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SPRINTER: A Tool for New Product Decision Makers

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Abstract

This article presents a mathematical model and computational routine called SPRINTER to aid in decisions for a new product development. The model integrates the demand, cost, profit, and decision factors that affect the problem. Interdependencies that may be present between the new product and the firm's existing products are reflected in "differential" criteria which represent incremental changes in the firm's profit and risk positions. The final new product decision is based on the probability of achieving the corporation's target rate of return. The basic output of SPRINTER is a recommendation either to introduce the product, reject the product, or investigate the product more fully. The model also recommends the best price, advertising allocation, and distribution level for the new product. A case study is presented to show how SPRINTER has been utilized in an actual new product decision situation.

Introduction

The necessity of introducing new products has become widely recognized by today's business executives. Firms which do not innovate and produce new product offerings soon find their profitability impaired. But those who do attempt to introduce new products are plagued by a high failure rate in their new products.[1] This large proportion of failures does not reflect the incompetence of decision makers, as much as it indicates the complexity and difficulty associated with the decision to market a new product.

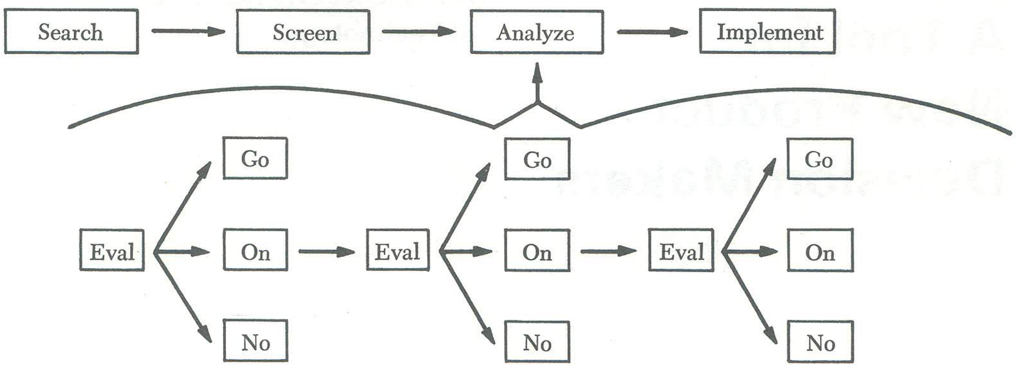
The decision concerning the adoption of a new product takes place in the total product planning system. This process begins with a search procedure designed to generate a large number of new product ideas. These ideas are then screened to remove those suggestions that are not compatible with the goals of the firm or are obviously unsuitable. The new product proposals that pass through the screening step are then analyzed. This analysis takes place in an information network. At each step in the process the product can be adopted (GO decision), rejected (NO decision), or investigated further (ON decision).[2] (See Figure 1.) If an ON decision is reached, the evaluation analysis is repeated, and the sequence continues until either a GO or NO exit is made. If a GO decision is reached, the firm has committed itself to the product, and implementation of the new product marketing plan is begun. The implementation step may include additional efforts in the area of product development or market testing before full commercialization, but a GO decision represents a commitment which will not be reversed unless the underlying parameters of the analysis change. The problem of the new product decision is then: should a GO, ON, or NO decision be made for the product?

This problem will be attacked by the development of a mathematical model and an associated computational routine. After the factors underlying the new product decision are identified, they are related in an inte-

[1] A study carried out by Booz, Allen and Hamilton, Inc., indicated that 51 per cent of new products marketed are not a financial success. See [4], p. 14.

[2] This networking approach was first presented by A. Charnes, W. W. Cooper, J. K. DeVoe, and D. B. Learner. See [5].

Figure 1 Product Planning System



grated mathematical model made up of demand, cost, profit and decision elements. To find solutions for the model, a search routine called SPRINTER is developed.[3] The model is further described in the context of a case study that explains how SPRINTER was applied in an actual new product decision situation.

A Mathematical New Product Model

Before building a model of the GO-ON-NO decision, all factors that may affect the decision should be identified. In Figure 2 the basic factors relating to the decision are listed. The over-all considerations relate to the demand for the product, the cost of producing it, the profit to be generated by the new product, the investment required to obtain this profit, and uncertainty associated with the proposed product.

