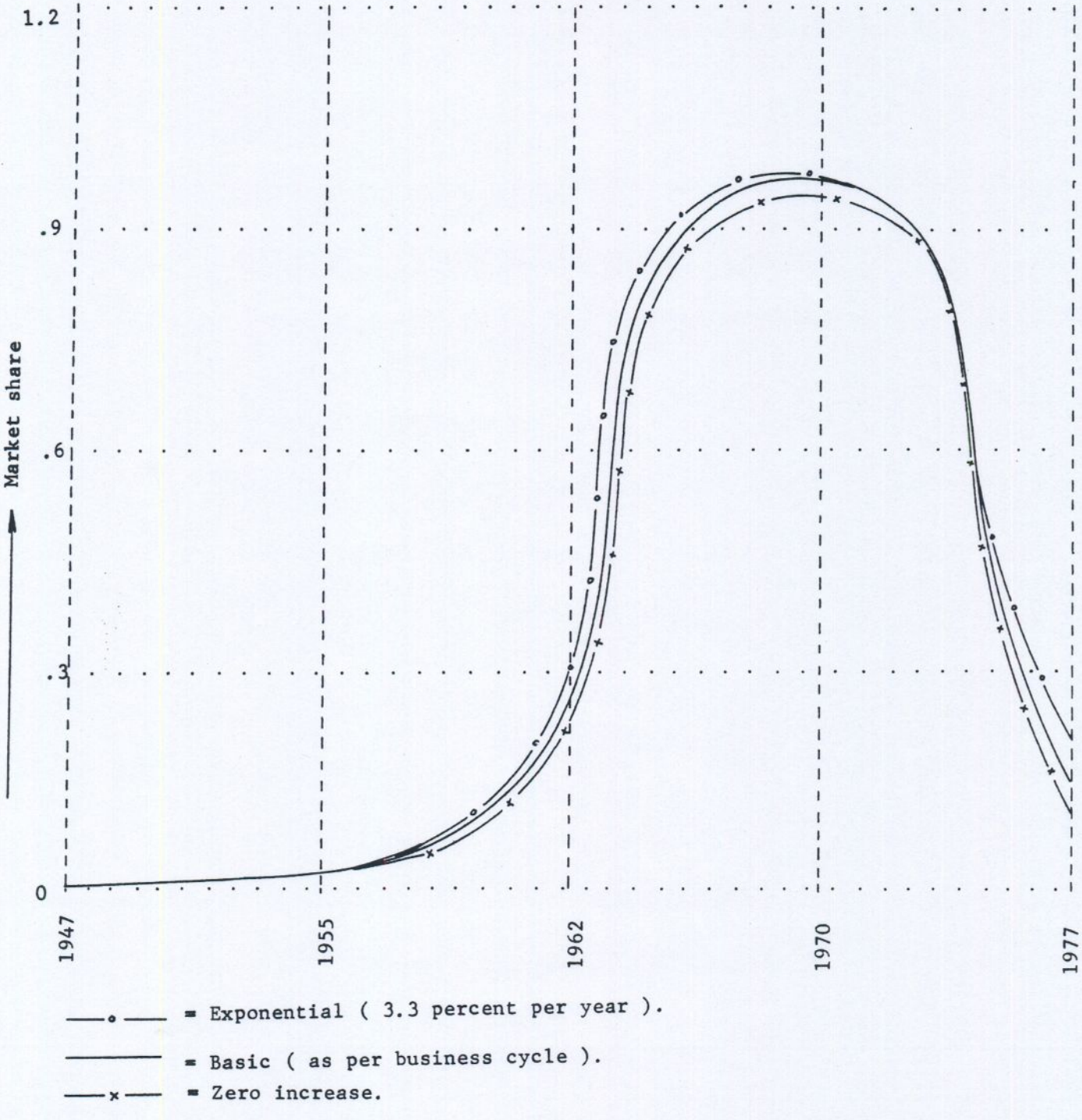

Figure 17. Impact of GRO (industry growth rate) on Life Cycle of Product One

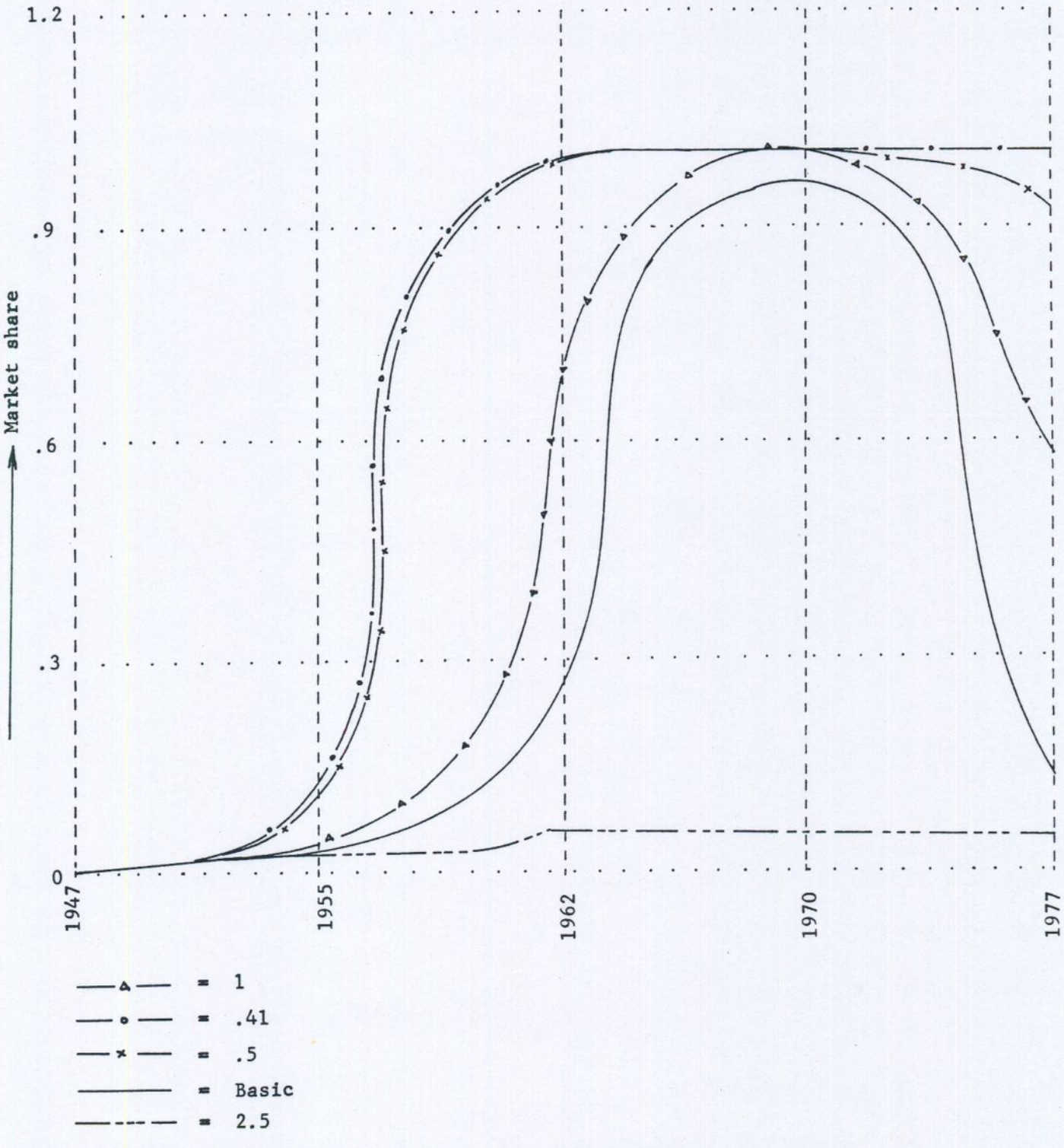

Figure 18. Impact of PROFIT (Profitability index) on Life Cycle of Product One

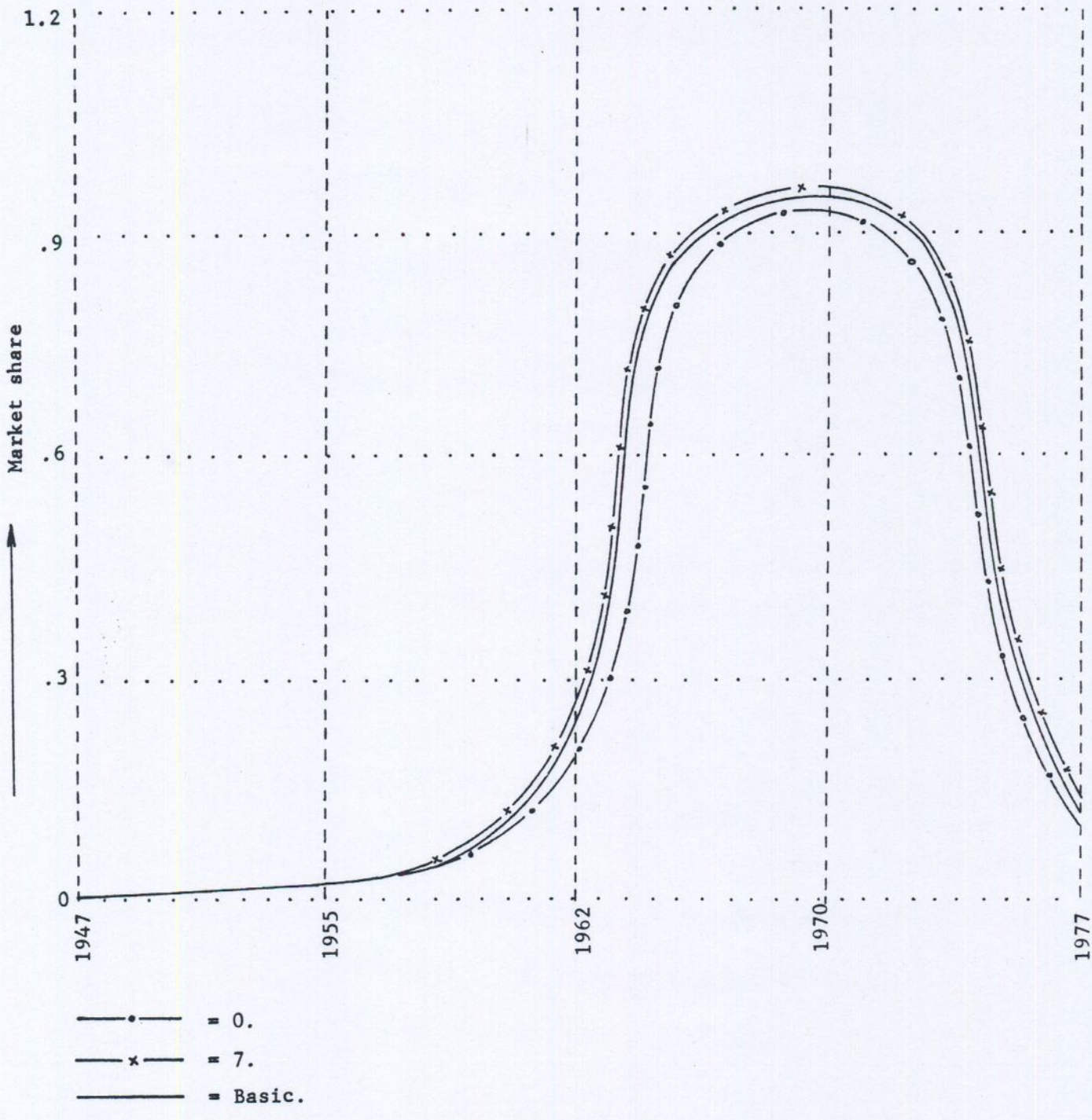

Figure 19. Impact of TTIME (Time to capture .0075 of the Market Share) on Life Cycle of Product One

