NEW INDUSTRIAL PRODUCT PERFORMANCE: MODELS AND EMPIRICAL ANALYSIS

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ABSTRACT

New products are important elements in the success of most industrial enterprises. But they are risky and costly. In this chapter we review methods that are used to evaluate the likely sales level for new industrial products prior to launch, and discuss the relation between those methods and what we know about innovation diffusion. Then we report the results of a study of industrial product diffusion, focusing on those factors associated with successful market penetration. Those results are incorporated into a decision support system that can be used to help plan the entry strategy for a new industrial product as well as to forecast its level of success.

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INTRODUCTION

Few products, whether industrial or consumer, gain immediate acceptance in the marketplace. And few companies appear satisfied with their level of success in the marketplace.

According to Hopkins (1980) as many as two thirds of industrial firms consider their success rates "disappointing" or "unacceptable." Cooper (1982) reports a mean failure rate of 41% for fully developed new products (those that successfully passed through the development process). There is high variance in these failure rates, some reported to be 50% to 90% (Choffray and Lilien 1980). Booz-Allen and Hamilton (1982) report a failure rate of 35% for new products.

These high failure rates underscore the difficulty both of separating successful strategies from those that are less successful and of assessing the level of sales for new industrial products with an acceptable degree of accuracy. Such forecasts are critical not only for production planning, but also for financial planning. Indeed, severe losses are often observed over the first four years following market introduction. Based on a sample of 68 new ventures launched by 35 U.S. companies, Biggadike (1979) reports that the median ROI was −40% in the first two years and −14% in years 3–4. In addition, early profitability does not necessarily guarantee future success. Most of the time, the key to improving financial results is to balance profitability with rapid sales growth via a suitable marketing program.

In this chapter we review how industrial firms forecast sales for their new products. We then discuss the theoretical and empirical determinants of the rate of "diffusion" of industrial products.

We report on results of a recent research project conducted over the last five years in Europe. The foundation of the study was a large, international data base, containing detailed information on the development process, the market entry strategy and the associated level of success for 112 new industrial products. Statistical analysis lead to the identification of some key determinants of success. These results, currently incorporated into a decision support system, can be used to develop and study the likely sales paths of new industrial products prior to market entry. Special attention should be given when using this system in a different environment than Europe, however, as the generalizability of our results to other countries is still under study.

FORECASTING INDUSTRIAL SALES PRIOR TO MARKET INTRODUCTION: THE STATE OF PRACTICE

The past few years have seen an explosion in the number and sophistication of methods used to assess likely market sales prior to market entry. Most of these methods have been concerned with frequently purchased consumer goods, how-

ever, a product class that has a long history of investing heavily in market research. Numerous methods for concept evaluation, test market simulation, early market sales-monitoring and so forth are in regular use (Choffray and Dorey 1983; Urban and Hauser 1980; Wind 1982).

In the industrial products area, the research tradition is not as rich. At a recent seminar given at ESSEC[1], the most common method that top industrial marketing executives reported using to assess markets for their new products was. . . . no method at all! This observation is consistent with a report by Piatier (1981) that 68% of industrial firms who had introduced products during the last 5 years had done so without any prior market assessment, and survey results reported by Yanahan (1982) that reported only 37% of a group of 129 widely diversified firms used new product models.

Those firms that use market assessment appear to rely on three broad categories of methods.

The subjective approach: Many industrial firms that report using no method of market assessment mean that they do not rely on any *formal* method. But, they usually make use of their past experience in the launching of new products and activities. The sales force is often a key "reservoir" of that experience.

Delphi-like procedures fall into this category. Such methods consist of grouping together several individuals who are knowledgeable about the product and market, often an interfunctional management group within a firm supplemented by external "experts." Then, the methods require that the individuals agree on their assessment of the market for the new product, as well as the factors that are likely to affect it.

The experimental approach: In this method, industrial firms offer the new product for sales or consideration on a scaled down basis, limited by geography or, perhaps, to a few friendly firms. Measurements of how prospective buyers react are then obtained along with constructive product feedback.

Such data may be collected in industrial exhibition halls, at trade shows or at actual test installations in prospective customer plants.

Once data are collected, several methods can be used to assess future market acceptance. Among these, conjoint analysis (Wind, Grashof and Goldhar 1978) and the DESIGNOR procedure (Choffray and Lilien 1982) may lead to insights about how the new product is likely to be accepted.

In a way, these experimental methods are the counterpart of "test markets" for frequently purchased consumer goods.

The analogue approach: Here, industrial firms proceed by comparison. They consider "look-alike" product-market situations about which they have past information, to infer what their new product's market acceptance might be at various points in time.

All three classes of methods have their pros and cons. The subjective approach may be most useful when the firm is about to introduce a fundamentally new product which bears little resemblance to previous products. Here the market not only has to be identified; it has to be created. Methods used in decision analysis (Keeney and Raiffa 1976) and in mathematical psychology (Saaty 1977) can be used for this kind of problem as they systematize the subjective evaluation process, and measure the risks involved. They also provide a mechanism for consensus building in the evaluation process.

Experimental, market-based methods, are most useful in situations where the target market is well defined and forecasting short-term product penetration is the objective. They tend to be less useful for assessing long-term product performance or the actual time path of market penetration. In addition, experimental methods use expensive data collection procedures.