This factor listing is important, but it does not become meaningful until the factors have been integrated into a framework which solves the proposed problem. The factors could be related by a subjective weighting procedure.[4] However, it is more beneficial and enlightening to examine the underlying relationships between factors. An explicit statement of these interrelationships is necessary if a mathematical model of the decision is to be formulated. The mathematical integration begins by specifying the relationships in the areas of demand, cost, profit, and decision making.

[3] SPRINTER is an abbreviation for Specification of PRofits with INteraction under Trial and Error Response.

[4] See [13].

Demand Factors

The basic demand relationship is a forecast of the quantities of the new product to be sold in future periods. This is called the life cycle. By the nature of the new product, this estimate of the life cycle is subject to uncertainties. The uncertainties of estimation can be specified by establishing confidence limits about the best estimate in each year. For example, it may be estimated that the reference life cycle sales will be 400,000 units in a given year, but with the added realization that there is a nine out of ten chance that sales will be between 200,000 and 600,000 units in that year. The best estimate is used as the basis of the specification of the marketing parameters, and the confidence information is used in evaluating the uncertainty associated with the project.

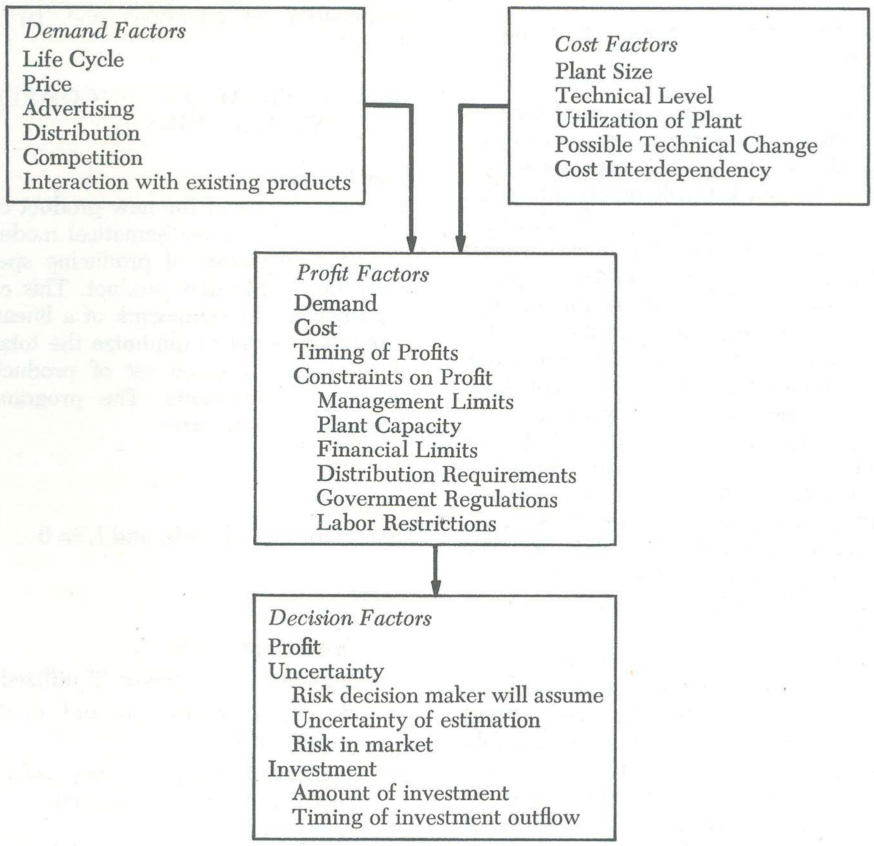
The estimate of sales in each year is made with a specific marketing program in mind. If these variables were changed, one would expect the sales level to change. To include these considerations, the reference value can be multiplied by a series of mathematical functions that reflect the effects of parameter levels other than those implied in the reference forecast. Mathematically these relationships can be expressed as:

$$X_{1t} = \bar{x}_{1t} \cdot PR_{1t} \cdot AR_{1t} \cdot DR_{1t} \qquad (1)$$

X_{1t} = industry sales of product one in year "t"

$\bar{x}_{1t}$ = reference life cycle sales estimate for the industry of product one in year "t"

Figure 2 Factors Affecting New Product Decision



PR_{1t} = price response function for product one in year "t"

AR_{1t} = advertising response function for product one in year "t"

DR_{1t} = distribution response function for product one in year "t"

The response functions are estimates of how sales would respond if price, advertising, or distribution were changed from the reference level. For example, if the price level were increased from $100 per unit to $125 per unit, the sales might decrease by 50 per cent. At this point, the price response function would have a value of one-half. The sales fall to one-half the reference value with the $25 increase in price. All price-sales changes may not be in this proportion, so the function will take on different response values for different price-levels. In general, the response function will specify the proportionate changes in the sales of the product (i.e., $X_{1t}/\bar{x}_{1t}$) as a result of changes in a marketing parameter.

