AN INVESTIGATION OF THE PRODUCT LIFE CYCLE CONCEPT AND ITS APPLICATION TO NEW PRODUCT PROPOSAL EVALUATION WITHIN THE CHEMICAL INDUSTRY

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ABSTRACT

AN INVESTIGATION OF THE PRODUCT LIFE CYCLE CONCEPT AND ITS APPLICATION TO NEW PRODUCT PROPOSAL EVALUATION WITHIN THE CHEMICAL INDUSTRY

By

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This quantitative investigation of industrial chemical product life cycles and their relationship to both performance and new product evaluation methodology has the major goals of:

1) classifying product life cycles by patterns on sales, profits, and related financial data for new industrial chemical products,

2) identifying those structural characteristics of new industrial chemicals which relate to performance, and

3) screening historical data of new industrial chemical product histories in order to formulate predictive multivariate models.

This study specifically seeks to integrate product life cycle and capital budgeting theories. Documenting the structural characteristics of new industrial chemical products certainly promotes our fundamental understanding of product behavior; but it also sets the limits within which we may generalize from the experiences of major chemical marketers over the 1955-1964 period studied. An effective new product program demands high resolution of all relevant variables affecting the investment decision. And this research has confirmed the feasibility of using established structural characteristics as inputs in a statistical capital budgeting model for evaluating new product proposals, thus facilitating a more optimum investment choice among a complex set of simultaneous alternatives.

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A detailed analysis of 27 new product offerings randomly drawn from among the new industrial chemical products introduced by participating firms between 1955 and 1960 revealed three basic shapes of sales patterns (five if we add the time dimension). These showed no measurable statistical differences on all performance variables except the growth rate for sales and the payback period. The overall shape of the sales cycle for a firm typically resembled that of the industry consumption pattern. This evidence runs counter to the premise that the profit cycle begins to descend while the sales curve is still rising during the maturity phase of the product life cycle: over fifty percent of the products studied had coincident or lagging profit life cycle structures. Known patterns of product behavior suggest a time horizon of at least eleven years for more accurately evaluating the experiences of new industrial chemical products, including an additional three years required for planning plant and equipment commitments to cover the time gap between authorizing capital expenditures and bringing facilities on-stream.

Simple relationships were sought between performance and possible correlates of performance—factors associated with market structure, buyer behavior, product characteristics, and related intrafirm experiences. These factors were screened by appropriate statistical tests to reduce the number of possible determinants of product behavior. It was found that performance generally related to derived demand patterns, duplication difficulties by competitors, dependence on field coverage, impact of advertising on source selection, and product loyalty. The tests also generally supported relationships between performance and investment requirements, research and development expenditures, export patterns, production scheduling experiences, aggregate marketing costs, and plant capacity utilization. Performance was not shown to have an association with a number of variables, including import patterns, patent protection, technological innovation, buyer purchasing patterns, merger activities, type of distribution channel, marketing development approach, type of product, and source of product discovery.

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Multivariate statistical models of product behavior were found to be tenable. For example, the number of years required for discounted present value sums to shift from negative to positive values depended on the following variables (all contributing individually to variance reduction): aggregate research and development commitment, number of minor consuming industries, promotional outlays, effect of industrial advertising on manufacturer selection, trade relations, product loyalty, customer backward integration, buyer acceptance of the product concept, technical service requirements, export patterns, and the orientation of the research and development program. But variable definition, data collection, and scoring must be further refined before improvements in predictions can be expected.

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In surveying possible dissertation subjects, I noticed a general dearth of any integrated approach to screening and evaluating new product marketing opportunities. Specifically, the literature revealed little empirical evidence on how resources were allocated for new industrial product development activities and what determinants of demand directly influence new product decisions.

So I sought to define and structure new product behavior rigorously, first utilizing the product life cycle concept as a basis for financial and marketing measurement because this concept actively focuses on those strategies which may thrust a firm into a position of profitable leadership. Having limited this study to the industrial experiences of large chemical manufacturers, I investigated a number of product histories with the assistance of many individual company representatives: to all of those I owe my sincere appreciation.

