WHEN TO GO TO MARKET?: A NEW PRODUCT LAUNCH-TIME DECISION MODEL*

Eunsang Yoon, Auburn University
Gary L. Lilien, The Pennsylvania State University

ABSTRACT

R&D decisions and the dynamics of diffusion for new product innovation have been studied separately by economists and marketers. This paper develops a new product launch-time decision model that integrates that research. The best time to launch the new product balances the risks of premature launch against the sales (and profit) lost by unnecessary delay. Several objective functions are evaluated to illustrate the rationale and implications of the model.

INTRODUCTION

In this paper, we recognize the launch-time of a new product as the bridge between the R&D phase and the market diffusion phase of a new product innovation. We develop a model in which the "diffusion power" of a new product and its market potential are two major determinants of the optimal time for a new product introduction. A basic premise of the model is that a delay in launch time increases the diffusion power or attractiveness of the offering on the one hand, but is accompanied by a higher level of market penetration by existing products and lowered potential penetration on the other. Therefore, the model suggests that a new product should be launched when those two effects are properly balanced.

The paper is organized as follows. First, we review the literature on issues and modeling approaches to the R&D decision and first purchase diffusion dynamics. Then we build a new product launch time decision model that analyzes the relationships among (a) R&D and marketing investments, (b) the diffusion dynamics of the market, and (c) new product sales performance, and we analyze the model to develop an optimal launch time. Finally, we discuss uses and limitations of the work and outline directions for future research.

LITERATURE REVIEW

The market launch of a new product usually accompanies a transition from R&D to marketing investment, although these two categories of investments overlap. These two phases, R&D decision-making and market-diffusion dynamics, have been studied separately.

New Product/R&D Decision Models

A number of economists have developed R&D models that can be classified as decision theoretic models, game theoretic models, models of industry evolution, stage models and sequential or nonsequential optimal stopping models.

Kamien and Schwartz (1972, 1982) developed a decision theoretic R&D model and found that the speed of innovation will increase with an increase in the intensity of rivalry up to a point, but will slow down as it continues. In game theoretic models, the interdependence among rivals' R&D spending decisions is analyzed as an internal variable (Loury 1979; Lee and Wilde 1980; Dasgupta and Stiglitz 1980; Reinganum 1981, 1982). And Nelson and Winter (1982) suggest that the evolution of industry structure over time should be incorporated in R&D decision models.

Stage models of R&D decisions are based on the assumption that an R&D decision involves continuous information search and decision making through a well-defined sequential development process. Roberts and Weitzman (1981) suggested a sequential stopping rule approach where a decision is made at each stage based on the available information about the expected terminal benefit and the R&D costs of the project. Urban and Hauser (1980) suggested a series of GO/NO-GO decisions over the R&D and commercialization stages: opportunity identification -- design -- testing --introduction -- profit management. Optimal R&D stopping rules also have been developed in nonsequential (or continuous) R&D search models. Deshmukh and Chickte (1977) developed a markovian R&D decision model that allows technological and market uncertainties; Lee (1982) also analyzed a continuous-type R&D search model.

The literature on R&D decision models suggests: (a) the uncertainties related to technological and market successes are important factors influencing the expected benefit of an R&D project; and (b) the objective for R&D decision making is usually taken to be a function of the expected benefit of new product profit performance and R&D costs. However, we note that most of the models ignore the uncertainty or dynamics of the customer-side. Most R&D models have assumed that the demand or the sales growth of the new product is given and known in advance of the market launch of the product. The dynamic aspect of new product sales over time has been studied through first purchase diffusion models in the marketing literature.