If there is no competition in a particular year, the firm will receive all the sales indicated by equation one. When competition exists, the firm will only get a share of these sales. Its market share would be based on its marketing effectiveness relative to other firms in the industry. Mathematically, this could be expressed as:

$$(COMPY) = \frac{PR_{11t}\,AR_{11t}\,DR_{11t}}{\sum_{i=1}^{m} PR_{1it}AR_{1it}DR_{1it}} \qquad (2)$$

PR_{1it} = price response function for product one for firm "i" in year "t"

AR_{1it} = advertising response function for product one for firm "i" in year "t"

DR_{1it} = distribution response function for product one for firm "i" in year "t"

m = number of firms competing in the industry

If each firm has the same response functions and establishes the same price, advertising, and distribution levels, this expression predicts that the market will be equally split. If, however, some firms specify different levels of some variables, the market shares will change depending upon the response function for that firm and parameter. For example, if all three firms in the industry have the same program, except that firm one raises its price $25, that firm's market share would decrease. Before the price change, firm one would receive a share of 33 per cent $[1/(1+1+1)]$. If the price response function value at the new price is one-half, firm one would obtain 20 per cent of the market $[.5/(.5+1+1)]$ after the price increase. Similar effects would be produced if any of the firms changed their marketing program.

One other factor may affect the sales of product one. This is the interdependence between the demand for this product and other products. The new product probably will not be offered as an entity independent of other products currently being sold by the firm. The new product may reduce or increase the sales of other existing products offered by the firm. The interactions can be expressed by cross-response functions that measure the proportionate changes in the sales of one product as a result of changes in the marketing parameters of another product offered by the firm. If the firm offers "n" products, the interaction effects can be expressed as:

$$(\text{INTERACTIONS})_t = CPR_{12}CAR_{12}CDR_{12}\ CPR_{13}CAR_{13}CDR_{13} \ldots CPR_{1n}CAR_{1n}\ CDR_{1n} \quad (3)$$

CPR_{1j} = cross-price response function between product one and "j"

CAR_{1j} = cross-advertising response function between product one and "j"

CDR_{1j} = cross-distribution response function between product one and "j"

$j = 2, 3, \ldots n$

The mathematical equation for the demand for product one for the firm in year "t" is a combination of equations one, two, and three:[5]

$$x_{1t} = \bar{x}_{1t} \cdot PR_{1t}AR_{1t}DR_{1t} \cdot (\text{COMPY})_t \cdot (\text{INTERACTIONS})_t \quad (4)$$

Cost Factors

The cost aspects of the new product can be encompassed in a mathematical model that minimizes the costs of producing specified quantities of the new product. This can be described in the framework of a linear programming model to minimize the total cost of producing a given set of product line quantity requirements. The programming problem is to minimize:

$$TC = \sum_j c_j I_j \quad (5)$$

$$\text{subject to: } \sum_j a_{kj} I_j \geq b_k \text{ and } I_j \geq 0$$

where

c_j = cost of input factor "j"

I_j = amount of input factor "j" utilized

a_{kj} = technical production and marketing relationships

b_k = constraint on input values and quantities of goods to be produced.

This linear programming model considers cost interdependencies that may be introduced by the nature of the over-all productive system. If there are no cost interdependencies, the cost model would be an equation relating production costs to the quantities of the new product produced.

Profit Factors

The combination of the demand and cost relationships can produce estimates of profit. The demand model can be used to estimate total revenue and the cost model to estimate total costs. The question now is: what is the appropriate profit measure to use in making the new product decision? Since the product may affect the profit of other products because of its demand, cost, and resource relationships with them, the new product should be judged on the basis of the change

[5] When competition is present, PR_{1t}, AR_{1t}, and DR_{1t} become industry response functions which reflect sales effects of over-all average industry parameter levels.

in the total firm's profit. This change in total firm profits will be called the "differential profit." The differential profit is the best measure of the returns to the firm as a result of adding the new product. Mathematically, the differential profit in year "t" is

$$DP_t = Profit_{new,t} - Profit_{old,t} \quad (6)$$

$Profit_{old,t}$ = estimate of total line cash flow profits in year "t" if the new product is not introduced.

