New Industrial Product Performance: The Effects of Market Characteristics and Strategy*

Eunsang Yoon and Gary L. Lilien

There's no need to state again the complexity of the problem of achieving high performance in the new product process. What we do need is a framework to help sort out the complexity, and that is what Eunsang Yoon and Gary Lilien provide in this article. They first differentiate between original and reformulated new products. Then they examine how patterns of R&D and marketing activities determine short and long-run success.

Introduction

The long-term health of many organizations is tied to their ability to innovate—to provide existing and new customers with a continuing stream of new products and services. Under modern conditions of competition, it is becoming increasingly hazardous not to innovate. The firm that does not maintain a program of managed innovations can quickly find itself behind competition.

Although innovation is important, it is risky and costly. Booz, Allen & Hamilton [3] estimate that almost half of the resources spent on new products are allocated to products that are never successful in the market. They also report that of over 13,000 new products of 700 U.S. manufacturers, approximately one-third have not been successful. A survey of 148 companies by Hopkins [17] indicates that only half of the companies have achieved successful performance in two-thirds or more of their new industrial products. In a study of 122 industrial product innovations, Cooper [8] reports that for every 100 products that are fully developed, only 60 become commercial successes.

There are good reasons to believe that successful new product development will be even harder in the future. These factors include the shortage of new product ideas, the fragmentation of markets, increasing governmental restriction, capital shortages, and shorter product life cycles.

Thus, management is faced with a dilemma: It must develop new products to survive, yet the odds are weighted against their success. The recognition of this situation is instrumental in stimulating managements'

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BIOGRAPHICAL SKETCH

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strategic concern and academic research on new product innovation. In a study of 125 firms, Crawford [12] found that managements are increasingly recognizing that a new product R&D and marketing strategy should be explicit and central elements of corporate strategy. Empirical research has suggested the reasons for new product success and failure, and what separates successes from failure [6, 7, 11, 13, 17, 21, 22]. For normative purposes, key dimensions of new product strategy were identified [12], and scenarios for successful innovation were also suggested [4]. But relatively few empirical investigations have focused on testing the relationships between a firm's new product R&D/marketing/launch strategy and the new industrial product performance [1, 6, 9].

In the next section, we suggest a conceptual model of industrial new product performance, based on findings from recent innovation research. We then test several hypotheses and develop implications for new product market introduction strategies. Because of the nature of the sample and data collection, we consider this to be an exploratory study.