Analogue methods are an interesting alternative. Their drawback has been the limited base of experience any individual has and the determination of an appropriate analogue. Several studies have demonstrated how both these problems can be overcome by (a) pooling a large base of commonly collected information; and, (b) developing "analogues" along commonly measured product/market dimensions (value-in-use, ROI, number of customers, etc.). The ADVISOR models (Lilien 1979; Lilien and Weinstein 1984) and the PIMS Program (Shoeffler, Buzzell and Heany 1974) are examples of the use of the analogue approach in the industrial marketing budgeting and strategic planning area. The fourth section of this chapter describes how this approach is applied to the new industrial product market assessment area.

INDUSTRIAL PRODUCT ACCEPTANCE AS A DIFFUSION PROCESS

We refer to the process by which a new product penetrates its target market as a diffusion process. For most industrial products, this process incorporates two types of behavior:

> *Adoption Behavior*, that is, the process by which potential adopting firms try the new product independently of each other (innovative adoption) or as result of the influence exerted by other firms (imitative adoption behavior).
> *Replacement Behavior*, that is, the process by which adopting firms repeat purchases of the product when needed.

The relative importance of these two behaviors will vary depending on the product use cycle and the length of the forecasting horizon. For new capital goods and processed materials, adoption behavior will be the most important determinant of market acceptance over a medium-range horizon (5 to 10 years).

Rogers (1983) and Rogers and Stamfield (1968) have investigated the factors that influence the diffusion of innovations in different environments. They observed, all others things being equal, that an innovation will gain faster acceptance if:

- it has a strong relative advantage
- it has a high degree of compatibility with existing attitudes and values[1]
- it fulfills felt needs
- it rates low on complexity
- it is divisible and may be tried on a limited basis
- it is communicable
- it is available, and
- it offers an immediate or short-term benefit.

More formal models of the diffusion process have been developed to allow users to better understand and forecast the rate of adoption of new products, on the basis of limited data (Lilien and Kotler 1983). These diffusion models attempt to produce a life-cycle sales curve based on a small set of observations whose minimum number varies according to the number of parameters included in the model.

Of key importance is the work of Mansfield (1968). He investigated how rapidly the use of twelve innovations spread from enterprise to enterprise in four industries—bituminous coal, iron and steel, brewing and railroads. These innovations included new products and processes such as the by-product coke oven, the continuous wide-strip mill, pallet-loading equipment, a high-speed bottle filler, etc. The model hypothesized by Mansfield had essentially the following form:

$$\text{increase in the new product's penetration} = \text{adoption rate constant} \times \text{current penetration level} \times \text{maximum penetration level minus current penetration level}$$

where:

- *the adoption rate constant* characterizes the adoption rate associated with a particular new product or technology,
- *the current penetration level* corresponds to the proportion of target adopters that have accepted the new product at the moment of interest, and
- *the maximum penetration level* is a limit on the proportion of target adoptives that the new product or technology will capture in the long run.

The difference (maximum penetration level minus current penetration level) corresponds to the untapped potential of the new product at a point in time. The model states that the increase in the new product's penetration is proportional to the current penetration level multiplied by the untapped potential. This particular mathematical form illustrates the effect that current adopters exert on potential adopters (imitative adoption behavior). For example, if the current penetration level were 10%, the maximum attainable level were 60%, and the adoption rate constant were 20%, then the change in new product penetration (this period's sales) would be .20 × .10 × (.50-10) or about 1%.

The most important contribution of Mansfield (1968) lies more in the analysis that he did of the adoption rate—the constant—than in the actual structure of his model. Based on his empirical studies, he showed that this rate was higher when:

- the relative profitability associated with the new product was *high;* and,
- when the initial investment relative to the average assets of adopting firms was *low*.

He also observed substantial variations in the market acceptance rate across industrial sectors.

Blackman (1974) built on Mansfield's results. He defined an industry-innovation-index that indicates the relative tendency of various industrial sectors to innovate. His index is derived from a factor analysis of various input variables that reflect how resources are allocated to achieve innovation. It is then related to interindustry differences observed in the achievement of new product and process innovation.

The Mansfield-Blackman analysis was the first attempt to relate the adoption rate for a new product to some operational measure of its economic effectiveness and to the "receptivity" of the target market. This analysis has some limitations, however. In addition to its age, it deals with a small set of macroeconomic variables as the driving force of the diffusion process and neglects the results from other studies, (Schoeffler, Buzzell and Heany 1974) that indicate that a business' performance is closely tied to its marketing strategy, the quality of its products, and to the structure of the markets with which it deals. The study described below addresses several of these limitations.

A STUDY OF INDUSTRIAL PRODUCT DIFFUSION

In 1980, the Center for Research in Management Science at ESSEC in conjunction with The French Ministry of Industry and Novaction International, a leading European consulting firm, launched a project to study the reasons for new product success and to provide the basis for developing analogues for sales growth patterns for new industrial products. It was decided to develop a data base of individual new products, including information on the development process, the marketing strategy and the rate of market penetration for a five year period.

The products studied represent a convenience sample from a list of 500 industrial firms reflecting 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 five 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%. The original target was 100 products and the final sample size was 112, from 92 different firms due to time lags and some over-sampling. Data were collected by personal interview, requiring about threeman-days per product. Although these products were mainly developed by French companies, most are marketed in several major industrial countries, including the United States.

Three types of new industrial products were distinguished in this study:

Repositioned new products (RPNP: 7%), are "me too" products whose physical characteristics are not fundamentally different from those of existing products (e.g., extended after-sales service added to existing mini computers). The innovative firm tries to change the way potential buyers perceive the product. These would for instance, correspond to "Repositionings" in the Booz-Allen and Hamilton (1982) study.