Market Diffusion Models

A number of models with varying levels of complexity and applicability have been developed to aid in forecasting and controlling a new product's market performance. Recent reviews of diffusion models (Lilien and Kotler 1983; Mahajan and Peterson 1985; Yoon 1984) suggest that: (a) innovation and imitation effects are two major components of these models (Bass 1969; Dodds 1973; Nevers 1972); (b) marketing variables have been successfully incorporated into diffusion models for some specific products and situations (Robinson and Lakhani 1975; Horsky and Simon 1983; Lilien, Rao, and Kalish 1981; Dolan and Jeuland 1981), but no single best model has been identified; (c) market potential has been assumed constant or a function of information level (Bass and Bultez 1982), reservation price (Kalish 1983), or other relevant external variables (Mahajan and Peterson 1979; and (d) most of

*This research was supported in part by the Institute for the Study of Business Markets at The Pennsylvania State University.

the diffusion models are purposely kept simple to permit the development of analytic results. Most models have focused on the behavior of a single product's sales. Recently Peterson and Mahajan (1981), Teng and Thompson (1983), and Eliashberg and Jeuland (1982) have analyzed competition among new products in a limited framework.

The new product entry decision in a diffusion environment has been studied by Kalish and Lilien (1986). They develop a market diffusion model that incorporates possible negative feedback associated with introducing a product before it is completely, technically ready and find that significant penalties may be associated with introducing a new technology too soon.

Through this review we see that economists have studied R&D decisions, usually assuming a given reward for innovation without considering the dynamic aspects of the diffusion process and the uncertainty on the customer's side. Marketing scientists, on the other hand, have mainly studied diffusion dynamics or optimal marketing policies assuming a given R&D result. We proceed to develop a model-framework that bridges that gap.

THE LAUNCH-TIME MODEL

A new product's diffusion power (or competitive strength or attractiveness) and market potential are two major factors affecting its optimal launch-time. We assume that a delay in launch time increases diffusion power, but also permits a higher level of market penetration by existing products. Our analysis will show that to maximize initial sales penetration, a new product should be launched when the ratio of the new product's diffusion power relative to the untapped market potential level is equal to (minus) the ratio of the marginal diffusion power of the new product to the marginal untapped market potential. When the innovating firm's objective is NPV maximization over more than one period, the optimal launch time may come earlier or later than when it is one-period sales maximization, depending on the discount rate, the level of diffusion power and the untapped market potential.

Product Type and Market Situation

Product type, market structure, stage in the product life cycle and the nature of market potential are important in modeling a new product situation. We look at the following conditions here: (a) the new product is expected to be superior to existing products in terms of quality; (b) we assume that the product has passed the screening, evaluation, and basic development stages, and we focus on R&D effort made for the improvement of the product's quality; (c) we assume that the new product and other competing products in the market can be characterized by their quality levels. This implies that product positioning in terms of price, distribution, production capacity, and target market can be incorporated into the definition of quality; (d) we assume that the market is in the early stage of its life cycle (introduction or growth stage). Potential market size may vary depending on the quality level of the new product; we consider an oligopolistic, rather competitive market where both competitive entry and marketing competition are common. Innovation rivalry influences the size of market potential through the improvement of product quality, while marketing competition influences the market share composition among brands.

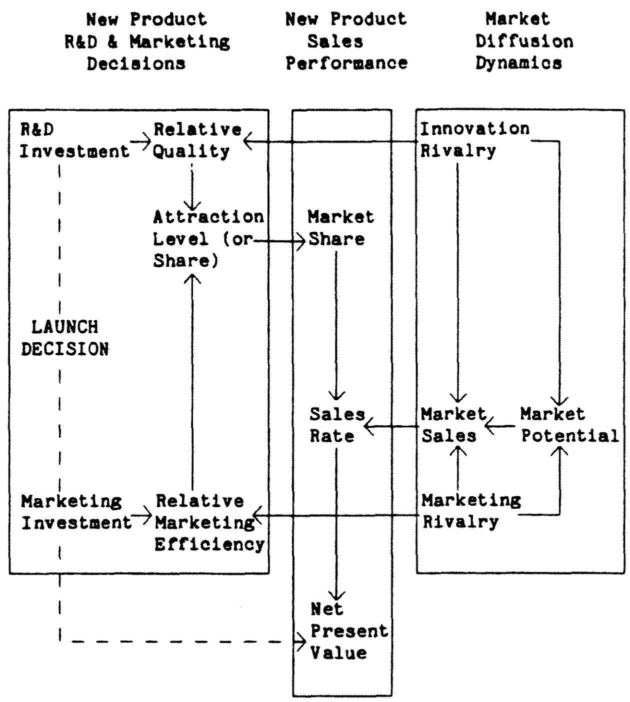
Consumer or business goods such as personal computers, home VCR's, word processors, or electronic copiers in the 1980's are examples of the product type specified above.