A Model of Innovation Performance

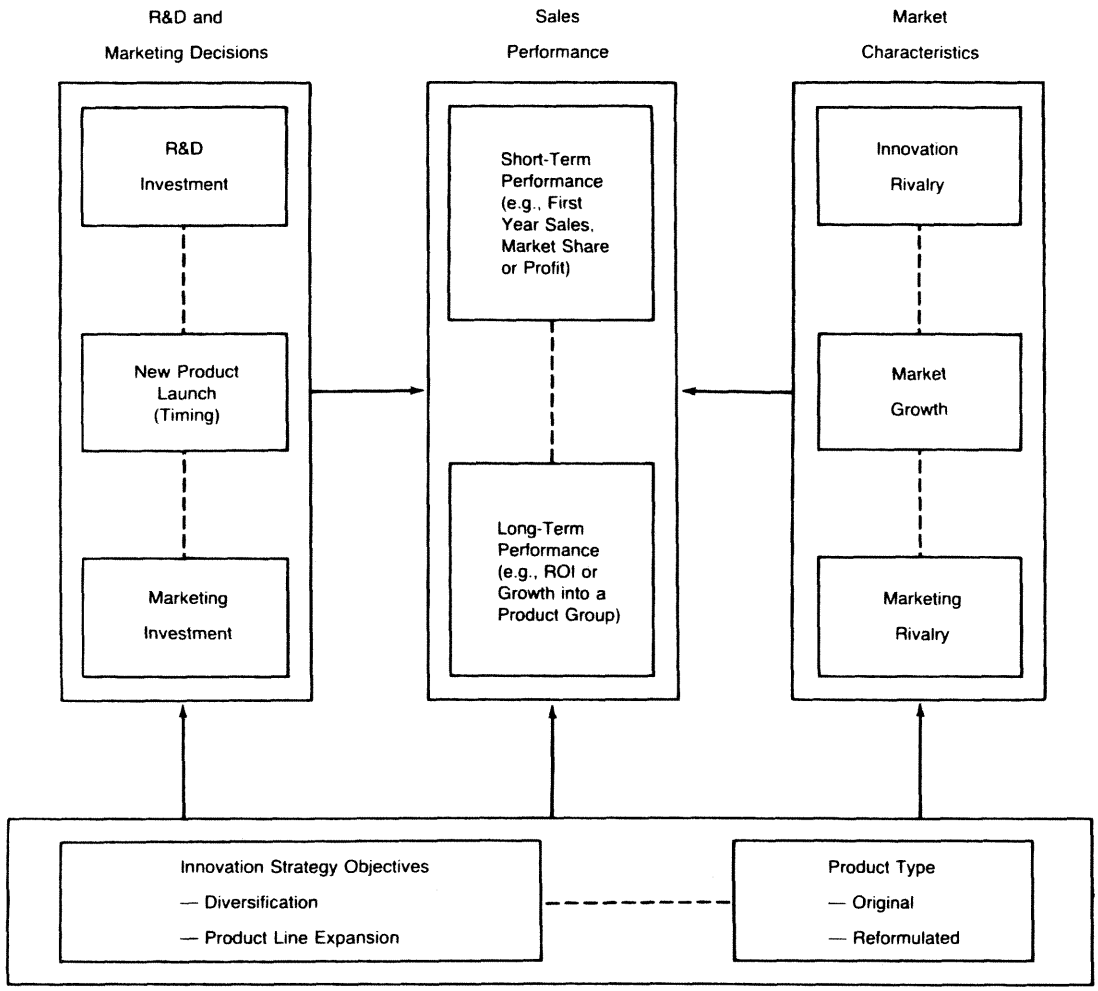
Our investigation centers around a set of research hypotheses derived from the conceptual model on new product performance in Exhibit 1. The model indicates the interactions between R&D and marketing investments, between short-term and long-term performance, and between innovation and marketing rivalry in the market. The model also suggests that product type/innovation strategy is related to R&D/marketing programs and the market environment, and that R&D/marketing decisions, market characteristics, and product type/innovation strategy all influence new product sales performance. This conceptual model of new product innovation performance is an extension of the new product R&D diffusion model, suggested by Yoon and Lilien [23] in developing a new product launch-time decision framework. It is also based on the results of empirical research on the determinants of new industrial product performance [1, 6, 10]. From the conceptual model, the following hypotheses have been selected for their normative value: each has important implications for new industrial product market introduction strategy.

Our discussion below will focus on two general classes of new products that we will call "original" and "reformulated" products. These are defined as follows:

- *Original new products* (ORNP's). ORNP's are technological breakthroughs, often relying on technologies never before used in the industry. They are referred to elsewhere [3] as "new product lines" and "new to the world" products.

- *Reformulated new products* (RFNP's). RFNP's are product line extensions or modifications. Here, the innovating firm modifies physical product characteristics. Such modifications reduce costs or enlarge the range of possible usage. They are referred to in other contexts as "cost reductions," "improvements," and "additions" [3].

Exhibit 1. A Model of Innovation Performance



Product Type and Innovation Strategy Objective

Our research hypotheses, below, focus on many key differences between these general classes of products.

Hypothesis 1 (H1)

ORNP's and RFNP's are heterogeneous in key strategic aspects of their R&D and marketing activities.

Comment 1. This hypothesis is a dichotomous version of the empirical finding that the degree of newness is one of the most important factors affecting a new product's success/failure [7, 14, 16]. In particular, we expect that ORNP's will provide the means for business line expansion for firms looking for diversification, whereas RFNP's will provide the mechanism for firms looking for product line expansion. These categories correspond, roughly, to Cooper's [10] "high budget, diverse strategy" and "low budget, conservative strategy," respectively.

Hypothesis 2 (H2)

The initial sales performance of a new product innovation is closely associated with the product's competitive marketing program strength and market characteristics, including the stage of the product life cycle and market structure.

Comment 2. Empirical studies show that new product success depends directly on product/market variables, including (1) the degree of newness and marketing efficiency, (2) the vulnerability of existing

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brands, (3) the long-term attractiveness of the product market, and (4) the ease of distribution access and other profit/sales-growth/share relationships [7, 16]. The relationship between market concentration and the success of a new product has been one of the logical derivatives of oligopoly theory [15]. But in some empirical studies, the inverse relationship between the market share of a new product and concentration was not supported [19].