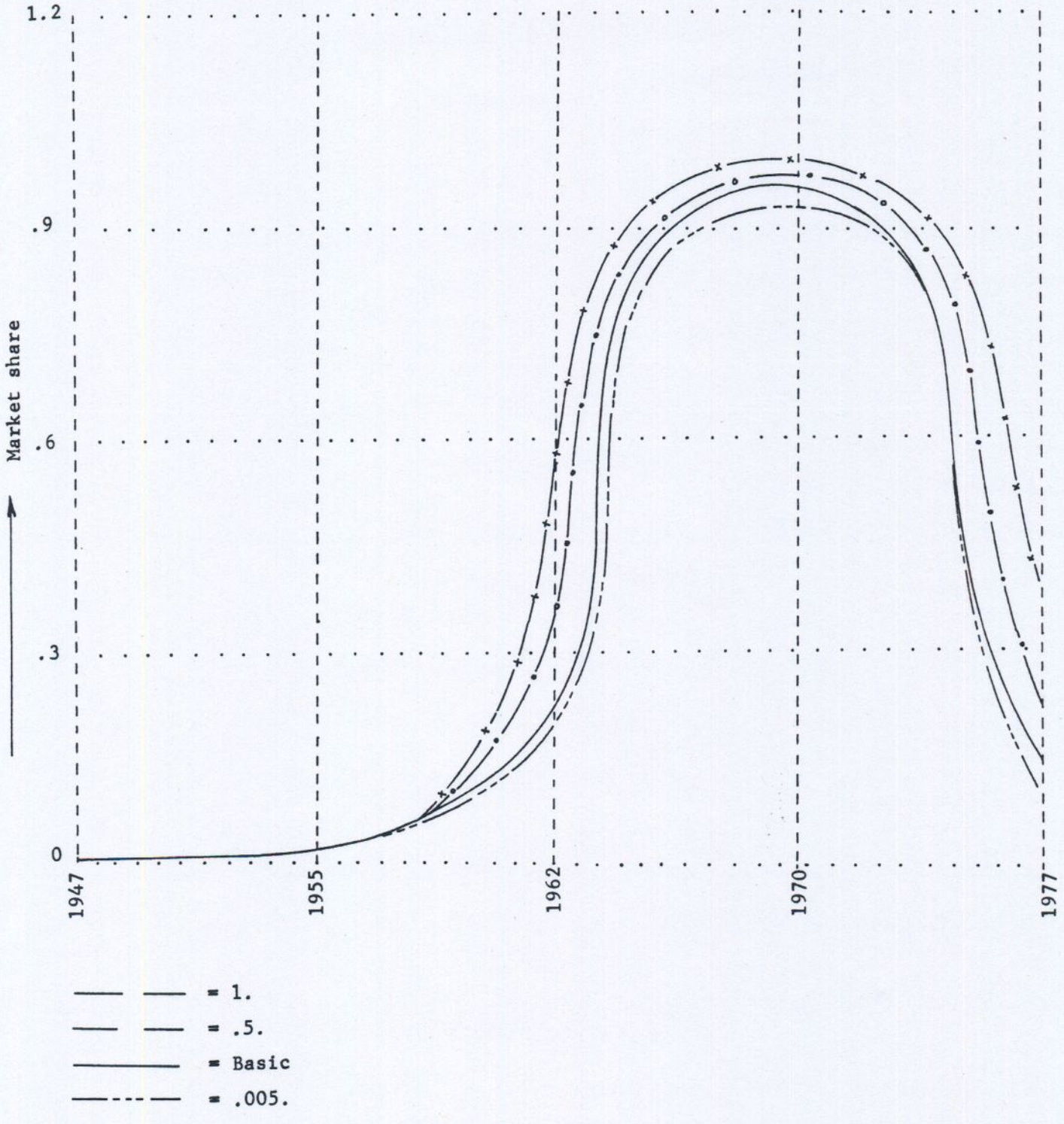

Figure 20. Impact of INVEST (size of investment) on LIfe Cycle of Product One

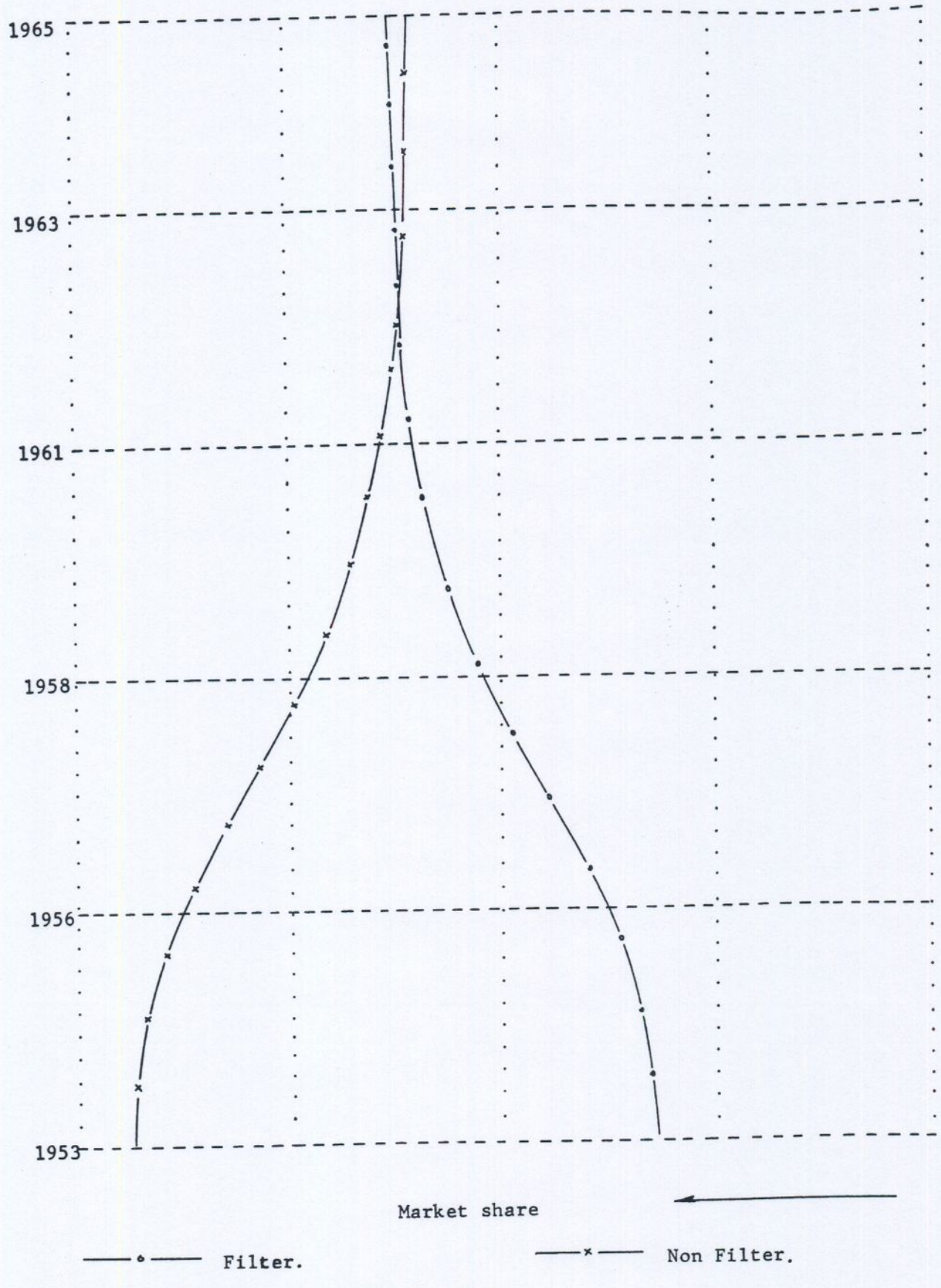

Figure 21. Change of Market Share of Filter and Non Filter Cigarette

Table: 1 Table for comparison of results

Market share of filter cigarette			
Year	Actual	System Dynamics	Calculated (exponential)
1953	0.2488	0.2488	0.3200
1954	0.3050	0.25509	0.3356
1955	0.3858	0.28107	0.3511
1956	0.4037	0.32623	0.3674
1957	0.4452	0.36963	0.3845
1958	0.4514	0.41315	0.4023
1959	0.4650	0.45285	0.4210
1960	0.4613	0.47028	0.4404
1961	0.4650	0.48371	0.4608
1962	0.4712	0.49406	0.4822
1963	0.4937	0.49938	0.5045
1964	0.4937	0.50413	0.5279
1965	0.5000	0.50451	0.5524