Conceptual Framework

For the situation specified, we suggest the conceptual model illustrated in Exhibit 1, which shows interactions between R&D and marketing decisions, market diffusion dynamics, and sales performance.

EXHIBIT 1

A CONCEPTUAL FRAMEWORK FOR THE NEW PRODUCT R&D-DIFFUSION MODEL



<u>New product R&D and marketing decisions</u>. The relative quality level of a new product is determined by the firm's R&D investment for the new product and intensity of innovation rivalry. Relative marketing efficiency is determined by marketing investment for the new product and market rivalry. Relative quality level and relative marketing efficiency determine the attraction level (or attraction share) of the new product.

<u>Market diffusion dynamics</u>. Market potential, intensity of innovation rivalry, and marketing rivalry determine market sales. Market potential is influenced by innovation rivalry and marketing rivalry.

<u>New product sales performance</u>. The market share of the new product is determined by the current attraction share and the carryover effects of previous market share. The sales rate of the new product is computed from the market share of the new product and market sales over a specific planning horizon. Finally, the profitability of the new product can be estimated from the sales rate, the product's price and the costs for R&D and marketing.

The length of the planning horizon affects the complexity of the analysis of this model. We will study a one-period planning horizon by assuming that the competitive strength of the new product will remain fixed over a specific planning horizon. This assumption makes the model simple but leads to the elimination of some dynamic interactions. Therefore, we also study the implications of the model in a multiple period framework.

OPTIMAL LAUNCH-TIME CONDITIONS

Maximization of Initial Market Penetration

Achieving a target sales level is frequently mentioned as a major objective of new product R&D/marketing decisions. For example, in a study of 81 new business products, maximization of sales is the most frequently cited measure of performance (48.1%, Yoon 1984). A sales maximization objective is based on the observation that the destiny of a new product (especially a new industrial product) is determined by the sales achieved during the first few years following its introduction into the market (Choffray and Lilien 1980; Yoon and Lilien 1985). For this analysis to be appropriate, we assume that product price is set by the market.

The product's sales is equal to the market sales level times its market share or:

$$S(t) = Sm(t)\ SH(t), \text{ where:} \tag{1}$$

S(t) = sales of a new product during a planning period beginning at time t,
Sm(t) = market sales during that planning period,
SH(t) = market share during that planning period.

The market sales on the right-hand side of this equation, Sm(t), can be decomposed to yield:

$$S(t) = Um(t)\ Dm(t)\ SH(t), \text{ where:} \tag{2}$$

Um(t) = untapped market potential during a planning horizon beginning at time t, and
Dm(t) = market diffusion rate during the same planning period.

Here we define "diffusion power," D(t), as follows:

$$D(t) = Dm(t)\ SH(t), \text{ where:} \tag{3}$$

D(t) = diffusion power of a new product in a dynamic and competitive diffusion market during a planning period beginning at time t.

Diffusion power is a measure of the competitive strength of a new product in a dynamic diffusion market because it combines the effect of the relative attraction share of the new product compared to other products, and the market diffusion rate. Then, new product sales becomes a function of the diffusion power of a new product and untapped market potential:

$$S(t) = Um(t)\ D(t) \tag{4}$$

A simple and intuitive way of modeling market share, SH(t), is:

$$SH(t) = a\ AS(t) + (1-a)\ SH(t-1), \text{ where:} \tag{5}$$

AS(t) = attraction share of the new product during the planning period, and
a = rate of realizing equilibrium market share.