Hypothesis 3 (H3)

The initial sales performance (operationalized as market share after 1 year) of a new product is related to the timing of the product launch, with initial success related to launch delay via a bell-shaped curve.

Comment 3. A premature entry may risk pushing an underdeveloped product into the marketplace, with possible negative feedback from customers and poor initial performance. On the other hand, potential sales will be sacrificed if entry is delayed too long, and poor initial sales will result as well. Kalish and Lilien [18] studied this issue for a government demonstration program for photovoltaics. Yoon and Lilien [23] also developed a launch-timing decision model based on the proposition that underlying controllable dimensions determining the performance of a new product innovation can be grouped as R&D efficiency and marketing efficiency.

Hypothesis 4 (H4)

A new product must gain rapid market acceptance and achieve a satisfactory market share within a short period of time if it is to become a market leader. If a new product does not realize a significant market share quickly (within a year or so), then its chance of becoming a leader is slim.

Comment 4. This hypothesis suggests that the destiny of a new industrial product is determined in the first few years following its introduction into the market [5]. Most new product-planning models, designed to forecast and diagnose short-term new product performance before and after test marketing, explicitly or implicitly accept this proposition [2].

The Data Base

In 1980, the Center for Research in Management Science at ESSEC,[1] in conjunction with The French Ministry of Industry and the Novaction Company,[2] launched a project to provide the basis for studying new industrial product innovation patterns.

The products studied represent a convenience sample from a list of 500 industrial firms registered in France, drawn randomly from a national directory in proportion to the importance of top priority sectors for French national policy. Firms were contacted in a two-step procedure. They were selected after a telephone interview, checking whether they had introduced a new product in the last 5 years. Next, selected firms were contacted sequentially and asked to participate in the study, after receiving a statement of the project objectives. The acceptance rate was 83%, and the final sample size was 112 products of 52 firms. Data were collected by personal interview, requiring about 3 man-days per product. Although these products were developed mainly by French companies, most were marketed in several major industrial countries, including the United States.

The following data were collected for this project for each product studied.

- *R & D process.* Cost structure, financing, duration, methods of product evaluation, types of protection, etc.
- *Market introduction strategy.* Basis for decision, success or failure, evaluation criteria, initial marketing mix, etc.
- *Market penetration.* Sales of the new product and its prime competitors, market structure, changes in the marketing mix, etc.

Other data included managerial judgments about how the new product performs relative to competition, information on the objectives set for the new product,

[1]ESSEC is Ecole Superieure des Sciences Economiques et Commerciales.

[2]Novaction Company, a leading European consulting firm and a member of the Institute for the Study of Business Markets at the Pennsylvania State University, provided access to these data for this research.

Exhibit 2. Major Industrial Sectors Represented in the Data Base

Industrial sector	Number of new products	Percent of total
Electronics, electrical equipment, scientific instrumentation	43	38
Chemistry, biochemistry	17	15
Construction, earth moving	15	14
Transport, services	11	10
Metal processing, metallurgy	10	9
Food, agriculture	9	8
Miscellaneous	7	6
Total	112	100

the way these objectives evolved over time, and how they were achieved.

We have reproduced the distribution of the sample across industrial sectors in Exhibit 2. The electronics and scientific instrumentation area is well represented, reflecting both national policy emphasis and the high level of innovation in this sector. The miscellaneous sector includes a heterogeneous set of new industrial products, ranging from computer software to tank engines.

Analysis Results

H1: Comparison between Original and Reformulated Products

Of the 112 products in the data base, 100 had sufficiently complete data for the items under test. Of these, 41 items are ORNP's and 52 items are RFNP's. We performed a (two-tailed) t-test of two group means, along with an equal variance test between ORNP's and RFNP's, to test for strategic differences between these groups. The complete details of that comparison are available elsewhere [24], and those results can be summarized as follows: compared with reformulated new industrial products, original new industrial products

1. are more diversification oriented/less expansion oriented;
2. have higher R&D cost for basic research and lower R&D cost for prototype development;
3. are in markets where potential buyers show lower satisfaction with existing products;
4. are developed by firms with higher production expertise/lower marketing expertise;
5. have higher degree of innovativeness/lower market competition;
6. are in an earlier stage of the product life cycle, smaller number of competitors/lower market concentration ratio;
7. use more direct selling/infrequently use a high price strategy.