I owe much to the direction and stimulus provided by my dissertation chairman, Professor Adolph E. Grunewald, and the other members of my committee, Professors William J. E. Crissy and Thomas A. Staudt; their allowing me the freedom to test many concepts in action forced a more penetrating examination of the fundamental sources of product responses. Bruce Tracy reviewed drafts of the manuscript and offered many helpful suggestions and constructive comments. The manuscript was typed by Betty Hendricksen and Geri Galloner with utmost competence and patience. I am indebted to the ideas and encouragement given me by Professor Robert Headen and Edward Nepkie. Much of my motivation and enthusiasm in this endeavor, furthermore, was derived from my parents and the balanced family environment they provided, emphasizing individual development and value formation. Needless to say, the present work required innumerable sacrifices from my family. I owe sincere appreciation especially to my wife, Nancy, whose thoughtfulness, understanding and patience have made my educational pursuits truly worthwhile.

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CHAPTER I

INTRODUCTION

General Background

Most major chemical firms confront each year an avalanche of new product proposals, more than they can exploit profitably, for the emphasis on chemical research and development generates an ever-increasing output of new chemical intermediates and specialties. There are two basic reasons for the accelerating stream of new products. The above-average growth record of the chemical and allied products industry has been a source of funds for reinvestment in research and development in both exploratory and applied research ventures. The chemical industry has long emphasized the need for innovation. As products become technologically obsolescent, inputs for research and development have included in-house observations and experimentation as well as an increasing awareness by technical and marketing people of the needs of industrial users.

Many technical and professional people directly involved in the evaluation of new products make important decisions influencing the future growth and performance of the total enterprise. So this study focuses on one of the key problems facing management, how to best handle the new product development effort. Specifically, this research seeks to integrate product life cycle and capital budgeting theories, since they are viewed as having pertinence to an understanding of new product planning and management.

Research and Development Expenditure Patterns

Industrial research and development has emerged in the last decade as a major source of technological change and economic growth, with actual expenditures for industrial research nearly tripling between 1953 and 1960 (see Table 1-1). The long term trend of research performed by industrial

organizations since 1953 equates to a 11.0% annual compound growth rate. The significance of these figures is enhanced by comparing this industrial research and development growth with that of the Gross National Product, though such growth in this decade has generally paralleled that of the general economy.

Research by industrial firms consists largely of scientific investigations having commercial orientations: approximately three-fourths of R&D spending in the United States in 1966 was limited to development work defined as the "systematic use of scientific knowledge directed toward the production of useful materials, devices, systems or methods, including design and development of prototypes and processes."[1] Industrial firms cooperate in research and development work in many sectors of the economy, including the aerospace, defense, and chemical industries, a diversity indicated in Table 1-2.

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[1] National Science Foundation, Reviews of Data on Research and Development, No. 41 (Washington, D.C.: U.S. Government Printing Office, September, 1963), p. 10. National Science Foundation, Reviews of Data on Science Resources, NSF 68-5, No. 12 (Washington, D.C.: U.S. Government Printing Office, January, 1968), p. 9.

SOURCES FOR TABLE 1-1

National Science Foundation, Basic Research, Applied Research, and Development in Industry, 1965, Surveys of Science Resources Series, NSF 67-12 (Washington, D.C.: U.S. Government Printing Office, June, 1967), p. 20.

National Science Foundation, National Patterns of R&D Resources, Funds and Manpower in the United States (1953-68), NSF 67-7 (Washington, D.C.: U.S. Government Printing Office, April, 1967), p. 22.

National Science Foundation, Reviews of Data on Science Resources, NSF 68-5, No. 12 (Washington D.C.: U.S. Government Printing Office, January, 1968), p. 4.

U.S. Department of Commerce, Office of Business Economics, The National Income and Product Accounts of the United States, 1929-1965 (Washington, D.C.: U.S. Government Printing Office, August, 1966), pp. 2-3.