Reformulated new products (RFNP: 52%), are often product line extensions (e.g., new mini computer). For these products the innovative firm actually modified physical product characteristics. Such modifications reduce production costs or enlarge the range of possible uses. ("Cost Reductions," "Improvements," "Additions" in Booz-Allen and Hamilton 1982).

Original new products (ORNP: 41%) are those new products that constitute "break-throughs" in their field (e.g., satellite imagery). Products in this category often rely on new technologies never used before in that industry. ("New Product Lines," "New-to-World Products" in Booz-Allen and Hamilton, 1982).

For each of the 112 products included in the data base, over 500 pieces of information were collected on the:

R&D Process: Cost structure, financing, duration, methods of evaluation, types of protection, etc.

Market Introduction Strategy: Bases for decision, success or failure, evaluation criteria, initial marketing mix, etc.

Rate of Product Penetration: Sales volume and $ sales for the new product and its prime competitors, market structure, changes in the marketing mix, etc.

Marketing penetration information was collected on a quarterly basis, when possible, over a five year period after market introduction. Other data include managerial judgments about how the new product performs relative to competition, information on the objectives set for the new product, 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 1. The electronics and scientific instrumentation area is well represented

Exhibit 1. 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

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.

NEW PRODUCT PERFORMANCE

Model and Hypothesis

Prior to developing a model for forecasting market penetration, we describe and study the relationship among factors affecting new industrial product success. We formalize this study in a series of hypotheses, as follows:

HYPOTHESIS 1: Original new products and reformulated new products differ with respect to key strategic aspects of their R&D and marketing activities.

Comment: 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 (Cooper 1979; Finkin 1983; Heany 1983). In particular, we expect that Original New Products will provide the means of business line expansion for firms looking for diversification while Reformulated New Products will provide the mechanism for firms looking for product line expansion. These categories correspond roughly, to Cooper's (1984) "High Budget, Diverse Strategy" and "Low Budget Conservative Strategy" respectively.

HYPOTHESIS 2: The initial sales performance of a new product innovation is closely associated with the effectiveness of the product's marketing program relative to competition and market characteristics, including the stage of the industry life cycle and market structure.

Comment: Empirical studies show that new product success directly depends on product/market variables including (a) the degree of newness and marketing efficiency, (b) the vulnerability of existing brands, (c) the long-term attractiveness of the product market, and (d) the ease of distribution access and other profit/sales-growth/share relationships (Cooper 1979; Heany 1983). The relationship between market concentration and the success of a new product has been one of the logical derivatives of oligopoly theory (Friedman 1977). But in some empirical studies the inverse relationship between the market share of a new product and concentration was not supported (King and Thomson 1982).

HYPOTHESIS 3: The initial sales performance (operationalized as market share after one year) of a new product is related to the timing of the product launch. Initial success will be highest if product launch is delayed for an intermediate amount of time (6 mo. to 1 yr.) after the product is technically ready relative to success when delay is shorter or longer.

Comment: 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 to competition if entry is delayed too long and poor initial sales will result as well. Kalish and Lilien (1986) studied this issue for a government demonstration program for photovoltaic cells (solar batteries). Yoon and Lilien (1986) 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: 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: This hypothesis suggests that the destiny of a new industrial product is determined in the first few years following its introduction into the market. 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 (Blackburn 1982). This hypothesis is supported by the work of Horsky and Simon (1983), who found that optimal allocation of new product advertising resource requires heavy spending shortly after introduction to build the best possible early market position.

Results

H1: *Comparison Between Original and Reformulated Products*

We performed a (two-tailed) T-test of two groups means, along with an equal variance test between ORNP's and RFNP's to test for strategic differences between these groups. Both these groups contained about one-quarter truly successful products and three-quarters somewhat less successful products according to the definition we develop in analyzing hypothesis 2. Our results can be summarized as follows: compared with reformulated new industrial products, original new industrial products

a. are more diversifications-oriented/less expansion-oriented;
b. have higher R&D cost for basic research and lower R&D cost for prototype development;
c. are in markets where potential buyers show lower satisfaction with existing products;
d. are developed by firms with higher production expertise/lower marketing expertise;
e. have higher degree of innovativeness/lower market competition;
f. are in an earlier stage of the industry life cycle, smaller number of competitors/lower market concentration ratio;
g. 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 might be used as guides for developing launch strategies. For example, managers of original new industrial products are more likely to launch products 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 be more likely to launch products if the target market is less satisfied with existing products, is less competitive, and is in an earlier stage of the industry life cycle.

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

Hypothesis 2 deals with short-term performance of new industrial products. The results of Hypothesis 1 showed that Original New Products and Reformulated New Products are quite dissimilar. We therefore 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 as shown in Exhibit 2. In Exhibit 2a we see that for ORNP's, 86 percent of the variation in the first-year market share is explained by five categorical variables and their interactions.

1. Four market situation variables are important in explaining the initial market share achievement of an original new industrial product: the relative competitiveness 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, and
- the number of competitors is small

2. The level of stated efficiency of the firm's marketing strategy relative to competitors 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, and
- the degree of competitiveness in the market is lower.

An important implication of these results is that, since 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.

(a) 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 buyer's satisfaction with the "service" level of existing products is lower

Exhibit 2. 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 import. (ATS) Potential buyers' satisfaction with the service level of existing products: 1 indicates completely satisfied; 2 indicates totally dissatisfied.

Note: All efficiency measure were scaled "relative to the average in this market." The scores—from 1 to 7—were given as those

- 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, and
- the competitiveness level of the market is low.

(b) 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.

(c) The stage in the industry 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, while 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 is 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 original new products, while distribution effort is important for reformulated new products. The structure of these relationships is summarized in Exhibit 3.