Note that these results describe the circumstances and strategies of products of these two types. There are many differences. To the extent that these differences reflect the sound judgment of successful decision makers, the results may be used normatively as guides for successful launch strategies [20]. For example, a firm will have a higher chance of success with an original new industrial product when the firm has a strategic plan to expand its business line, has the capability to invest for basic research, and has high expertise in production. It will also have an improved chance for success if the target market is less satisfied with existing products, is less competitive, and is in an earlier stage of the product life cycle.

H2: Short-Term Performance: First-Year Market Share

Hypothesis 2 deals with short-term performance of new industrial products. The results of H1 showed that ORNP's and RFNP's are quite dissimilar. Therefore, we study them separately below.

We use analysis of variance as the mechanism here, where the criterion (dependent) variable is first-year market share. That variable is then related to independent variables,[3] as shown in Exhibit 3. In Exhibit 3A, we see that for ORNP's, 86% of the variation in the first-year market share is explained by five categorical variables and their interactions.

Four market situation variables are important in explaining the initial market share achievement of an original new industrial product: the relative competit-

[3]The heavily skewed distribution of the independent variables led us to transform them into 0–1 dichotomous variables to stabilize the analysis.

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Exhibit 3. ANOVA Results on First-Year Market Share

First-year market share (dependent variable)

A. ORNP Model[a]

Source	df	ANOVA SS	F value	$p > F$
Model	8	28592.2	14.35	0.0001
DGRCM	1	8996.5	36.12	0.0001
LFCLA	1	6091.0	24.45	0.0001
GRWTH	1	4906.0	19.70	0.0003
BLCOM	1	3857.8	15.49	0.0001
MEF2	1	1991.1	7.99	0.0112
MEF2*GRWTH	1	1070.9	4.30	0.0527
MEF2*LFCLA	1	865.9	3.48	0.0786
MEF2*DGRCM	1	813.0	3.26	0.0876
Error	18	4483.4		
Total	26	33075.6		

[a]Mean square (model) = 3574.0; mean square (error) = 249.1; R square = 0.864.

B. RFNP Model[a]

Source	df	ANOVA SS	F value	$p > F$
Model	10	16766.0	11.86	0.0001
ATS	1	5516.7	40.86	0.0001
MEF3	1	3212.6	23.79	0.0001
OBJEX	1	3063.0	21.67	0.0001
BLCOM	1	709.4	5.25	0.0310
DGRCM	1	462.2	3.42	0.0766
MEF3*OBJEX	1	2209.5	16.36	0.0005
DGRCM*LFCLA	4	1592.6	2.82	0.0467
Error	25	3534.2		
Total	35	20300.2		

[a]Mean square (model) = 1676.6; mean square (error) = 141.4; R square = 0.826.

Variable Definitions: (DGRCM) Relative degree of competitiveness of the market, compared with the other markets: 1 indicates strong or average; 2 indicates weak. (LFCLA) Stage of product life cycle at the product's market launch time: 1 indicates introductory stage; 2 indicates growth stage. (GRWTH) Market growth rate in the existing market (more or less than 10%). (BLCOM) Number of competitors before market launch (more or less than 5%). (MEF2) The average of the scores of the marketing efficiency of advertising (MEFAD) and of distribution-supporting advertising (MEFDA); both were scaled over ranges from 1 to 7 (much less or much more efficient, respectively; broken at scale-median). (MEF3) The average of the scores of the marketing efficiency of advertising (MEFAD), distribution-supporting advertising (MEFDA), and distribution effort (MEFDI). All three were scaled over a range from 1 (much more efficient) to 7 (much less efficient). (OBJEX) Degree of importance of the strategic objective—to expand the product group: 1 indicates most important; 4 indicates least important. (ATS) Potential buyers' satisfaction with the service level of existing products: 1 indicates completely satisfied; 2 indicates totally dissatisfied.

iveness level of the market (DGRCM), the stage in the product life cycle (LFCLA), market growth rate (GRWTH), and the number of competitors (BLCOM).

First-year market share is higher when

- the degree of competitiveness in the market is low,
- the product-class life cycle is in the introductory stage;
- the market growth rate is low;
- the number of competitors is small.