$Profit_{new,t}$ = new line profit

The new line profit is the firm's total cash flow profit, given that the new product is introduced.

$$Profit_{new,t} = \sum_{k=1}^{n} P_{kt}x_{kt} - TC_t \quad (7)$$

P_{kt} = price for product "k" in year "t"

x_{kt} = quantity of product "k" sold in year "t." This is the output of the demand model (see Equation 4)

TC_t = total variable cost of producing new line of products in year "t." This is the output of the cost model (see Equation 5)

Since the profits will be received over a period of years, the total differential profit is the sum of the profit for each year in the firm's planning period. To reflect the time value of the cash flow profits, the profits may be discounted at the corporation target rate of return and summed to specify the total discounted differential profit.

$$TDDP = \sum_{t=1}^{pp} [1/(1 + RR)^t] DP_t \quad (8)$$

TDDP = Total discounted differential profits

DP_t = differential cash flow profit in year "t"

RR = corporation target rate of return on investment

pp = number of years in the firm's planning period

TDDP is a representation of the profit attributable to the new product given a level of price, advertising, and distribution for each year in the planning period. This may not be the level of the parameters that produces the greatest total discounted differential profit. The product should be judged at its best marketing program. The problem is to locate the best marketing program without violating the constraints on the firm's technical, financial, and managerial constraints. Mathematically, the model must maximize:

$$TDDP = f(P_{1t}, A_{1t}, D_{1t}, \ldots P_{kt}, A_{kt}, D_{kt}, \ldots P_{nt}, A_{nt}, D_{nt}, c) \quad (9)$$

subject to:

$$\sum_k A_{kt} \leqq A_{Tt}, \quad \sum_k D_{kt} \leqq D_{Tt}, \text{ and } X_{kt} \leqq X_{Tkt}$$

for

all t in the firm's planning period

where

P_{kt} = price of product "k" in year "t"

A_{kt} = advertising expenditure for product "k" in year "t"

D_{kt} = distribution expenditure for product "k" in year "t"

A_{Tt} = advertising budget for the line in year "t"

D_{Tt} = distribution capacity for line in year "t"

x_{Tkt} = productive capacity level for product "k" in year "t"

c = competitive effects (see Equation 2)

Decision Factors

The problem formulation given in Equation 9 includes a mathematical consideration of the factors surrounding the demand, cost, and constraints associated with the product. The solution to this constrained maximization is the maximum total return attributable to the product. This return must now be combined with the other factors listed in Figure 2. The return must be compared to the investment required to produce it and the uncertainty surrounding the project to reach a GO, ON, or NO decision.

If there were no uncertainty, the decision would be simplified. In this case, if the discounted differential profit were greater than the investment, the rate of return used to discount the profit flow (see Equation 8) would be achieved and a GO decision would be made. If the discounted differential profit were less than the investment, the target rate of return would not be achieved and a NO decision would be reached.

With uncertainty, a third decision alternative is present – ON. The ON decision is the choice of carrying out further studies on the project to sharpen the input estimates. For example, a market test might help narrow the confidence limits on the life cycle estimates. To consider explicitly the factor of uncertainty, a parameter must be defined to measure it. If the decision maker could establish probabilities for the occurrence of profit levels other than the best estimate calculated in the profit model, a distribution of the differential profits could be determined. The variance of this total discounted differential profit distribution would be meaningful because it reflects the change in the level of the total uncertainty that is produced by the introduction of the product. This may be conceived of as "differential uncertainty," and it is mathematically expressed as:

$$DU = [V' + V - 2\,COV(Pr, Pr')]^{1/2} \quad (10)$$

where

DU = differential uncertainty

V' = variance of the new line profits

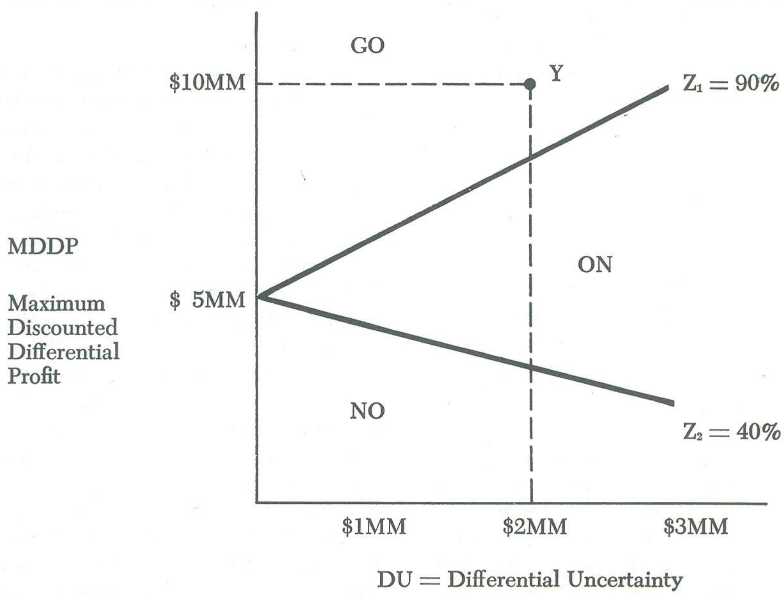
V = variance of old line profits

COV(Pr, Pr') = covariance of new line profits (Pr') and old line profits (Pr) or $E[(Pr - E(Pr))(Pr' - E(Pr'))]$.

The decision either to add, reject, or study more extensively the new product can be determined by combining the differential profit, differential uncertainty, and investment. If the probability of making a minimum rate of return on investment (i.e., probability of TDDP > Investment) is above a specified acceptance level, a commitment is made to market the product; if the probability is below a specified rejection level, the product idea is not accepted; and if the probability is intermediate, the product will receive further study. This criteria can be shown graphically. (See Figure 3.) In this figure Z_1 and Z_2 divide the area into three areas – GO, ON, and NO. Z_1 and Z_2 represent probabilities of making a minimum rate of return on investment.[6] The GO–ON area is divided by a line which represents a Z_1 probability of making the minimum rate of return on investment. For the example in Figure 3, the Z_1 probability is 90 per cent;

[6] The rather lengthy proof of this fact for the normal distribution is given in [16], pp. 83-85. This proof is not identical but is based on the lognormal proof applied by A. Charnes, W. W. Cooper, J. K. DeVoe, and D. B. Learner, [6], pp. 10-12.

Figure 3 An Example of a New Product Decision Plot



Z_2 is 40 per cent; five million dollars of investment is required; and the minimum rate of return on investment used to discount the cash flow is 20 per cent.[7] If the maximum profit were 10 million dollars, point Y indicates that the decision for the new product would be GO. This means that 90 per cent of the time TDDP > Investment, or the achievement of a 20 per cent return on investment is more than 90 per cent probable.

At this point in the analysis the integrated mathematical decision framework can be specified. The demand and cost models combine to specify a profit relationship which is to be maximized, subject to the firm's constraints. This optimization would produce the maximum level of discounted differential profit. This profit is combined with the differential uncertainty and investment to determine a GO, ON, or NO decision for the new product.

Implementation of the Model

The mathematical model outlined in the previous section must be solved to specify the new product decision. To determine a GO, ON, or NO decision, the maximum expected value of the total discounted differential profit and differential uncertainty must be calculated. The equation of total discounted differential profit is very complex (see Equations 6 to 9). Maximizing it presents a problem. The analytic methods of mathematical programming and Lagrangian analysis are not powerful enough to cope with the complications arising from considerations of interdependency. The optimization must be carried out by a systematic trial-and-error search routine which maximizes the differential profit generated by the product.

A computer program called SPRINTER can be used to maximize the profit attributable to the new product. SPRINTER is an abbreviation for Specification of PRofits with INteraction under Trial and Error Response. This program is a trial-and-error simulation that evaluates discrete points in a range of marketing programs and identifies the best price (P), advertising (A), and distribution (D) levels for the new product in each year of the planning period. The simulation is described in Figure 4. It begins at the reference program and then systematically evaluates the effects of various discrete marketing mixes on the new line profit. By varying the number of discrete points to be tested, any desired level of accuracy can be obtained. After maximizing the new line profits, the estimated old line profits are subtracted from the new line profits to ascertain the maximum differential profits. These are summed to give the maximum total differential profits. The value of maximum total differential profits is then compared to the differential uncertainty to see if the point when plotted on the profit-uncertainty graph falls in the GO, ON, or NO area of the quadrant (see example in Figure 3).