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 (Kalish and Lilien 1986; Rothwell et al., 1974). 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 (a) the new product items that realized 100% market share are not appropriate for our analysis because they are monopoly items, and (b) many product items that realized low levels of initial market share, not more than 10 percent, were generally unsuccessful (Hypothesis 2) and are inappropriate for our analysis.

In order to test this hypothesis on a homogenous data base, we separated the data into Original and Reformulated *successful* new products. We defined a successful product as one that achieved an initial market share of at least 10 percent and had grown into a product group in the long-run.

In Exhibit 4a, first-year market share of the successful original new products

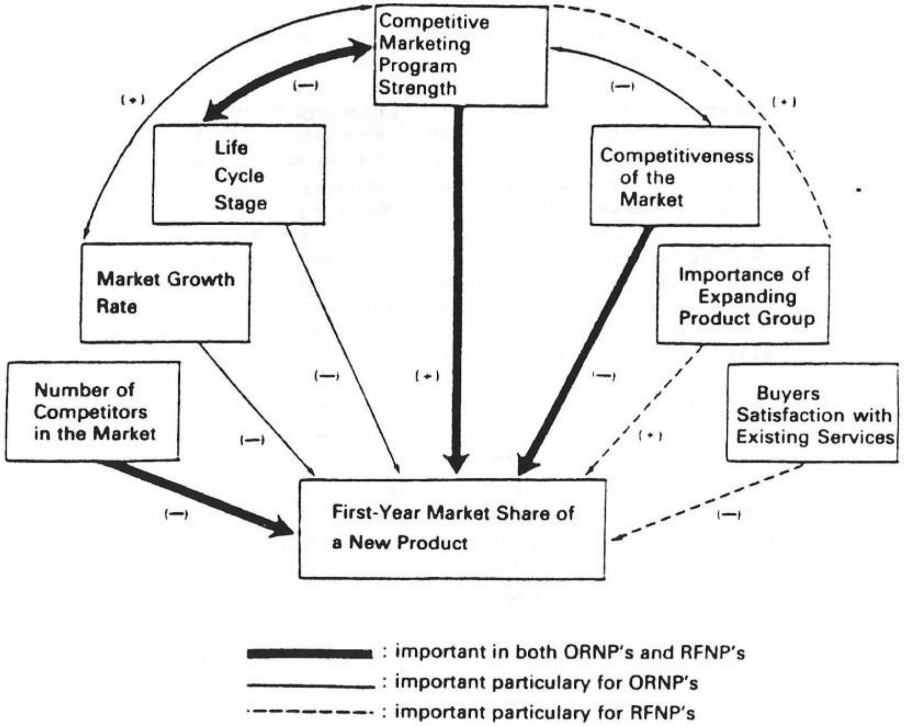

Exhibit 3. The Determinants of First-Year Market Share for Original and Reformulated New Industrial Products.

shows an increasing trend at first, but decreasing later as the launch time is delayed. This curving trend is statistically tested in Exhibit 4c, Eq. 1 by fitting a quadratic function. The regression analysis shows that the first-year market share of (successful) original new products is explained by a quadratic function of launch time delay. On the other hand, first-year market share of (successful) reformulated new products monotonically decreases with a launch time delay as shown in Exhibit 4b. This down-sloping trend is statistically tested in Exhibit 4c, Eq. 2 through linear and long-linear functions.

This analysis leads us to conclude that Hypothesis 3 is partially supported by a limited (and ex post) data base of new industrial products; for (successful) original new products, first-year market share increases with delay of launch time up to a certain point and decreases thereafter. For reformulated new products, however, we found that initial market share performance decreases with delay of new product launch time. This contrast between the original and the reformulated new products may reflect differences in product-market situations: in particular, the market is relatively better developed for reformulated new products than for original new products; the longer an incremental innovation

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

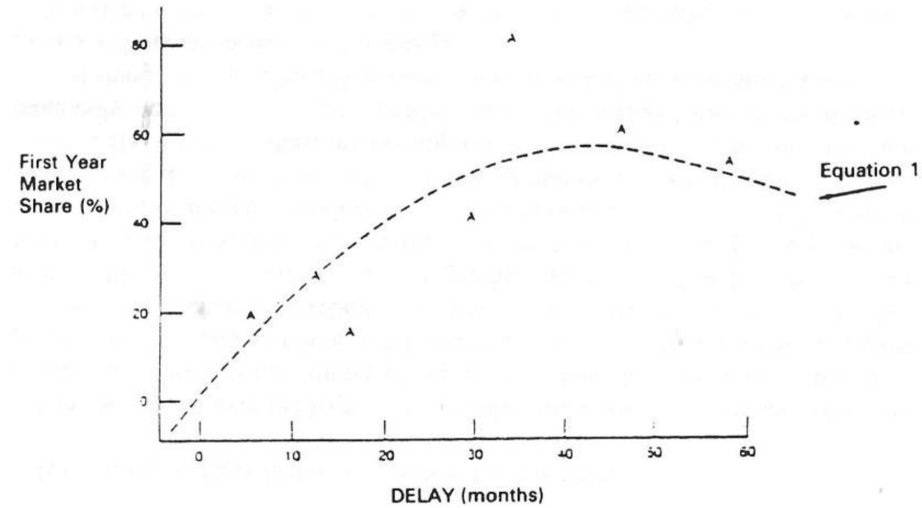

Exhibit 4.a Original and Reformulated New Products and Regression Models.