The level of relative efficiency of the firm's marketing strategy influences the new product's performance level not only directly but also by interacting with market condition variables, such as degree of competitiveness of the market, stage of the product life cycle, and market growth rate.

Higher marketing efficiency, such as in advertising, leads to better market share performance. Its influence is particularly important when

- the market growth rate is lower;
- the product-class life cycle is in the introductory stage;
- the degree of competitiveness in the market is lower.

An important implication of these results is that because the success of the original new industrial product depends heavily on *uncontrollable* market variables, the selection of the market opportunity, as well as the product itself, is critical to the success of ORNP's.

In Exhibit 3B for RFNP's, 83% of the variation in the first-year market share is explained by seven categorical variables and their interactions.

The potential buyer's attitude toward existing products (ATS), the marketing efficiency level of the innovating firm (MEF), the strategic objective of product line expansion (OBJEX), the number of competitors in the market (BLCOM), and the competitiveness level of the market (DGRCM) are important in explaining the initial market share performance of a reformulated new

industrial product. First-year market share is higher when

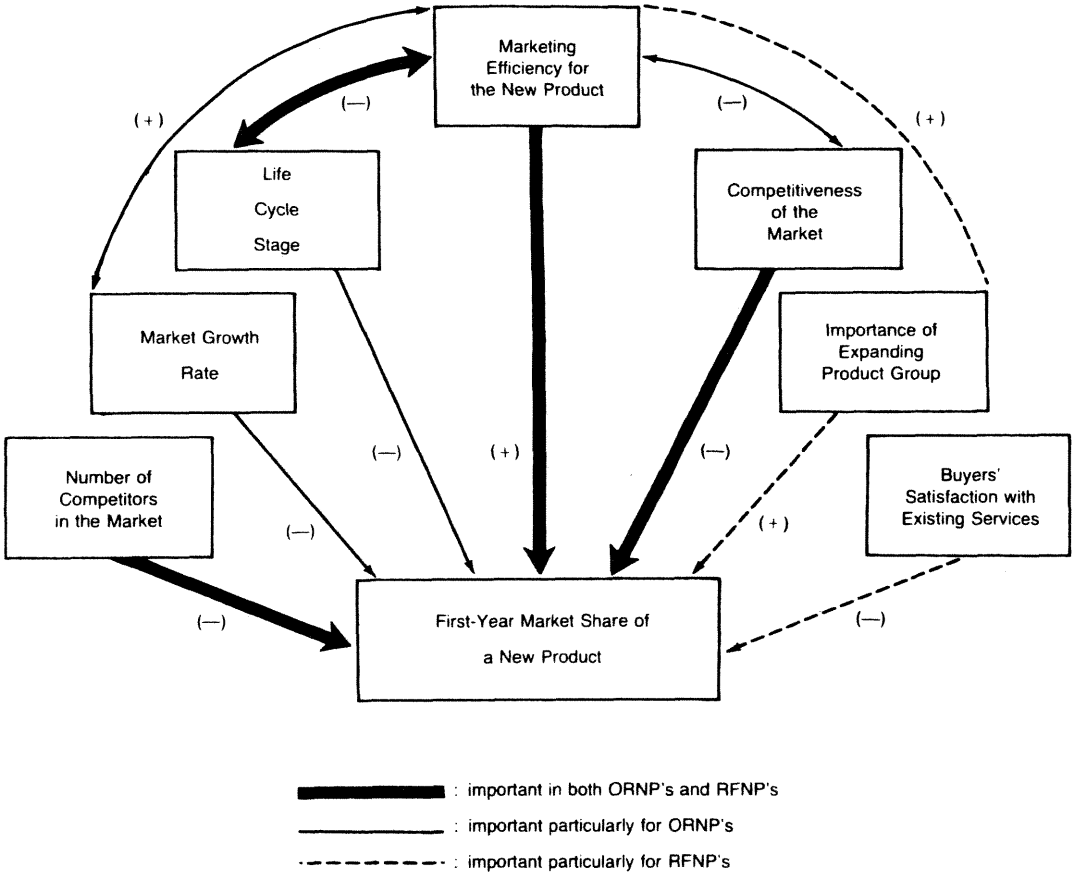
- potential buyers' satisfaction with the "service" level of existing products is lower;
- marketing efficiency in advertising and distribution is perceived to be higher;
- a strategic objective for the reformulated new product is for expansion of the product group;
- the number of competitors in the market is small;
- the competitiveness level of the market is low.