U.S. Department of Commerce, Office of Business Economics, Survey of Current Business, Vol. 48, No. 1 (Washington, D.C.: U.S. Government Printing Office, January, 1968), p. S-1.

U.S. Department of Commerce, Office of Business Economics, Survey of Current Business, Vol. 48, No. 11 (Washington, D.C.: U.S. Government Printing Office, November, 1968), p. S-1.

TABLE 1-1

RELATIONSHIP OF INDUSTRIAL R&D TO ECONOMIC AGGREGATES: 1953-1968

Year	Industrial R&D Expenditures (Millions of dollars)[1,2]	GNP (Billions of dollars)	Percent of GNP	Nonresidential Fixed Investment (Billions of dollars)[3]	Percent of Nonresidential Fixed Investment
1968[4]	17,300	860.9	2.0	89.4	19.8
1967	16,610[4]	789.7	2.1	83.6	20.1
1966	15,541	747.6	2.1	81.3	19.2
1965	14,197	684.9	2.1	71.3	20.0
1964	13,512	632.4	2.1	61.1	22.1
1963	12,630	590.5	2.1	54.3	23.3
1962	11,464	560.3	2.1	51.7	22.2
1961	10,908	520.1	2.1	47.0	23.2
1960	10,509	503.7	2.1	48.4	21.7
1959	9,618	483.7	2.0	45.1	21.3
1958	8,389	447.3	1.8	41.6	20.2
1957	7,731	441.1	1.8	46.4	16.7
1956	6,605	419.2	1.6	43.7	15.1
1955	4,640[4]	398.0	1.2	38.1	12.2
1954	4,070[4]	364.8	1.2	33.6	12.1
1953	3,630	364.6	1.0	34.2	10.6

[1] Data exclude company-financed work contracted to outside organizations.

[2] Research and development work includes basic and applied research in the natural sciences, including the medical sciences and engineering, and development.

[3] Includes the net acquisition of fixed capital goods by private business and nonprofit institutions.

[4] Estimated.

TABLE 1-2

INDUSTRIAL RESEARCH AND DEVELOPMENT FUNDS
BY INDUSTRY AND SOURCE: 1957-1966

Industry	Total Funds (Millions of dollars)[1]				Private Industry Funds (Millions of dollars)[2]			
	1957	1960	1963	1966	1957	1960	1963	1966
Food and kindred products	74	104	130	166	74	95	N.A.	165
Textiles and apparel	15	38	30	42	14	29	28	N.A.
Lumber, wood products, and furniture	14	10	11	14	14	9	N.A.	N.A.
Paper and allied products	35	56	69	85	35	N.A.	69	85
Chemicals and allied products	705	980	1,239	1,515	616	807	1,004	1,324
Petroleum refining and extraction[3]	211	296	317	441	200	276	296	385
Rubber products	107	121	156	182	70	83	111	156
Stone, clay, and glass products	69[4]	88	100	131	N.A.	N.A.	97	125
Primary metals	108	177	183	228	103	162	174	221
Fabricated metal products	135	145	153	164	97	109	129	148
Machinery	669	949	958	1,301	397	558	709	958
Electrical equipment and communication	1,804	2,532	2,866	3,570	608	847	1,017	1,409
Motor vehicles and other transportation equipment	707	884	1,090	1,321	517	668	799	976
Aircraft and missiles	2,574	3,514	4,712	5,446	299	364	452	756

(Continued)

TABLE 1-2

INDUSTRIAL RESEARCH AND DEVELOPMENT FUNDS BY INDUSTRY AND SOURCE: 1957-1966

(Continued)

Industry	Total Funds (Millions of dollars)[1]				Private Industry Funds (Millions of dollars)[2]			
	1957	1960	1963	1966	1957	1960	1963	1966
Professional and scientific instruments	249	329	284	444	140	176	202	301
Other industries[5]	N.A.	287	330	490	N.A.	105	137	193
TOTAL	7,731	10,509	12,630	15,541	3,396	4,428	5,360	7,254

N.A. = Not available separately, but included in total.