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

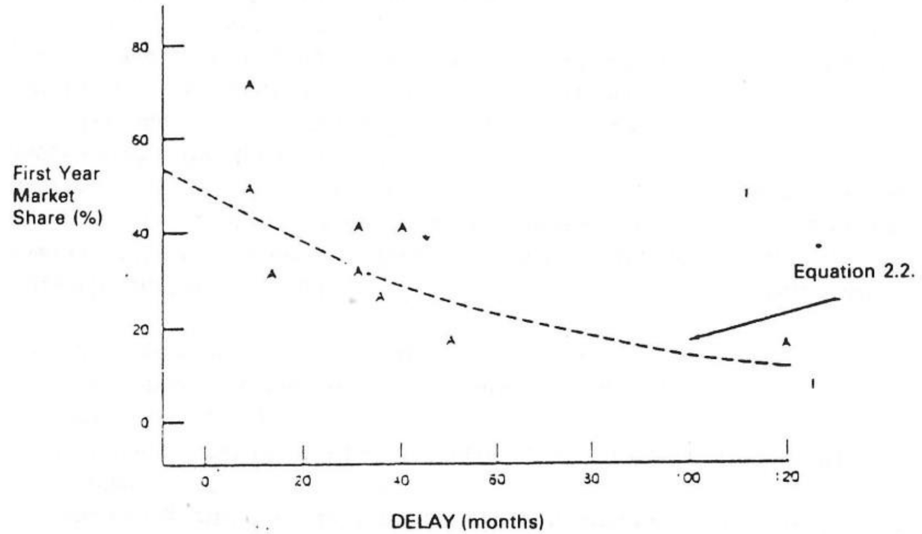

Exhibit 4.b

Exhibit 4c

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	30.90	0.925
	(4.09)^a (−2.00)^a	(0.002)	
	(0.01)^b (0.10)^b		

$n = 7$

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

		F value	*R square*
Equation 2.1.	FSTSH = 46.609 − 0.344 Delay	6.50	0.482
	(7.30)^a (−2.55)^a	(0.038)	
	(0.00)^b (0.04)^b		
Equation 2.2.	log(FSTSH) = 3.846 − 0.012 Delay	12.85	0.647
	(23.91)^a (−3.59)^a	(0.009)	
	(0.00)^b (0.01)^b		

$n = 9$

where FSTSH is the market share of a new product realized during the first launch year, and Delay is the time lag between the completion 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.

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 5, we again run separate analyses for original and reformulated new products. We see that the following factors are important in determining the

Exhibit 5. 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.

Note: The expertise and efficiency questions were self reported and are measured relative to an average competitor. Expertise relates to potential or capability of the firm; efficiency relates to how well the firm actually performs.

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 activities relative to the average competitor
- the marketing effectiveness, relative to the average competitor for the new product launch, and
- the stage of industry life cycle.

Potential buyer's 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 original new products and 0.21 for original new products and 0.21 for reformulated new products.) This suggests that, as expected, short-run success is a positive determinant or predictor of long-run success.

We now turn to the question of modeling the actual sales-growth rate.

A MODEL OF NEW PRODUCT SALE GROWTH

A key objective of this project was to identify and quantify the determinants of sales growth for new industrial products. The first step of the analysis was the measurement of:

- *the initial rate of penetration:* the percentage of total industry demand—used as a surrogate for target market size—that the new product captured during its first year of commercialization, and
- *the adoption rate of diffusion:* the speed with which the new product gained market acceptance over time (See Exhibit 6).

For total industry demand, we used the cumulative volume of sales for all products in the market during the five years of observation. Following Mansfield (1968), Fisher and Pry (1971) and Blackman (1974) the adoption rate of each product was computed assuming a logistic curve of the form:

$$\ln\left[\frac{p_{ti}}{P - p_{ti}}\right] = a_i + d_i t \qquad (3)$$

where p_{ti} = fraction of industry demand captured at time t by new product i
d_i = adoption rate of product i over the observed period
P = maximum fraction of industry demand attainable by product i (respondent estimate)
a_i = initial penetration rate parameter

For each product (i), we used ordinary least square to estimate the b_i and a_i parameters over the three to five years of available observations. The fit of the

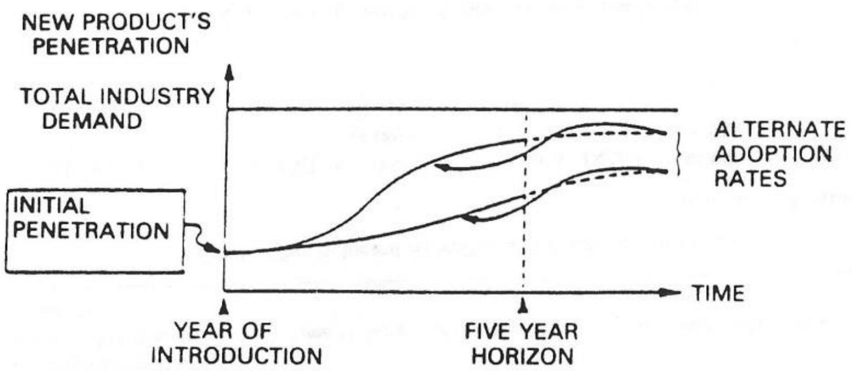

Exhibit 6. Sales penetration curve for a new industrial product and the two key model parameters.

model was good, with R^2 averaging 0.87, and with an average standard deviation of .08.

Two models were then developed to relate the initial penetration (p_{1i}) and the adoption rate (d_i), to a set of key descriptive variables. These variables were screened from a set of well over 50 candidate measures developed from the questionnaire responses. A simple correlation analysis method was used to screen these variables, resulting directly in the set of measures used here.