VI CONCLUSION

It has been found from the study that promotional expenditure at the introductory stage of product and profitability has profound impact on the life cycle. Promotional expenditure is very important as it diffuses the product information into the market which eventually leads to a trial purchase by the prospective customer. Profitability has a reverse effect as the more profitable the investment is, the more the number of firms will be interested to enter in the market, thus will effect the life span of the product. Other factors like investment size, advertising expenditure, diffusion, price ratio, price perception have substantial effect and factors like industry growth rate (expansion of economy), quality, time and experience have very little impact on life cycle. The study considered that impact of consumer behavioural factors on life cycle to be very negligible compared to other factors. After identification of the factors which exert substantial effect on life cycle, different parameters in connection with these factors were varied in order to assess their effect on life cycle.

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APPENDIX–A

SYSTEM DYNAMICS EQUATIONS

```
*   THE PRODUCT LIFE CYCLE AND ADVERTISEMENT
*   MARKET SHARE OF PRODUCT ONE AND TWO
L   MSP1.K=MSP1.J+DT*CMS.JK                          1,L
N   MSP1=0.0075                                      2,N
L   MSP2.K=MSP1.J–DT*CMS.JK                          3,L
N   MSP2=0.9925                                      4,N
*   MSP = MARKET SHARE OF PRODUCT
*   CMS = CHANGE OF MARKET SHARE
*
*   RATE OF CHANGE OF MARKET SHARE
R   CMS.KL=RCMS.K                                    5,R
A   RCMS.K=PMF.K*PPF.K*CMVMSP1.K*CMVMSP2.K           6,R
*   RCMS = RATE OF CHANGE OF MARKET SHARE
*   PMF = MARKET FACTORS
*   PPF = PRODUCER FACTORS
```

```
*     CMVMSP = CONTROL MINIMUM VALUES OF PRODUCTS
*
*     PRODUCER FACTORS
A     PPF.K=APPF.K+HBF.K                                                    7,A
*     APPF = PARAMETER WHICH DETERMINES RCMS
*     HBF = CONSUMER BEHAVIORAL FACTORS
*
*     FACTORS DIRECTLY CONCERN TO PRODUCER
A     APPF.K=DPPF.K*MSP1.K*MSP2.K                                           8,A
*     DPPF = PARAMETER WHICH DETERMINES APPF
A     DPPF.K=C1+C2*IMADV1.K+C3*DIFF.K-C4*PRPER.K-C5*PRATIO.K
X     -C6*IMADV2.K+C7*QUAL.K                                                9,A
*     IMADV = ADVERTISING EXPENDITURE
*     DIFF = DIFFUSSION OF PRODUCT
*     PRPER = PRICE PERCEPTION BY THE CONSUMER
*     PRATIO = UTILITY ADJUSTED PRICE RATIO
*     QUAL = QUALITY RATIO OF PRODUCTS
C     C1=132.19                                                             10,C
C     C2=0.8                                                                11,C
C     C3=1.14                                                               12,C
C     C4=0.4532                                                             13,C
C     C5=0.94                                                               14,C
C     C6=0.90                                                               15,C
C     C7=1                                                                  16,C
A     IMADV1.K=PERCEN*MSP1.K+PROM.K                                         17,A
*     PERCEN = ADVERTISING EXPENDITURE AS PERCENTAGE OF SALES
*     PROM = PROMOTIONAL EXPENDITURE
A     PROM.K=CLIP (VZERO,VPROM.K,MSP1.K,REF)                                18,A
*     VPROM = DETERMINES PROM
*     REF = % OF MARKET SHARE UPTO WHICH EXTRA PROMOTION IS DONE
C     VZERO=0.0                                                             19,A
C     REF=0.30                                                              20,A
A     VPROM.K=TABHL (TPROM,TIME.K,1947,1962,1)                              21,A
T     TPROM=12/12.2/12.4/12.8/13.4/13.9/14.5/15/14.5/13.4/
X     10.8/7.2/4.5/3.2/1.5/0.05                                             22,T
A     IMADV2.K=PERCEN*MSP2.K+PROM1.K                                        23,A
A     PROM1.K=CLIP (SPROM.K, VZERO,MSP2.K,BASE1)                            24,A
*     SPROM = DETERMINES PROM1
*     BASE1 = TIME AT WHICH A NEW PRODUCT BY A FIRM IS LAUNCHED
A     SPROM.K=CLIP (VZERO, PSPROM.K,MSP2.K,REF)                             25,A