Equation (5) says that we can interpret AS(t) as the long-run equilibrium market share of the product and a ($0 \leq a \leq 1$) is the rate of realizing that share. For the one-period problem, SH(t-1) = 0, and so we have SH(t) = a AS(t).

Thus for the one-period problem we get:

$$D(t) = Dm(t)\ a\ AS(t) \tag{6}$$

And the one-period new product sales function becomes:

$$S(t^*) = Um(t^*)\ D(t^*), \text{ where:} \tag{7}$$

S, Um and D are evaluated at the new product launch time, t*.

In equation (7) we assume that the relative diffusion power, D(t*), increases over t*(= new product launch time). Untapped market potential, Um(t*), may increase or decrease over the early phase of the life cycle depending on the behavior of market potential and penetration level, but it will ultimately decrease as the market penetration level goes up. In such situations, one-period sales performance is likely to increase initially but ultimately decrease with t*. To derive optimal launch time conditions for a new product, we set the first derivative of equation (7) with respect to t* equal to zero, yielding:

$$(dD(t^*)/dt^*)/D(t^*) = -(dUm(t^*)/dt^*)/Um(t^*) \text{ or} \tag{8}$$
$$D(t^*)/Um(t^*) = -(dD(t^*)/dt^*)/(dUm(t^*)/dt^*) \tag{9}$$

which implies that for maximizing the initial one-period sales penetration, a product should be launched when the ratio of the new product's diffusion power is equal to (minus) the ratio of the marginal rate of diffusion power to the marginal untapped market potential.

When D(t*) increases and is concave and Um(t*) decreases monotonically with t*, the optimal launch times are shown in Exhibit 2 for four situations.

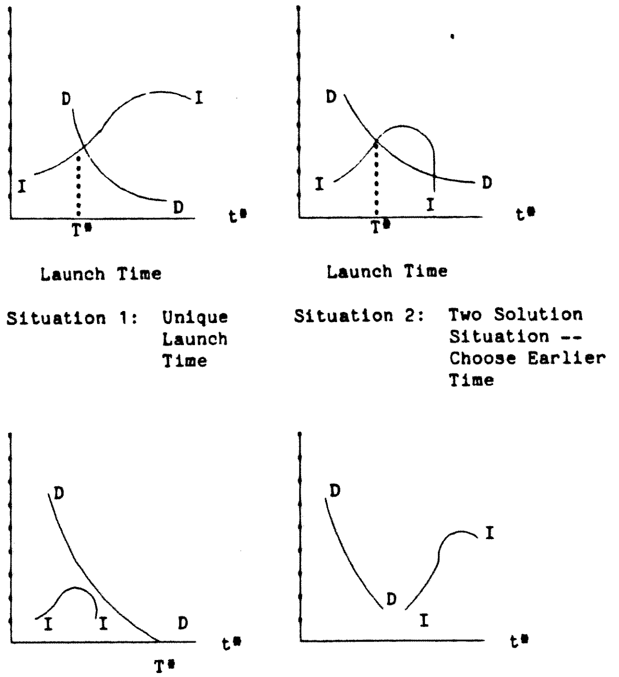
In situation 1 of Exhibit 2, the optimal launch time, T*, is found where a decreasing function DD (=marginal diffusion power/diffusion power level of the new product) and an increasing function II (=-marginal untapped market potential/untapped market potential level) intersect. As long as curve DD lies above curve II, an innovating firm should delay the launch time of the new product because a higher initial sales performance can be achieved through the higher diffusion power, resulting from a delay in the new product's launch time. In situation 2, curves DD and II intersect twice, but the first intersection will be optimal if the market is stable over the relevant planning horizon. In situation 3, curve DD lies above curve II for all t*, which indicates that the effect of the untapped market potential on the initial sales performance of the new product is insignificant. Thus, the optimal launch time is obtained when the marginal diffusion power becomes zero. In this situation, only the behavior of diffusion power is relevant for the optimal launch time decision. In situation 4 curve DD lies below curve II for all t*, meaning that the new product project should be terminated.