[1]Includes basic research, applied research, and development work performed within industry; excludes quality control work, routine product testing, market research, sales promotion, sales service, and other nontechnical activities.

[2]Excludes contribution of federal funds.

[3]Excludes geological and geophysical exploration activities of petroleum companies.

[4]Estimated by the National Science Foundation.

[5]Includes data for all other manufacturing and nonmanufacturing industries not specifically listed and industry data specified as not available.

SOURCES: National Science Foundation, Basic Research, Applied Research, and Development in Industry, 1965, Surveys of Science Resources Series, NSF 67-12, (Washington, D.C.: U.S. Government Printing Office, June, 1967), pp. 21 and 30.

National Science Foundation, Reviews of Data on Science Resources, NSF 68-5, No. 12 (Washington, D.C.: U.S. Government Printing Office, January, 1968), p. 6.

Once we delete the effect of federally supported funds, the chemical and allied products industry accounts for one of the largest amounts of total private funds spent on research and development. These expenditures have been growing rapidly, more than doubling since 1957. Most of its influence on the economy emerges in changes in productivity induced by technological change.

Research and development activities in the chemical industry have received ever-increasing emphasis. Having thought to accelerate new product introductions as well as to increase the obsolescence rate of existing products, applied new product development has altered existing market structures and competitive forces profoundly. Recent projections by the McGraw-Hill Department of Economics indicate continued increases in research and development outlays: by 1970, they estimate the chemical and allied products industry will be spending $1.84 billion.[2] Of such funds spent in 1966, the chemical industry committed approximately 13% to basic research, 41% to applied research and the remaining 46% to development (see Tables 1-3 and 1-4).

Emphasis on New Product Development as an Industrial Marketing Strategy

Chemical manufacturing firms have relied on four basic types of activities to generate product growth:

1. Acquisition, merger, or combination arrangements,
2. Product improvement work,
3. New process discoveries, and
4. New product development.

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[2] "R&D Looms Big in Fiscal Budgets," Business Week, No. 1967 (May 13, 1967), pp. 68-69+.

TABLE 1-3

ESTIMATED RESEARCH AND DEVELOPMENT EXPENDITURES OF U.S. INDUSTRY BY TYPE: 1967-1970

	(Millions of dollars) 1967	1970
Chemicals and allied products	1,561	1,842
Petroleum and coal products	488	571
Rubber products	176	208
Stone, clay, and glass products	151	205
Nonferrous metals	99	117
Paper and allied products	88	104
ALL INDUSTRY	16,605	20,792

SOURCE: "R&D Looms Big in Fiscal Budgets," Business Week, No. 1967, May 13, 1967, pp. 68-69+.

TABLE 1-4

RESEARCH AND DEVELOPMENT EXPENDITURES OF U.S. INDUSTRY BY STATE OF RESEARCH: 1966

	1966 Basic Research	(Percent) 1966 Applied Research	1966 Development
Chemicals and allied products	12.5	41.1	46.4
Petroleum and coal products	9.9	39.0	51.1
Rubber products	5.0	36.2	58.8
Stone, clay and glass products	6.2	45.1	48.7
Nonferrous metals	9.9	51.4	38.7
Paper and allied products	8.3	39.3	52.4
ALL INDUSTRY	7.2	24.1	68.7

SOURCE: "Rousing Forecast for Research," Chemical Week, Vol. 98, No. 20, May 14, 1966, p. 61.

In 1962, a committee of Congress studying the acquisition experiences of major industrial and merchandising firms concluded that "chemical companies have joined forces in order to exploit joint interests and garner captive sources of raw material."[3] This reflects the growing concern over the impact of merger activity by major firms on the general economy and the welfare of the ultimate consumer. Table 1-5 indicates the relative extent of recent acquisition activities by major industrial manufacturing sectors. Clearly many firms within the chemical industry have taken the merger and acquisition route to broaden marketing horizons and improve financial performance records, as well as relying on internal growth. While future antitrust action by governmental special interest groups may reduce its significance as an alternate industrial strategy for major firms, acquisitions and mergers will continue as an open alternative to the internal development of new products.