A     PSPROM.K=TABHL (TSPROM, TIME.K,1967,1975,1)                           26,A
*     PSPROM = DETERMINES SPROM
T     TSPROM=12/12.5/13.8/15.8/17/15.6/9.8/4.7/1.5                          27,T
C     PERCEN=5                                                              28,C
C     BASE1=1968                                                            29,C
A     DIFF.K=MARKET.K*RDIFF.K                                               30,A
A     MARKET.K=POP.K*CONST2                                                 31,A
```

```
*    MARKET =GROWTH OF MARKET
*    RDIFF = DETERMINES DIFF
*    POP =TOTAL POPULATION
A    RDIFF.K=TABHL (TRDIFF.K,TIME.K,1947,1977,1)                          32,A
A    POP.K=TABHL (TPOP,TIME.K,1947,1977,1)                                33,A
T    TRDIFF=0/.0005/.002/.0055/.012/.021/.033/.045/.055/
X    .06/.055/.045/.033/.021/.012/.005/0/-.0005/-.0012/
X    -.018/-.022/-.035/-.046/-.059/-.066/-.072/-.081/-.088
X    -.095/-.099/-.1                                                      34,T
T    TPOP=1/1.0037/1.01/1.0175/1.025/1.0325/1.0375/1.045/
X    1.0525/1.06375/1.065/1.0725/1.0775/1.085/1.0925/1.1/
X    1.1062/1.1137/1.1175/1.12625/1.1325/1.14/1.1475/1.1525/
X    1.16/1.1675/1.1725/1.18/1.1875/1.195/1.2                             35,T
C    CONST2=100                                                           36,C
A    PRPER.K=TABHL (TPRPER,TIME.K,1947,1977,1)                            37,A
T    TPRPER=30/27.5/26.5/24.5/22.5/20/17/13.5/11/8.5/5.75/
X    3.75/1.5/0/1.5/9/14.5/21/28/35/44/55/64/70/76/81/86/
X    90/94/97.5/100                                                       38,T
A    PRATIO.K=TABHL (TPRATIO,TIME.K,1947,1977,1)                          39,A
T    TPRPER=105/106.5/108/109.5/111.75/114/116.5/118.75/
X    121.25/123.5/125.5/127.5/128.5/130/127.5/124.75/121/
X    116.25/112/108/104/100/99.6/99.4/98.8/98.1/97.2/96.1/
X    94.9/93.3/90                                                         40,T
A    QUAL.K=TABHL (TQUAL,TIME.K,1947,1977,1)                              41A
T    TQUAL=1.0/1.04/1.07/1.11/1.14/1.18/1.21/1.26/1.3/1.33/
X    1.36/1.39/1.4/1.39/1.37/1.34/1.3/1.25/1.21/1.16/1.11/
X    1.00/.99/.93/.86/.78/.7/.62/.54/.44/.4                               42,T
*
*    CONSUMER BEHAVIOURAL FACTORS
A    HBF.K=DHBF.K*MSP1.K*MSP2.K                                           43,A
A    DHBF.K=A*ATTEMOT.K-B*ATTRISK.K+C*ATTTECQ.K+D*ATTECON.K
X    -E*ATTLOYAL.K+F*ATTPROM.K                                            44,A
*    DHBF = DETERMINES HBF
*    ATTEMOT = ATTITUDE CHANGE DUE TO EMOTIONAL MOTIVE
*    ATTRISK = ATTITUDE DUE TO RISK INVOLVE
*    ATTTECQ = IMPACT OF TECHNOLOGICAL MOTIVE
*    ATTECON = IMPACT OF ECONOMIC MOTIVE
*    ATTLOYAL = IMPACT OF BRAND LOYALTY
*    ATTPROM = ATTITUDE TOWARDS PROMOTION
C    A=1                                                                  45,C
C    B=1                                                                  46,C
C    C=1                                                                  47,C
C    D=1                                                                  48,C
C    E=1                                                                  49,C
C    F=1                                                                  50,C
A    ATTEMOT.K=VAR1.K*EMOTIVE.K                                           51,A
*    VAR1 = FRACTION OF CONSUMERS ACTUALLY MOVE FOR THE NEW PRODUCT DUE TO
```

```
                EMOTIONAL MOTIVE
*       EMOTIVE = FRACTION OF CONSUMERS INFLUENCED TO POSTPONE THE PURCHASE OF
                  OLD PRODUCT DUE TO EMOTIONAL MOTIVE
A       VAR.1K=CONST5*(.5+NOISE())                                          52,A
C       CONST5=.005                                                         53,C
A       EMOTIVE.K=CLIP(REMOTIVE.K,AEMOTIVE.K,TIME.K,BASE)                   54,A
C       BASE=1967                                                           55,C
A       REMOTIVE.K=TABHL(TREMOT,EADQ.K,0,1.5,.15)                           56,A
A       AEMOTIVE.K=TABHL(TAEMOT,EADQ.K,0,1.5,.15)                           57,A
A       EADQ.K=CLIP(ADQ2.K,ADQ1.K,TIME.K,BASE)                              58,A
A       ADQ2.K=TABHL(TADQ2,TIME.K,1967,1977,1)                              59,A
A       ADQ1.K=TABHL(TADQ1,TIME.K,1947,1967,1)                              60,A