If curve DD shifts downward, an earlier entry of the new product will be desirable since curves DD and II will intersect at an earlier launch time. A downward shift of curve DD may occur due to a change in "a" or "Dm(t*)" in equation (8). A higher value of "a," which means a faster rate of realizing equilibrium market share in the initial period, will shift the diffusion power of the new product upward and so will shift the DD curve downward resulting in an earlier optimal launch. Similarly, a higher market diffusion rate, Dm(t*), will hasten the launch time of the new product.

A higher II curve will stimulate an earlier entry of a new product, due to either a lower market potential level or a higher market penetration level. A lower market potential will result in a higher II curve, and an earlier optimal launch time. A higher market penetration level raises curve II, resulting in an earlier optimal launch time.

EXHIBIT 2

FOUR POSSIBLE LAUNCH TIME SITUATIONS



Launch Time — Situation 1: Unique Launch Time

Launch Time — Situation 2: Two Solution Situation -- Choose Earlier Time

Launch Time — Situation 3: Diffusion Power Drives Launch Time

Launch Time — Situation 4: Do Not Launch Product

DD: ratio of the marginal diffusion power to the diffusion power level of a new product.

II: ratio of the marginal untapped market potential to the untapped market potential level.

T*: optimal new product launch time.

$(dD(t^*)/dt^*)/D(t^*)$: DD $-(dUm(t^*)/dt^*)/Um(t^*)$: II

In summary, the optimal launch time for maximizing the initial sales penetration of a new product balances product's diffusion power and untapped market potential. A unique optimal launch time is obtained in most situations where a new product's diffusion power increases concavely and untapped market potential decreases monotonically.

Two-period NPV Maximization

In a multi-period environment, an innovating firm may consider NPV maximization, combining such issues as discounting, dynamic pricing and advertising policies, the dynamic behavior of production costs, and the word-of-mouth effects in the diffusion market. Here we analyze a simple NPV maximization problem that allows discounting over a two-period planning horizon after the market launch of the new product.

We write the objective function as follows, evaluating it at the launch time of a new product:

$$Z(t^*) = m(S(t^*) + (1-r)\, S(t^*+1)) \text{ where:} \qquad (10)$$

$Z(t^*)$ = NPV of a new product launched at time t^*,
$S(t^*+1)$ = second-period sales volume of the new product launched at t^*,
m = unit margin of the new product,
r = discount rate, $0<r\leq 1$, and
t^* = new product launch time.

If we assume that the unit margin of the new product, m, is constant, (10) becomes:

$$Z'(t^*) = S(t^*) + (1-r)\, S(t^*+1) \qquad (11)$$

This two-period NPV problem becomes the same as the initial one-period sales problem when the discount rate "r" approaches 1.

Applying a conventional maximization rule, we set the first derivative of equation (11) with respect to the new product launch time t^* equal to zero, or:

$$dZ'(t^*)/dt^* = d(S(t^*) + (1-r)\, S(t^*+1))/dt^* = 0 \qquad (12)$$

Substituting for $S(t^*)$ from equation (7) we get the first-order condition:

$$d(Um(t^*)\, D(t^*))/dt^* = -(1-r)\, d(Um(t^*+1)\, D(t^*+1))/dt^* \quad (13)$$

$Um(t^*)$ = untapped market potential during the first period for a new product launched at time t^*,
$D(t^*)$ = diffusion power of the new product during the first period,
$Um(t^*+1)$ = untapped market potential during the second period for the new product launched at time t^*,
$D(t^*+1)$ = diffusion power of the new product during the second period.

To explore this relationship and relate it to the one-period sales maximization problem analyzed earlier, we express $Um(t^*+1)$ and $D(t^*+1)$ in the second period as proportions of $Um(t^*)$ and $D(t^*)$:

$$Um(t^*+1) = b(t^*)\, Um(t^*), \text{ where:} \qquad (14)$$

$b(t^*)$ = change in the rate of untapped market potential over the initial two periods for the new product launched at time t^*, and

$$D(t^*+1) = e(t^*) D(t^*), \text{ where:} \qquad (15)$$

$e(t^*)$ = changing rate of diffusion power of the new product over the initial two periods.