The marketing efficiency level influences the new product's performance level not only directly but also through interaction with the strategic objective: expansion of the product group. The effect of marketing efficiency on market share performance is higher when the expansion of the product group is an important objective for the new product.

The stage in the product life cycle has a negative effect on first-year performance, particularly in a strongly competitive market.

In summary, those variables related to market potential and structure are critical for explaining short-term performance for ORNP's, whereas those variables related to the level of customer satisfaction with the existing products and the strategy-product type fit are particularly critical for RFNP's. The relative marketing efficiency of the innovating firm for the new product diffusion are important for the new product's initial market share performance, both for ORNP's and RFNP's. Among marketing instruments, advertising was found to be an important factor for ORNP's, whereas distribution effort is important for RFNP's. The structure of these relationships is summarized in Exhibit 4.

Exhibit 4. The Determinants of First-Year Market Share for Original and Reformulated New Industrial Products



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H3: Launch-Time Delay and Initial Market Share

Here, we investigate the hypothesis that the initial sales performance of a new product is related to the timing of the product launch: for example, the sales performance increases up to a certain point and decreases thereafter with respect to a delay of launch time [18, 23]. We analyze the market share of the new product during the first launch year and relate it to the time lag between the decision to develop the product and the introduction of the new product into the marketplace. We only include a small subset of the data base here, however, noting that (1) the new product items that realized 100% market share are not appropriate for our analysis because they are monopoly items, and (2) many product items that realized low levels of initial market share, not more than 10%, say, were generally unsuccessful (H2) and are inappropriate for our analysis.

To test this hypothesis on a homogenous data base, we separated the data into original and reformulated *successful* new products where, to be successful, a product had to both achieve an initial market share of at least 10% and grow into a product group in the long run.

In Exhibit 5A, first-year market share of the successful original new products shows an increasing trend at first, but a decreasing trend later, as the launch time is delayed. This curving trend is statistically tested in Exhibit 5C, Equation 1, by fitting a quadratic function. The regression analysis shows that the first-year market share of (successful) ORNP's is explained by a quadratic function of launch-time delay. On the other hand, first-year market share of (successful) RFNP's monotonically decreases with launch-time delay, as shown in Exhibit 5B. This down-sloping trend is statistically tested in Exhibit 5C, Equation 2, through linear and log-linear functions.

This analysis leads us to conclude that H3 is partially supported by a limited (and expost) data base of new industrial products; for (successful) ORNP's, first-year market share increases with delay of launch time up to a certain point and decreases thereafter. For RFNP's, however, we found that initial market share performance decreases with delay of new product launch time. This contrast between ORNP's and RFNP's may reflect differences in product-market situations: in particular, the market is relatively better developed for RFNP's than for ORNP's; the longer an incremental innovation takes to get to market, the greater its risk of failure due to changing market conditions, competitive response, or further technological advances.

H4: Long-Term Performance: Growth into a Product Group

In studying short-term performance, we used analysis of variance because the dependent variable, first-year market share, was a continuous variable. For long-term performance, we used a dichotomous variable—whether or not the product developed into a product group—as the measure of success. Our analytical plan, then, is to use discriminant analysis to identify characteristics that distinguish between those products that do (and do not) develop into a product group.

In Exhibit 6, we again run separate analysis for ORNP's and RFNP's. We see that the following factors are important in determining the long-run success of a (reformulated or original) new industrial product innovation (measured in terms of whether it grows into a product group):

- the degree of expertise in marketing activity;
- the marketing effectiveness for the new product diffusion;
- the stage of product life cycle.

Potential buyers' satisfaction level with existing products is also important for the long-run performance of a reformulated product.