Initial Penetration Model

Logit (Initial Penetration) = Function of (Product Design and Development Process Descriptors (X_{ki})), and (Target Market Structure Descriptors (V_{ji}))

$$\ln(p_{1i}/(1 - p_{1i})) = a + \sum_{k=1}^{K} w_k X_{ki} + \sum_{j=1}^{J} c_j V_{ji} \qquad (4)$$

$$0 < p_{1i} < 1.0$$

Definitions of the X and V descriptors are provided in Exhibit 7, along with standardized importance weights.

Adoption Rate Model

Adoption rate = Function of (Entry Strategy Descriptors), and (Descriptors of changes in the Competitive Environment)

$$d_i = d \prod_{k=1}^{K^*} Y_{ki}^{b_k} \prod_{j=1}^{J^*} c_j^{W_{ji}} \qquad (5)$$

$$0 < d_i < 1.0$$

where $\{Y_{ki}\}$ are ratio-scaled descriptors of the firm's entry strategy, and
$\{W_{ji}\}$ binary descriptors of changes in the environment after market introduction

Model (5) was linearized, taking logs, prior to parameter estimation. Definitions of the Y and W variables, along with standardized importance weights, are also given in Exhibit 7.

To summarize the results in Exhibit 7, we found that industrial products with high initial penetrations were characterized by:

- having a short development process;
- being reformulated products without major internal demand;
- having few competitors;
- having lower price relative to competition.

INITIAL PENETRATION MODEL

	Descriptor	Definition	Measurement	Standardized Importance Weights $R^2 = 0.85$
DEVELOPMENT PROCESS	X_1 (Ratio sealed)	Duration of development	Number of months	(-) .15[a]
	X_2 (Dichotomous)	Original product with internal demand	Coded 1	(-) .42[b]
		otherwise	Coded 0	
	X_3 (Dichotomous)	Originated within marketing department and placed under the authority of an individual	Coded 1	(+) .39[a]
		Otherwise	Coded 0	
MARKET STRUCTURE	V_1 (Ratio scaled)	Price relative to competition during first year	Ratio of averages	(-) 1.25[b]
	V_2 (Dichotomous)	Order of entry less than three	Coded 1	(+) 5.70[a]
		Otherwise	Coded 0	

[a]Statistically significant at the 1% level
[b]Statistically significant at the 5% level

Exhibit 7.a Determinants of the Initial Penetration

Our analysis also indicates that the adoption rate will be greater for a new product if:

- its sales force effort relative to competition is higher;
- its price in the long-run is lower than that of competitive products;
- its R&D effort after launch as a percent of sales is low (few technical bugs—a good product design);
- no new competitors enter the market;

ADOPTION RATE MODEL

	Descriptor	Definition	Measurement	Standardized Importance Weights $R^2 = 0.77$
ENTRY STRATEGY	Y_1 (Ratio Scaled)	Sales force effort relative to competition (year 2 through year 5)	Ratio of averages	(+) .25[a]
	Y_2 (Ratio Scaled)	Price relative to competition (year 2 through year 5)	Ratio of averages	(-) .98[b]
	Y_3 (Ratio Scaled)	R & D effort relative to sales (year 2 through year 5)	Percentage	(-) .15[a]
CHANGES IN ENVIRONMENT	W_1 (Ratio Scaled)	Satisfaction level with current products and/ or technologies	Perceptual scale	(-) .19[b]
	W_2 (Dichotomous)	Entry of at least one new competitor (year 2 through year 5)	Coded 1	(-) .18[b]
		Otherwise	Coded 0	
	W_3 (Dichotomous)	Existence of price regula- tions	Coded 1	(-) .26[b]
		Otherwise	Coded 0	

[a]Statistically significant at the 1% level
[b]Statistically significant at the 5% level

Exhibit 7.b Adoption Rate of New Industrial Products.

- its pricing strategy is free of restriction (important in many European markets);
- its customers are not highly satisfied with existing products.

The results above have been integrated in an interactive decision support system. The system requires the user to specify the characteristics of the prod-

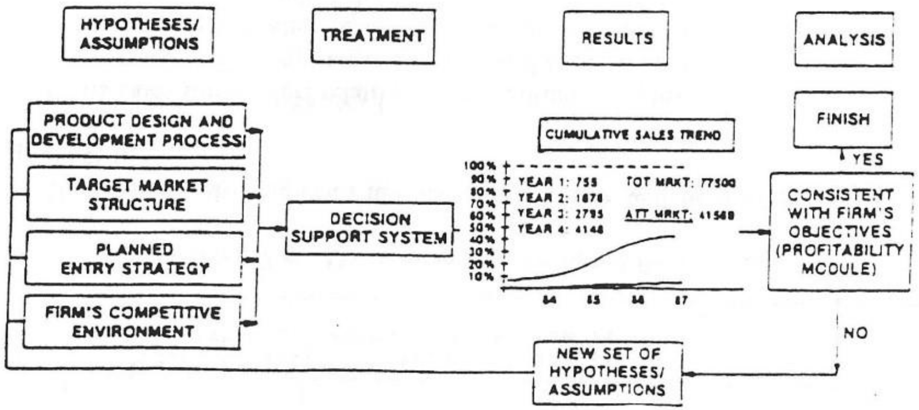

Exhibit 8. Use of the sales forecasting module.

uct's development process, and the competitive structure of its market. Assumptions are also introduced into the computer in terms of planned entry strategy and anticipated changes in the firm's competitive environment (Exhibit 8).