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[3]U.S. Congress, House of Representatives, Select Committee on Small Business, Mergers and Superconcentration: Acquisitions of 500 Largest Industrial and 50 Largest Merchandising Firms, 87th Congress (Washington, D.C.: U.S. Government Printing Office, November 8, 1962), p. 43.

TABLE 1-5

EXTENT OF ACQUISITION ACTIVITY OF MAJOR INDUSTRY GROUPS: 1960-1967

Major Industry Group of Acquiring Company[1]	Average 1955-1959	1960	1963	1966	1967
Food and kindred products	58	61	67	69	95
Tobacco manufactures	4	2	6	9	5
Textile mill products	30	42	37	27	22
Apparel	6	11	25	37	45
Lumber products, except furniture	11	26	21	15	24
Furniture and fixtures	3	6	8	14	16
Paper and allied products	31	52	16	21	36
Printing and publishing	13	26	31	23	33
Chemicals	57	68	78	105	123
Petroleum	14	10	14	13	10
Rubber and plastics	7	14	14	15	29
Leather products	4	1	6	6	7
Stone, clay and glass	23	27	15	27	35
Primary metals	34	29	35	33	65
Fabricated metal products	42	45	46	50	87
Nonelectrical machinery	86	77	88	102	155
Electrical machinery	64	113	109	145	257
Transportation equipment	51	67	46	64	103
Professional and scientific	24	35	28	50	92
Miscellaneous and ordnance	16	30	26	16	22
MANUFACTURING	576	742	716	841	1,261

[1]Data limited to mergers and acquisitions reported by Moody's Investors Service, Inc., and Standard and Poor's Corporation.

SOURCE: Bureau of Economics, Federal Trade Commission, News Release, March 18, 1968, p. 13.

The objectives proposed by executive management for research and development work should establish the relative importance of product improvements, new processes, and new products as industrial strategies. A McGraw-Hill Department of Economics survey showed that new products were usually one goal of the R&D efforts made by the respondents: Table 1-6 shows the breakdown of responses by industry. Note the difference in emphasis on new product development among the various industries listed.

TABLE 1-6

MAIN PURPOSE OF R&D PROGRAMS

	(% of companies responding)		
Industry	New Products	Improving Existing Products	New Processes
Chemicals and allied products	70	20	10
Petroleum and coal products	27	33	40
Rubber products	17	83	--
Stone, clay and glass products	41	41	18
Nonferrous metals	39	44	17
Paper and allied products	37	41	22
ALL INDUSTRY	45	41	14

SOURCE: "Rousing Forecast for Research," Chemical Week, Vol. 98, No. 20, May 14, 1966, p. 62

The nature of the product generally dictates the strategies employed and may itself be a limiting factor. In any event, new products are fundamental to corporate growth, most new product programs in fact receiving a disproportionate amount of attention by management because of the time required for the evaluation process and program implementation.

Basic Structure of the New Product Evaluation Process

New products are not commercialized randomly: each firm somehow has specific procedures for screening proposals, which may start as nothing more than notions. There is an attrition of new product ideas during the various phases through which proposals are channeled, with this decay rate presented in Figure 1-1. Most proposals are eliminated during preliminary and revised financial and marketing analyses. The Commercial Chemical Development Association has estimated that for each 540 new industrial chemical ideas proposed, only one product is commercialized.[4]

The stages faced by new product introductions can be understood in terms of the expenditures incurred. Each stage towards commercialization becomes increasingly more expensive, requiring more of a firm's resources to insure proper preparation of the product for introduction and subsequent buyer acceptance. Booz·Allen and Hamilton, one management consulting organization that has had the opportunity to analyze a number of new product programs, has drawn up the industry average cost relationships through time shown in Figure 1-2.[5] Notice how costs accumulate through time in the various stages. Since the major expenditures come after the decision has been made to develop the new product, it becomes imperative to exhaustively analyze all proposals on their financial and marketing merits before making a decision to develop; the cost of failing to make such an analysis can be too burdensome for any company, regardless of size.