The change in rate of untapped market potential, $b(t^*)$, depends on the behavior of market potential and cumulative market sales over the two-period planning horizon. And the term $e(t^*)$, will depend on the intensity of innovation and marketing rivalry in the new product's diffusion market.

Substituting equations (14) and (15) in the optimal launch time condition equation (13) we get:

$$d(Um(t^*)\, D(t^*))/dt^* = -(1-r)\, d(b(t^*)\, e(t^*)\, Um(t^*)\, D(t^*))/dt^* \qquad (16)$$

Letting $h(t^*) = b(t^*)\, e(t^*)$ we get the following relationship:

$$D\, Um' + D'\, Um = -(1-r)\, (h'\, D\, Um + h(D\, Um' + D'\, Um)), \quad (17)$$

where: $Um = Um(t^*)$, $D = D(t^*)$, $h = h(t^*) = b(t^*)\ e(t^*)$, $Um' = dUm(t^*)/dt^*$, $D' = dD(t^*)/dt^*$, and $h' = dh(t^*)/dt^*$.

The optimal launch time condition is obtained by rearranging (17) as:

$$D'/D = -Um'/Um - ((1-r)h')/(1 + (1-r)h) \quad (18)$$

Equation (18) is the same as the optimal launch time condition for maximizing the initial one-period sales penetration in equation (9), except for the term:

$$G = -((1-r)h')/(1 + (1-r)h), \text{ where:} \quad (19)$$

r = discount rate, and $h = b(t^*)\ e(t^*)$ where $b(t^*)$ is the changing rate of the untapped market potential and $e(t^*)$ is the changing rate of the diffusion power over the initial two periods.

Thus we can use the behavior of the term G to build on the analysis of the last section, characterizing the optimal launch-time conditions. G depends on the values of the discount rate, r, the growth rate of the untapped market potential $b(t^*)$ and its marginal rate of change, and the growth rate of diffusion power $e(t^*)$ and its marginal rate of change. Since (1-r) and $h(=b(t^*)\ e(t^*))$ are positive, the sign of G is determined by the sign of $h'\ (=d(bt^*)\ e(t^*))/dt^*)$.

A positive value of h' implies a delayed launch of the new product relative to the initial sales maximization objective when the objective is two-period NPV maximization. If h' is positive, G is negative, leading to a downward adjustment of curve II in Exhibit 2 and a delayed optimal launch time. A positive value of h' reflects the situation that:

$$(d(b(t^*))/dt^*)/b(t^*) > -\ (d(e(t^*))/dt^*)/e(t^*) \quad (20)$$

Inequality (20) looks very much like a comparison of elasticities. Indeed, the terms in the denominator -- $b(t^*)$ and $e(t^*)$ -- serve as normalizing factors, so we can read inequality (20) as saying h' is positive if the proportional growth rate in diffusion power is greater than the proportional decrease in market potential. This implies a delayed launch relative to the one-period case. The reverse situation implies an earlier launch.

As the discount rate, r, is lowered, it can be seen from equation (19) that the value of G increases if h' is negative (delaying introduction) and increases if h' is positive (hastening introduction).

Operationalizing the Model

Space limitations preclude a full illustration of how this model can be operationalized. (For details, see Yoon 1984.) Several observations can be made, however. (1) Product ratings along key performance dimensions (speed, versatility, reliability) can easily be combined into "attractiveness" ratings for the new and established products. These ratings can be combined in a form such as:

$$AS_i = \frac{AT_i}{\sum_j AT_j}$$

where: AT_i = overall attractiveness rating for product i

$= \sum_k w_k r_{ik}$

w_k = importance of dimension k (k=1 = reliability, e.g.)

r_{ik} = rating of product i on dimension k.