Based on this information, the model estimates the level of first year penetration and the rate of diffusion. These two parameters are then used to generate the time path of market penetration. The system normally calculates:

- the initial penetration;
- the adoption rate;
- the evolution of sales volume (actual and cumulative); and
- a break-even analysis, if cost information is provided.

The approach provides management with a tool to question the market entry strategy and to assess the likely sales impact of changes in that strategy or in the external environment.

As an example, we ran a set of sensitivity analyses for a new type of transportation equipment. The analysis concerned the impact on the new product's sales penetration of possible changes in sales force pressure, and the pricing policy, compared to a base case, reflecting the company's planned entry strategy.

Exhibit 9 gives output for the base case, both cumulatively and on an annual basis. The introduction strategy shows a slow penetration (projected peak around 1999). The maximum annual sales levels are around 4,700 units. This information might prove useful for long range facility planning.

Two points should be noted. First, only the first four years are printed. This is by design to prevent potential users from extrapolating beyond the range of the observed data used for calibration of the models. The system was developed for early forecasts; long-range forecasts can only be made on assumptions of market stability. Therefore, the DATE of MAX SALES and the level need to be taken as

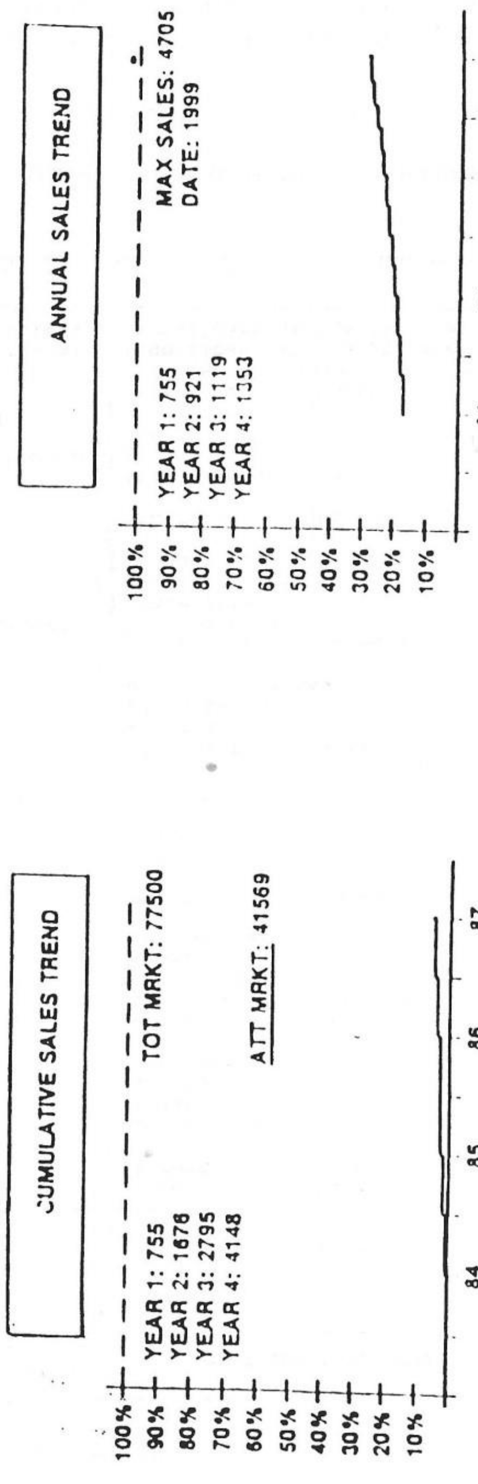

Exhibit 9. Base Case. Price is 10% below competition, sales force is 20% of total market spending.

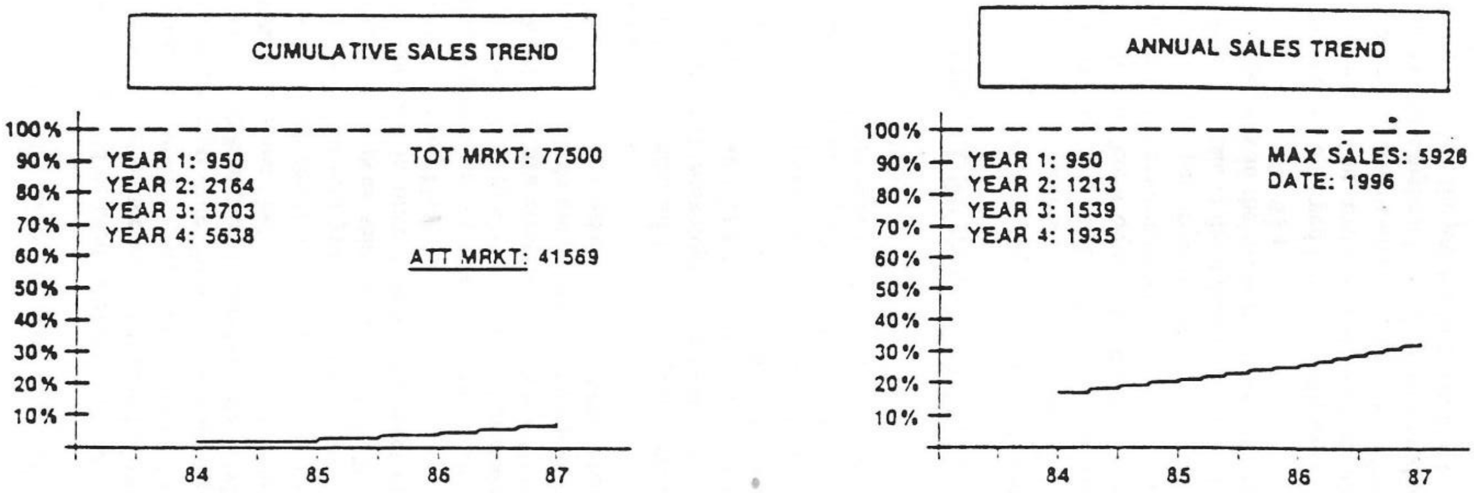

Exhibit 10. Same as Base Case, but there is 50% increase in sales force spending.