*       EADQ = ADVERTISING QUALITY
*       ADQ = ADVERTISING QUALITY
T       TADQ1=1.059/1.0625/1.0716/1.082/1.09435/1.1264/1.1432/
X       1.1698/1.1845/1.204/1.2184/1.3984/1.4563/1.4954/
X       1.3945/1.2102/1.041/.99/.97/.95/.9                                  61,T
T       TADQ2=1.059/1.0716/1.09435/1.1432/1.1845/1.2148/
X       1.4563/1.4954/1.2102/1.041/1.0                                      62,T
T       TAEMOT=0/.02/.046/.07/.09/.12/.146/.168/.1972/.225/.25              63,T
T       TREMOT=0/-.02/-.046/-.07/-.09/-.12/-.146/-.168/-.197/
X       -.225/-.25                                                          64,T
A       ATTRISK.K=VAR2.K*DRISK.K                                            65,A
*       VAR2 = FRACTION OF CONSUMER ACTUALLY SENSITIVE TOWARDS RISK
*       DRISK =FRACTION OF CONSUMER INFLUENCED TO POSTPONE THE PURCHASE DUE TO
                  RISK INVOLVE IN NEW PRODUCT
A       VAR2.K=CONST6*(.5+NOISE())                                          66,A
C       CONST6=.125                                                         67,C
A       DRISK.K=CLIP(RDRISK.K,ADRISK.K,TIME.K,BASE)                         68,A
A       ADRISK.K=TABHL(TADRISK,TIME.K,1947,1967,1)                          69,A
A       RDRISK.K=TABHL(TRDRISK,TIME.K,1967,1977,1)                          70,A
T       TADRISK=.5/.45/.39/.34/.27/.24/.19/.14/.09/0/0/0/0/0/
X       0/0/0/0/0/0                                                         71,T
T       TRDRISK=0/.04/.09/.14/.19/.24/.27/.34/.45/.5                        72,T
A       ATTTECQ.K=VAR3.K*TECNN.K                                            73,A
A       VAR3.K=CONST7*(.5+NOISE())                                          74,A
*       VAR3 = FRACTION OF CONSUMER ACTUALLY PURCHASE NEW PRODUCT DUE TO
                  TECHNOLOGICAL QUALITY
*       TECNN = FRACTION OF CONSUMER INFLUENCED TO POSTPONE THE PURCHASE DUE TO
                  TECHNOLOGICAL SUPERIORITY OF NEW PRODUCT
C       CONST7=.01                                                          75,C
A       TECNN.K=CLIP(RTECNN.K,ATECNN.K,TIME.K,BASE)                         76,A
A       RTECNN.K=TABHL(TRTECH,QUAL.K,0,1.5,.15)                             77,A
A       ATECNN.K=TABHL(TATECH,QUAL.K,0,1.5,.15)                             78,A
T       TRTECH=0/-.037/-.075/-.137/-.21/-.29/-.375/-.46/-.6/
X       -.72/-.8                                                            79,T
T       TATECH=0/0.37/.075/.137/.21/.29/.375/.46/.72/.8                     80,T
```

```
A   ATTECON.K=VAR4.K*ECON.K                                          81,A
*   VAR4 = FRACTION OF CONSUMER ACTUALLY PURCHASE THE NEW PRODUCT DUE TO
          ECONOMIC MOTIVE
*   ECON = FRACTION OF CONSUMER INFLUENCED TO MOVE FOR THE NEW PRODUCT
          FOR POSSIBLE ECONOMIC GAIN
A   VAR4.K=CONST8*(.5+NOISE())                                       82,A
C   CONST8=.001                                                      83,T
A   ECON.K=CLIP(RECON.K,AECON.K,TIME.K,BASE)                         84,A
A   RECON.K=TABHL(TRECON,QUAL.K,0,1.5,.15)                           85,A
A   AECON.K=TABHL(TAECON,QUAL.K,0,1.5,.15)                          86,A
T   TRECON=0/-.043/-.093/-.143/-.187/-.24/-.29/-.34/-.39/
X   -.45/-.5                                                        87,T
T   TAECON=0/.043/.093/.143/.187/.24/.29/.34/.39/.45/.5             88,T
A   ATTLOYAL.K=VAR5.K*LOYAL.K                                       89,A
A   VAR5.K=CONST9*(.5+NOISE())                                      90,A
*   VAR5 = FRACTION OF CONSUMER ACTUALLY POSTPONE THE PURCHASE OF
          NEW PRODUCT DUE TO BRAND LOYALTY OF OLD PRODUCT
*   LOYAL = FRACTION OF CONSUMER INFLUENCED TO POSTPONE PURCHASE OF
           NEW PRODUCT DUE TO BRAND LOYALTY OF OLD PRODUCT
C   CONST9=.01                                                       91,C
A   LOYAL.K=CLIP(RLOYAL.K,ALOYAL.K,TIME.K,BASE)                     92,A
A   ROYAL.K=TABHL(TRLOYAL,SUCPUR.K,0,10,1)                          93,A
A   ALOYAL.K=TABHL(TALOYAL,SUCPUR.K,0,10,1)                         94,A
T   TALOYAL=0/.085/.125/.155/.2/.255/.3/.33/.37/.42/.46            95,T
T   TRLOYAL=0/-.085/-.125/-.155/-.2/-.255/-.3/-.33/-.37/
X   -.42/-.46                                                       96,T