(2) Untapped market potential can usually be obtained by standard market research procedures. (3) Most of our numerical analyses resulted in Exhibit 2, situation 1 (unique launch time) or situation 4 (do not launch product). (4) An earlier launch time is associated with:

- A new product with a high degree of superiority
- Aggressive, rapidly growing competitors
- A high discount rate for the firm

SUMMARY, LIMITATIONS, AND FUTURE WORK

Based on the framework in Exhibit 1, we developed a new product launch time decision model and analyzed it to see how the optimal launch time conditions could be found. The main results are:

(a) In the new product launch time decision model, the diffusion power of a new product and untapped market potential are the two major factors determining the optimal launch time for maximizing the initial sales performance in a competitive, diffusion market. Since a delay in the launch time increases diffusion power but also accompanies a higher level of market penetration by existing products, a new product should be launched such that those two effects are balanced to optimize a relevant objective function. A key contribution of this model is its identifying and relating the important factors that must be measured and balanced in making the launch time decision.

(b) Optimal launch time conditions for initial sales maximization were derived and illustrated for several possible situations. When the marginal diffusion power decreases over time and is concave, a unique optimum exists in most situations. When the diffusion power is given by an S-shaped curve, an innovating firm may need to choose between an early entry and a delayed entry in certain situations. The two-period NPV maximization objective was also analyzed to show how the discount rate and the growth rates of the diffusion power of a new product and untapped market potential shift the optimal launch time derived for the initial sales maximization objective.

We recognize several limitations of this model. One originates from the assumption that the decision maker can estimate the untapped market potential and the effectiveness of the firm's R&D effort, and, thus, the growth rate of the diffusion power of the new product over time. A stochastic model would be an alternative formulation that could relax this assumption and deal with the inherent uncertainty related to the technological success of R&D investment and the evolutionary nature of the industry more directly. Another limitation is that several important issues in new product planning are not considered. For example, the company's reputation as an innovator of good quality products or product portfolio considerations may be major concerns in a new product launch time decision in addition to the direct sales performance of the new product. A long-range new product planning model would be able to deal with these issues within a comprehensive product planning framework.

Consider two possible extensions of the model. One is to relax the independence assumption between R&D and marketing budget decisions, leading to a flexible, budget-constrained R&D-marketing mix problem. For example, when a substitution relationship exists between the R&D budget and the marketing budget for achieving a target attraction level of a new product, the optimal R&D-marketing mix will include a longer delay in launch time than in the case of the budget-contrained R&D-marketing mix (Yoon 1984).

Another extension is a multi-period problem, including dynamic marketing policies. In a dynamic environment the NPV maximization objective may be appropriate. The distribution of new product sales over the multiple planning periods will be critical. Dynamic optimal policies should be developed for each marketing instrument. For example, more sales in the early periods of the planning horizon will increase the value of the objective function over the whole planning horizon if imitative potential buyers exist. In order to stimulate the earlier purchase of a new product, an innovating firm may develop an advertising policy that allocates more spending in the earlier periods of the planning horizon. The firm may need to develop a dynamic optimal pricing policy that considers cost dynamics.

On net, while recognizing its limitations, the model provides an appropriate framework to balance the R&D and marketing decisions that must be weighed in deciding when a product should be launched.

BIBLIOGRAPHY

Bass, Frank M. (1969), "A New Product Growth Model for Consumer Durables," Management Science, 15 (January) 215-227.

Bass, Frank M. and Alain V. Bultez (1982), "A Note on Optimal Strategic Pricing of Technological Innovations," Marketing Science, 1(4) (Fall), 372-378.

Choffray, Jean-Marie and Gary L. Lilien (1980), Market Planning for New Industrial Products, John Wiley & Sons.

Dasgupta, P. and J. E. Stiglitz (1980), "Uncertainty, Industrial Structure, and the Speed of R&D," The Bell Journal of Economics, 11(1) (Spring), 1-28.

Deshmukh, S. D. and S. D. Chickte (1977), "Dynamic Investment Strategies for a Risky R&D Project," Journal of Applied Probability, 14, 144-152.