The output of SPRINTER is a GO, ON, or NO decision for the product, the optimum level of price, advertising, and distribution for the new and old product, and the maximum level of differential profit generated by the new product. This maximization is carried out while full consideration is given to the interdependencies between the new product and old products, to the competitive environment surrounding the product, and to the constraints on the firm.

A Case Study Using SPRINTER

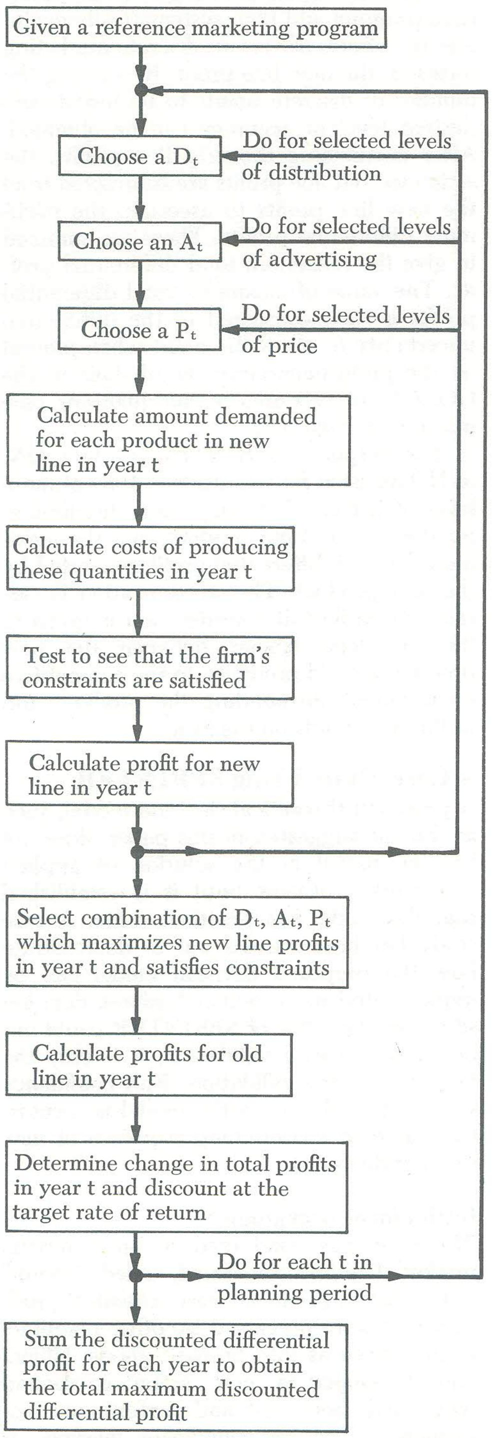
A proposed theoretical decision model, such as the one suggested in this paper, does not become useful in the solution of applied marketing problems until it is established that the model has practical value. A case study has been carried out to demonstrate how the proposed decision model can be implemented in an actual business decision situation. This test of SPRINTER could not be construed as a validation; it is only the first step in the validation. Full confidence will be gained only as the model is successfully used in a continuing sequence of new product decisions.

Institutional Background

The case was conducted in an industrial market. The firm concerned, called "Chemi" in this study, produced basic chemical products that were processed by other manufacturing concerns into finished goods. Chemi had developed a new nylon compound which had both cost and performance advantages in several significant markets. It was estimated that the new product would

[7] The equations are MDDP = I − (T_z) (DU) where T_z is the fractile associated with the probability Z of achieving the condition TDDP > I. I = Investment. For normal distributions and this example $T_{z_1} = -1.3$ and $T_{z_2} = +0.3$.

Figure 4 SPRINTER Model



experience demand interactions with two other products currently being marketed by the firm. The most important interaction was with a plastic compound used for small gears. The new product would compete with this product directly on the basis of price and performance advantages. The second market affected by the new product was a small specialty market for bearing linings. The new nylon would have performance advantages in this market, but its major advantage would be that its costs were much lower. The remainder of the sales for the new product would come from markets in which Chemi had no product offerings. The firm wanted to know if the product should be introduced, should be rejected, or if more studies should be done on the product.