A   SUCPUR.K=10*(.5+NOISE())                                       97,A
*   SUCPUR = NUMBER OF SUCCESSIVE PURCHASE
A   ATTPROM.K=VAR6.K*(ATPRO.K+PACDIS.K)                            98,A
A   VAR6.K=CONST10*(.5+NOISE())                                    99,A
A   ATPRO.K=TABHL(TATPRO,ADE.K,0,1.5,.15)                          100,A
A   PACDIS.K=TABHL(TPACDIS,ADE.K,0,1.5,.15)                        101,A
A   ADE.K=CLIP(ADQ2.K,ADQ1.K,TIME.K,BASE)                          102,A
T   TATPRO=0/.005/.011/.02/.03/.043/.056/.07/.09/.118/.15          103,T
T   TPACDIS=0/.008/.018/.028/.038/.048/.058/.07/.081/.09/.1        104,T
C   CONST10=.005                                                    105,C
*
*   VAR6 = FRACTION OF CONSUMER ACTUALLY MOVE FOR PURCHASE DUE TO
          PROMOTIONAL EXPENDITURE
*   ATPRO = FRACTION OF CONSUMER INFLUENCED TO POSTPONE PURCHASE OF
           OLD PRODUCT DUE TO PROMOTION OF NEW PRODUCT
*   PACDIS =FRACTION OF CONSUMER INFLUENCED TO BUY DUE TO PACKAGING & DISPLAY
*   PRODUCT MARKET FACTORS
A   PMF.K=APMF.K-OBSOL.K+USER.K                                     106,A
*   APMF = FACTORS DIRECTLY CONCERN TO THE PRODUCER
*   OBSOL = FACTORS AFFECTING LIFE CYCLE DUE TO OBSOLESCENCE
*   USER = PARAMETER DETERMINES RCMS CONSIDERING USER FACTORS
```

```
*
*    PRODUCT DIRECT MARKET FACTORS
A    APMF.K=DPMF.K*MSP1.K*MSP2.K                                    107,A
A    DPMF.K=PROMAR.K-INGRO.K                                        108,A
A    INGRO.K=GRO.K*CONST3                                           109,A
A    GRO.K=TABHL(TGRO,TIME.K,1947,1977,1)                           110,A
*    DPMF = DETERMINES APMF
*    PROMAR = ANOTHER DETERMINANT OF APMF
*    INGRO = INDUSTRY GROWTH RATE (EXPANSION OF ECONOMY)
*    GRO = DETERMINES INGRO
C    CONST3=0.042                                                   111,C
T    TGRO=1/0.92/1.0/1.12/1.05/0.91/1.152/1.031/1.02/
X    0.85/1.28/1.0/.963/1.133/1.039/1.02/.95/1.01/1.07/1.12/
X    1.1/1.05/1.12/1.17/1.2/1.3/1.23/1.32/1.34/1.29                 112,T
A    PROMAR.K=B1+B2*PROFIT-B3*INVEST+B4*ATIME.K                     113,A
*    PROFIT = PROFITABILITY INDEX
*    INVEST = SIZE OF INVESTMENT
*    ATIME = TIME & EXPERIENCE
A    ATIME.K=TTIME+RAMP(RPSL,RPT)                                   114,A
C    TTIME=5                                                        115,C
C    RPSL=.5                                                        116,C
C    RPT=1947                                                       117,C
C    B1=-.59                                                        118,C
C    B2=0.484                                                       119,C
C    B3=0.025                                                       120,C
C    B4=0.0017                                                      121,C
C    PROFIT=1.59                                                    122,C
C    INVEST=0.015                                                   123,C
C    TIME=1947                                                      124,C
*
*    DURABILITY AND OBSOLESCENCE FACTORS
A    OBSOL.K=CONST1*MSP1.K*MSP2.K                                   125,A
C    CONST1=.1038                                                   126,C
*
*    PRODUCT USER FACTOR
A    USER.K=TABHL(TUSER,MSP.K,MS1,MS2,MS3)                          127,A
A    MSP.K=CLIP(MSP2.K,MSP1.K,TIME.K,BASE)                          128,A
C    MS1=0.0                                                        129,C
C    MS2=1.0                                                        130,C
C    MS3=.10                                                        131,C
T    TUSER=0.0/.007272/.009696/.008484//.004848/0/-.004848/
X    -.008484/-.009696/-.007272/0                                   132,T
*
*    CONTROL MINIMUM VALUES OF PRODUCTS
A    CMVMSP1.K=CLIP(CP,CQ,MSP1.K,CREF)                              133,A
A    CMVMSP2.K=CLIP(CP,CQ,MSP2.K,CREF)                              134,A
C    CP=1                                                           135,C
```

```
C     CQ=0                                                          136,C
C     CREF=0                                                        137,C
*
PRINT MSP1,MSP2,IMADV1,IMADV2
PLOT MSP1=A,MSP2=B
PLOT IMADV1=C,IMADV2=D
SPEC DT=.25/LENGTH=1977/PRTPER=.75/PLTPER=.75
RUN BASIC
```