Dodds, Wellesley (1973), "An Application of the Bass Model in Long-Term New Product Forecasting," Journal of Marketing Research, 10 (August) 308-311.

Dolan, R. J. and A. P. Jeuland (1981), "Experience Curves and Dynamic Demand Models: Implications for Optimal Pricing Strategies," Journal of Marketing, 45, 52-62.

Eliashberg, Jehoshua and Abel P. Jeuland (1982). "New Product Pricing Strategies over Times in a Developing Market: How Does Entry Affect Prices?," The Wharton School Working Paper, No. 82-021 (August).

Horsky, D. and L. S. Simon (1983), "Advertising and the Diffusion of New Products," Marketing Science, 2(1) (Winter), 1-18.

Kalish, Shlomo (1983), "Monopolist Pricing with Dynamic Demand and Production," Marketing Science, 2(2) (Spring), 135-159.

Kalish, Shlomo and Gary Lilien (1986), "A Market Entry Timing Model for New Technologies," Management Science, 32(2) (February), 194-205.

Kamien, Morton I., and Nancy L. Schwartz (1972), "Timing of Innovations Under Rivalry," Econometrica, 40(1) (January), 43-60.

______ (1982), Market Structure and Innovation, Cambridge Surveys of Economic Literature, Cambridge University Press.

Lee, Tom K. (1982), "A Nonsequential R&D Search Model," Management Science, 28(8) (August), 900-909.

______ and Louis L. Wilde (1980), "Market Structure and Innovation: A Reformulation," The Quarterly Journal of Economics, (March), 429-436.

Lilien, Gary L. and Philip Kotler (1983), Marketing Decision Making: A Model Building Approach, Harper and Row.

______, Ambar G. Rao, and Shlomo Kalish. "Bayesian Estimation and Control of Detailing Effort in a Repurchase Diffusion Environment," Management Science, 27(5) (May), 493-506.

Loury, G. C. (1979), "Market Structure and Innovation," The Quarterly Journal of Economics, 93 (August), 359-409.

Mahajan, Vijay and Robert A. Peterson (1979), "Integrating Time and Space in Technological Substitution Models," Technological Forecasting and Social Change, 14, 231-241.

______ (1985), Innovation Diffusion: Models and Applications, Sage Press: Beverly Hills.

Nelson, Richard R and Sidney G. Winter (1982), An Evolutionary Theory of Economic Change, Cambridge, MA: Harvard University Press.

Nevers, John V. (1972), "Extensions of a New Product Growth Model," Sloan Management Review, 13 (Winter), 77-91.

Peterson, Robert A. and Vijay Mahajan (1981), "Multi-Product Growth Models," Research in Marketing, 4, JAI Press Inc., 201-231.

Reinganum, Jennifer F. (1981), "Market Structure and the Diffusion of New Technology," The Bell Journal of Economics, 12(2) (Autumn) 681-624.

______ (1982), "A Dynamic Game of R&D: Patent Protection and Competitive Behavior," Econometrica, 50(3) (May), 671-688.

Roberts, Kevin and Martin L. Weitzman (1981), "Funding Criteria for Research, Development, and Exploration Projects," Econometrica, 49(5) (September), 671-688.

Robinson, Bruce and Chet Lakhani (1975), "Dynamic Price Models for New-Product Planning," Management Science, 21(10) (June) 1113-1122.

Teng, J. T. and G. L. Thompson (1983), "Oligopoly Models for Optimal Advertising When Production Costs Obey a Learning Curve," Management Science, 29(9) (September), 1087-1101.

Urban, Glen L. and John R. Hauser (1980), Design and Marketing of New Products, Englewood Cliffs, NJ: Prentice-Hall.

Yoon, Eunsang (1984), New Product Introduction Timing Models: R&D and Marketing Decisions Considering Diffusion Dynamics, Ph.D. Thesis, The Pennsylvania State University (May).

______ and Gary L. Lilien (1985), "New Industrial Product Performance: The Effects of Market Characteristics and Strategy," Journal of Product Innovation Management, 3, 134-144.