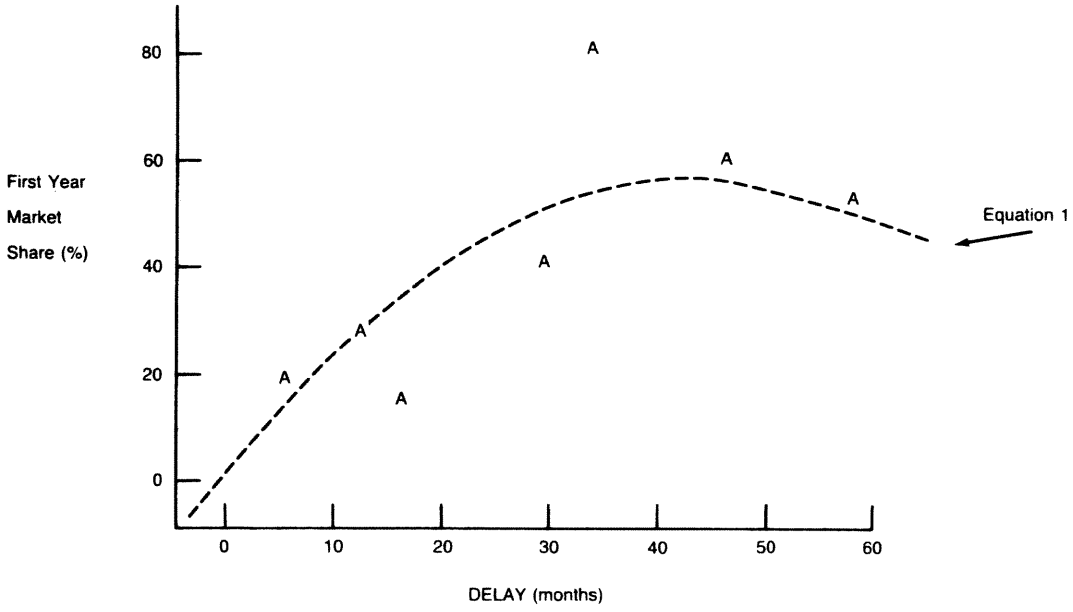
Finally, we investigated the relationship between short-term and long-term success. We found a significant, positive correlation between the chance for a product to grow into a product group and first-year market share. (Spearman's rho = 0.24 for ORNP's and 0.21 for RFNP's.) This suggests that, as expected, short-run success is a positive determinant or predictor of long-run success.

Conclusions and Implications

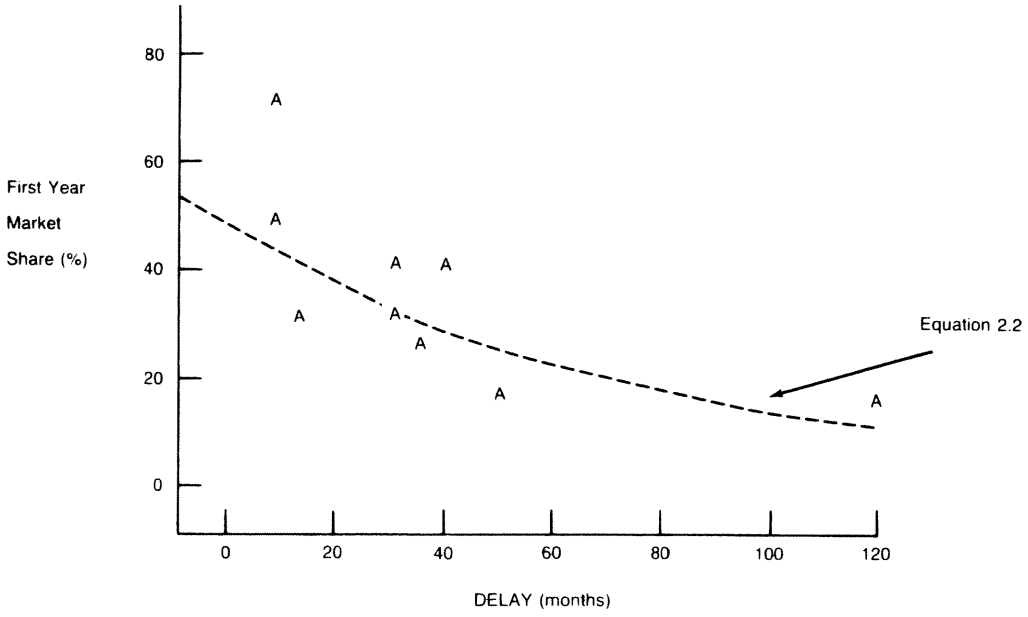
This research has focused on the development of a conceptual model of the determinants of new industrial product success and has derived several testable hypotheses from that model. When comparing ORNP's with RFNP's, we found that these product types had different objectives (e.g., ORNP's are more diversification oriented), different marketing programs (e.g.,