Input to Model

The starting point for the data gathering for SPRINTER was a description of some specific marketing program that this particular firm and its executives could visualize for the product over the planning period of 10 years. This program included the price, advertising, and distribution plans for the new and old products and the competitive strategies for these products over the 10-year period. Execution of the marketing program would result in the generation of sales for the new product in each year. Subjective estimates of these quantities for each year in the planning period were supplied by the firm's marketing executives and comprised the reference life cycle estimate for the planning period. The first four years were best described by an exponential function and the last six years by a Gompertz function. The input estimates for the life cycle were closely described by the equation:

$$X_{It} = H(4-t)\,(100\,e^{1.23(t-1)}) + H(t-5)\,(1000(10.07)^{1.08^{(t-5)}}) \quad (11)$$

where

$t = 1, \ldots pp$

$$H(4-t) \begin{cases} = 1 \text{ if } t \leq 4 \\ = 0 \text{ if } t > 4 \end{cases}$$

$$H(t-5) \begin{cases} = 1 \text{ if } t \geq 5 \\ = 0 \text{ if } t < 5 \end{cases}$$

and t = time period of analysis

pp = planning period.

This life cycle estimate was considered the reference point for the determination of the parameter response functions. All response functions measured the deviations from the reference life cycle estimates produced by changes in price, advertising, or distribution. For example, questioning revealed the new product price response function to be:

$$PR_1 = [268/(P_1 - 104.5)] - .844 \quad (12)$$

where

P_1 = new product price.

This function implies that if prices were decreased to $200 per carton, the sales would be almost twice the reference level in that period. The equation of this response function changed during the planning period to indicate the changing price sensitivity of the new product. Similar functions were determined for advertising and distribution response.

Demand interdependencies were considered by the development of interaction response functions. These functions were expressed in terms of the penetration the new product would make into existing product markets. For example, the cross price response function for the new nylon (product 1) and old gear (product 2) markets was:

$$CPR_{12} = PENYX \cdot (x_1/\bar{x}_1) \cdot (.1)(P_2 - P_1) + 1.0 \quad (13)$$

where

PENYX = reference penetration of product 1 into market 2 as a proportion of the reference sales level of product 1.

P_2 = price of product 2

P_1 = price of product 1

x_1 = sales of product 1

$\bar{x}_1$ = reference sales level of product 1

The term $x_1/\bar{x}_1$ reflects the belief that the penetration into market 2 will be proportionate to the total sales of product 1. This function measures the demand interactions between the two products and reflects the proportionate changes in the sales of the new product as the price of the new or old product is changed.

The competitive effects in the new product market were described on the premise that the competition's strategy would be to enter with a similar product at the same price, but with twice as much advertising and distribution effort. The market share of the introductory firm was defined on the basis of the relative marketing effectiveness of the firm (see Equation 2).

The best estimate of the entrance time of competition was five years after the introduction of the new product. As new firms entered the market, aggregate industry effects were produced and were functionally analyzed. The effect of the combined marketing effort was to increase the industry sales by 25 per cent at the reference marketing program for the new product.

The total life cycle, industry, competitive, and interaction effects were combined to define the total demand equations for each product in the line (see Equation 4). When the total minimum cost of producing the new line was subtracted from the total new line revenue (price times quantity demanded for each product), the new line profits were determined. The differential profit was specified when the estimated old line profits were deducted from the new line profits. The differential profit was summed and discounted to produce the total discounted differential profit. The total profit was then optimized, subject to the constraints on the decision. Several important constraints limited the number of feasible solutions to be tested by SPRINTER. The constraints upon the new product allocation model were in the form of constraints on the advertising budget, plant output capacity, technical service, and pricing policy.

The input data used to calculate the differential profit were not known with certainty. Distributions of each of the parameters about the best estimates were obtained and combined to produce aggregate confidence estimates. In calculating the total uncertainty, the same underlying factors affected the demand for the new nylon and the old gear and bearing products, so covariances were estimated to specify the differential uncertainty (see Equation 10).

Output of Model

To maximize profits SPRINTER utilized a simulation approach which began by evaluating Chemi's proposed marketing plan. Chemi's proposed pricing policy was to sell the new product at $350 per carton for the first three years and $250 per carton for the remaining seven years. One per cent of the sales force would be allocated to the new product and $10,000 per year of advertising would be purchased for the product. This marketing program resulted in the generation of a total new product profit of $8,350,000 when the product was evaluated independently. Since the total investment for the new product was eight million dollars, the product might have been accepted if certainty was assumed and if the product was considered independent of the existing products. But the product was not independent; significant interdependencies were present. The total discounted *differential* profit for the new product was only $5,999,000. The loss in the profits of existing gear and bearing products accounted for the reduction of the profit of the new product from 8.4 million dollars, when viewed independently, to six million dollars, when viewed as an integral part of the product line. The decision at the initially proposed marketing mix would have been to reject the product. The level of discounted differential profit was below the eight million dollars of required investment, and there was less than the specified probability (50 per cent for a rejection) of making the minimum rate of return (15 per cent).