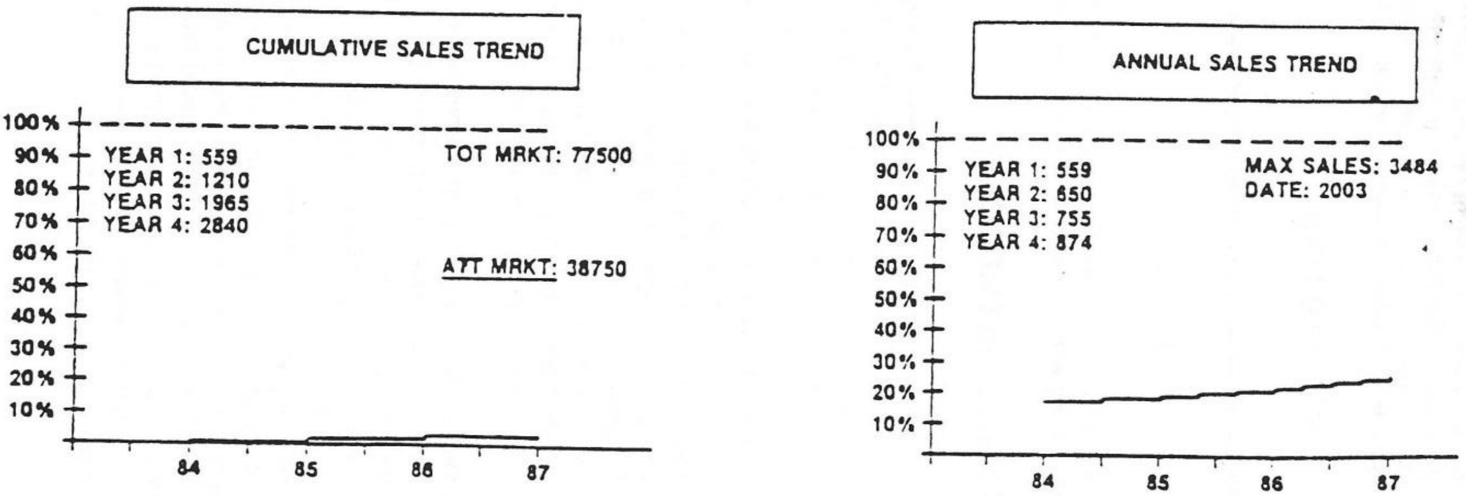

Exhibit 11. Same as Base Case, but price is equal to competition.

rough guides and should be used carefully. Second, the TOT MRKT and ATT MRKT terms are based on the 1984–88 period of analysis, too.

Several sensitivity analyses were run. Exhibit 10 shows the effect of a 50% increase in sales force pressure. Projected sales during the first 4 years are 5,638 vs. 4,148 units or 36% higher. In addition, the level of peak sales (5,926 vs. 4,705) is 26% higher and likely to occur 3 years sooner (1996 vs. 1999).

Exhibit 11 shows an analysis of the product priced equal to competition. As expected, the projected four-year sales level is lowered (2,840 vs. 4,148 for base) and the time to peak sales is lengthened (2003 vs. 1999 for base). In addition, the increase in price lowered the level of attainable market (ATT MRKT) to 38750 from 41569.

The system has been used by several European firms. The Arjomari Company, a leading European paper producer, recently reported that the results are encouraging, with less than a 30% error in cumulative sales over 5 years between actual and forecast sales on a hold-out product. They report that this system has allowed them to reduce the risk of market misassessment in new product development by 70% (Virolleaud 1983).

In an experiment conducted at Vieille Montagne, a world leader in zinc production and associated technologies, the system was used to simulate the time growth of cumulative sales for a new product introduced five years ago. Discrepancy with the actual sales rate was less than 15 percent over that horizon.

These examples, however, do not provide definitive evidence of the external validity of the analogue approach to new industrial product sales assessment. Experience to date does suggest, however, a strong need for such a tool and satisfaction with the approach followed here.

CONCLUSIONS AND IMPLICATIONS

This research has focused on the development of models of the determinants of new industrial product success and of their sales growth rate. When comparing original new products with reformulated new products, we found that these product types had different objectives, different marketing programs and are introduced in different environments.

New product sales performance is closely related to competitiveness in the marketplace, the state in the industry 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 suggests that, all things equal, it may be prudent to launch a reformulated product as soon after development as possible, while success levels are highest for original new products when launch somewhat delayed. This may reflect the greater care required to launch original new products successfully.

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. 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 (Wind 1982).

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 Exhibit 3 and 6, the manager can receive a first estimate of first-year market penetration 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 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 with 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.

Third, these results were integrated into a decision support system that is being used to test the economic viability of new industrial product projects. This latter system should still be considered as experimental. Validation studies are underway and more data is being collected in Europe, in the United States and in Japan. The early results are encouraging and provide new insight in the planning and controlling of new industrial product projects.

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NOTES

1. ESSEC stands for Ecole Superieure des Sciences Economiques et Commerciales

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