Exhibit 5. Original and Reformulated New Products and Regression Models

A. ORNP's Relationship between Launch-Time Delay and First-Year Market Share: Successful Industrial New Products



B. RFNP's Relationship between Launch-Time Delay and First-Year Market Share: Successful Industrial New Products



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C. Regression Models

Relationship between Launch Time Delay and First-Year Market Share: Successful Industrial New Products

ORNP's That Achieved Short-Run and Long-Run Successes

		F value	R square
Equation 1.	FSTSH = 2.354 Delay − 0.024 Delay^2 ⟨4.09⟩[a] ⟨−2.00⟩[a] (0.01)[b] (0.10)[b] $n = 7$	30.90 (0.002)	0.925

RFNP's That Achieved Short-Run and Long-Run Successes

		F value	R square
Equation 2.1.	FSTSH = 46.609 − 0.344 Delay ⟨7.30⟩[a] ⟨−2.55⟩[a] (0.00)[b] (0.04)[b]	6.50 (0.038)	0.482
Equation 2.2.	log(FSTSH) = 3.846 − 0.012 Delay ⟨23.91⟩[a] ⟨−3.59⟩[a] (0.00)[b] (0.01)[b] $n = 9$	12.85 (0.009)	0.647

where FSTSH is the market share of a new product realized during the first launch year, and Delay is the time lag between the decision of physical product development and new product launch into the market place.

[a]⟨ ⟩ indicates t value for the hypothesis (parameter = 0).
[b]( ) indicates significance level.

ORNP's used more direct selling), and are introduced in different environments (ORNP's are introduced in markets where potential buyers show lower satisfaction with existing products).

New product sales performance is closely related to competitiveness in the marketplace, the stage in the product-class life cycle, the market growth rate, the number of competitors in the marketplace, and the marketing efficiency of the seller.

An interesting result emerged from our analysis of the appropriate launch time for the new product. Our analysis suggested that, all things equal, it pays to launch a RFNP as early as possible, whereas success levels were highest for ORNP's when launch was delayed somewhat. This may reflect the greater care taken with new product and market development activities for ORNP's.

Our findings suggest that two major sets of variables seem to be at work in determining the success of a new industrial product. These are market-situation variables and R&D/marketing-strategy variables. We see varying levels of success for different product types in different market situations here. And strategy variables must be tuned to the specific market situation, determining the best use of marketing resources and the best time to launch the new product [23].

There are several ways a manager can use these results. First, they provide a quantitative checklist for the manager of a soon-to-be launched product, identifying an appropriate set of objectives and a marketing strategy. Indeed, by providing estimates of the level of key market situations and marketing strategy variables in Exhibits 3 and 6, the manager can receive a *prediction* of the level of first-year market share performance and the likelihood that the product will grow into a product group. Secondly, for a manager of a recently introduced product, these results provide diagnostic information, suggesting what product and market variables

Exhibit 6. Discriminant Analysis of Long-Run New Product Success

1. Original New Industrial Products

Linear discriminant function:

GRPGR = 5.65 − 2.88 LFCLA − 0.29 EMPMK − 0.24 MEF.

Percent properly classified = 94.4 (n = 18).

2. Reformulated New Industrial Products

Linear discriminant function:

GRPGR = 1.86 − 0.07 LFCLA − 0.42 EMPMK − 0.05 MEF − 0.38 ATR.

Percent properly classified = 91.3 (n = 22).

Variable definitions: (GRPGR) = 1) A new product item has developed into a product group; (GRPGR = 0) it has not. (LFCLA) Stage of the product life cycle at the new product's market launch time: 1 indicates introduction; 2 indicates growth; 3 indicates maturity. (EMPMK) Expertise in marketing activity of the innovating firm: 1 indicates strong; 2 indicates average; 3 indicates weak. (MEF) Marketing efficiency measure: 1 indicates much more efficient . . . 7 indicates much less efficient. (ATR) Potential buyers' attitudes toward the existing product's reliability: 1 indicates completely satisfied; 7 indicates totally dissatisfied.

may have caused the level of product performance to be different from what was expected. The results can even be used retrospectively, analyzing a firm's prior successes and failures by using the models developed here. Such an analysis can be developed into a new product performance screening procedure and can lead to higher future levels of new product success.

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