The final construct considered in the new product evaluation process, the success-failure rate of new products, again is reflected in the latest analysis of thousands of new product histories compiled by Booz.Allen and Hamilton. It is noteworthy to find few interindustry differences in success-failure rates among the six industrial sectors covered in the analysis (intrafirm differences within any industry are

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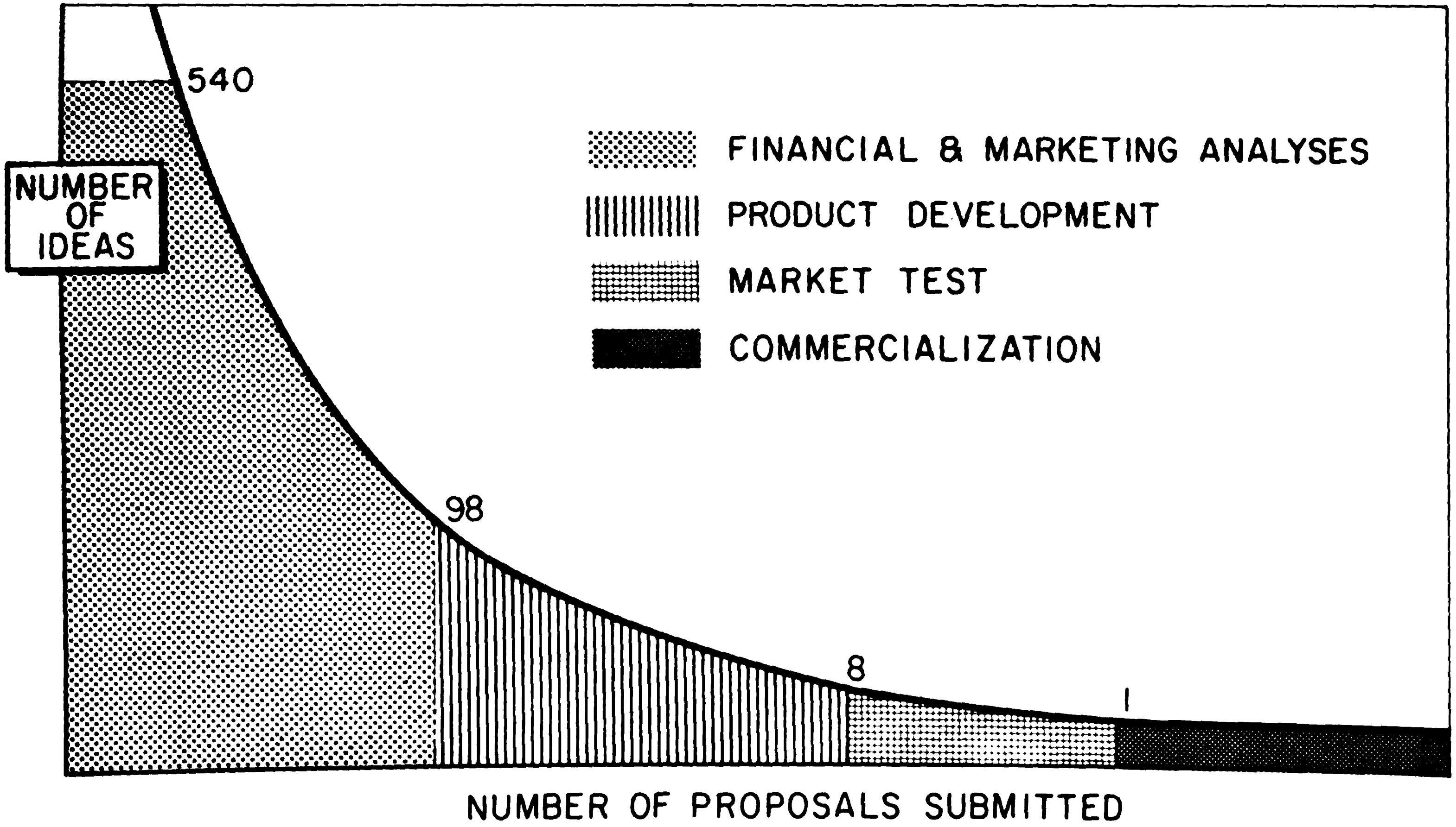
[4]As reported by Conrad Berenson (ed.), The Chemical Industry: Viewpoints and Perspectives, (New York: Interscience Publishers, 1963), p. 45.