Although the project would have been rejected by SPRINTER at the reference level, this did not have to be true for all marketing programs. By the application of a trial-and-error search routine, SPRINTER suggested a better marketing mix over the life cycle.[8] SPRINTER recommended a price of $250 per carton for the first three years and prices near $200 per carton for the remaining seven years. The use of this pricing policy and the original advertising and distribution allocations improved profits greatly. The total discounted differential profits attributable to the new product were increased to $10,830,000. The price determination was very sensitive in this case, and SPRINTER was able to improve profits by 4.8 million dollars by an optimal price determination routine. Even at this profit, however, the product could not be adopted because there was less than the specified probability (90 per cent for acceptance) of making the minimum rate of return (15 per cent) on the investment.

The management of Chemi was interested in the results of relaxing the profit constraints, so SPRINTER was used to analyze the effects of varying the constraint levels. Enlarging the plant size increased profits, but would not justify a decision to accept the product. Increasing the sales force by one man did produce a decision to accept the new product. With a larger sales force the total profit was 12.2 million dollars and, based on a differential uncertainty of 2.77 million dollars, there was a 91 per cent probability of making 15 per cent rate of return on investment.

Summary

The output of SPRINTER was the decision to add the new product to the line and to use a marketing mix over the life cycle that represented a simultaneous specification of price, advertising, and distribution at their best combination of values, given the best level of constraints on the firm's operations. The specification took full consideration of demand, allocation, and uncertainty interdependencies. The optimum price, advertising, and distribution mix occurred at a point where the differential profit was six million dollars more than the profit level which would have occurred at the marketing mix proposed by Chemi Corporation. The preliminary case study was a success. Real input data was processed to yield a meaningful decision and a significant increase in future estimated profits.

Conclusion

This paper began by defining explicitly the new product decision problem within the wider context of the total product planning system. The specific decision in the analysis stage of the system was whether the product should be introduced (GO decision), rejected (NO decision), or investigated more fully (ON decision). With this definition

[8] SPRINTER systematically evaluated a range of two million marketing programs in optimizing the differential profit. The running time for SPRINTER was one and one-half hours on a CDC3400 computer (about $650 of computing time).

of the problem in mind, a mathematical model was developed. The factors affecting the problem were identified, and the interrelationships between these factors were mathematically specified in an integrated decision framework.

A solution to the problem was found by a computer simulation called SPRINTER. This trial-and-error computer routine maximizes the profits attributable to the new product after giving full consideration to the effects of various levels of price, advertising, and distribution, the competitive environment surrounding the product, the constraints on the firm's operations, and the interdependencies between the new product and old products. This maximum differential profit is used to ascertain if the probability of making a specified rate of return on the investment justifies a final decision (GO or NO).

The greatest limitations of SPRINTER relate to the scope of the model. It assumes that the new product ideas are proposed and analyzed one at a time. This may not always be true. Sometimes the problem may be to choose from a number of new product ideas. Although SPRINTER can supply differential profit and uncertainty information about each product, the model in its present form cannot select from a group of alternatives unless they are all at the same stage in the information network. The second limitation is that although the model specifies the GO, ON, or NO decision, it does not specify what study to undertake if the ON decision is reached. SPRINTER does indicate which relationships are most uncertain, but it does not explicitly specify the optimal sequence of market research studies. The model assumes that the "best" study is carried out at each ON alternative. After the study is completed, SPRINTER again evaluates the GO, ON, and NO decision. In this way it proceeds step by step through the information network, leaving it as soon as sufficient information is present to warrant a GO or NO decision.

In addition to these limitations, this model is subject, as are all models, to limitations of the input data. The result can be no more accurate than the input, but at least SPRINTER does determine if there is enough confidence in the information to justify a final GO or NO decision. If there is too much uncertainty, an ON decision will be specified. The input and other limitations should be considered carefully to assure that they are reasonable in each particular situation before the model is applied. In the case study described in this paper the model was appropriate and produced a substantial improvement in the quality of the new product decision.

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