[5]Management of New Products, (4th edition, New York: Booz.Allen

FIGURE I-I

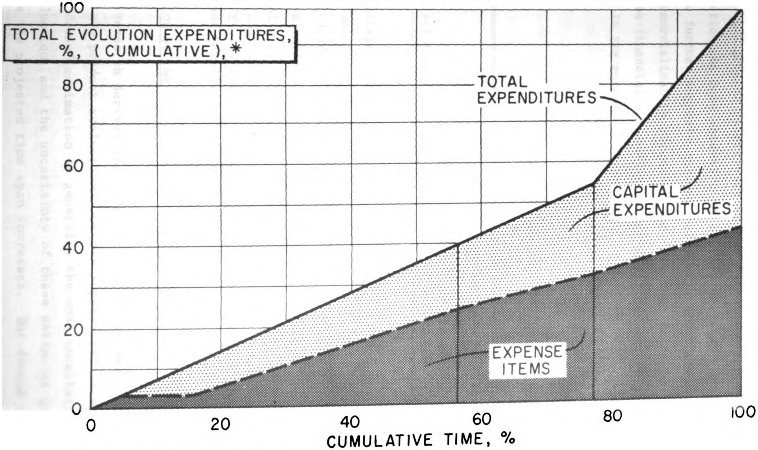
DECAY PATTERNS OF NEW PRODUCT IDEAS*



* Figure Adapted From Conrad Berenson, THE CHEMICAL INDUSTRY: VIEWPOINTS AND PERSPECTIVES (New York: Inter Science Publishers, 1963), p. 45

FIGURE I-2

CUMULATIVE EXPENDITURES & TIME
BY STAGE OF EVOLUTION -- ALL-INDUSTRY AVERAGE



* Expense Items Plus Capital Expenditures.

SOURCE: Management Research Department, Booz, Allen & Hamilton, Inc.

a different matter). Table 1-7 indicates that the average rate of commercial success for chemical products was 59%. Since most new products at the development stage are failures according to some criterion or another, we need greater selectivity in the evaluation process, requiring more information and more extensive marketing analysis. Yet this success-failure rate further suggests the unusually high uncertainty associated with the commercialization process. The firm that fails to take into account these financial and marketing uncertainties severely limits improvement in its success-failure rate.

TABLE 1-7

RATE OF COMMERCIAL SUCCESS

	(As percentages of success)		
Industry Classification	New Product Ideas	Product Development Projects	New Products Introduced
Chemicals	2	18	59
Consumer packaged goods	2	11	63
Electrical machinery	1	13	63
Metal Fabricators	3	11	71
Nonelectrical machinery	2	21	59
Raw material processors	5	14	59

SOURCE: Management of New Products, (4th edition, New York: Booz·Allen and Hamilton, Inc., 1965), p. 12.

Identification of the Problem

This research derived its inspiration from a number of factors relating to new product evaluation. Of all inputs used in any quantitative model, demand estimation is generally the most uncertain in new product evaluation; and the uncertainty of these estimates generally increases as the projected time span increases. But demand estimates appear to be the critical input in any capital budgeting model for evaluating new products; since material, labor, and related costs each vary with

the quantity produced, the projected level of demand is the single most important consideration. Any rejection or acceptance decision is based on the worth of a new product, which is directly influenced by the level of existing demand.

Other investigators have attempted in the recent past to establish criteria for new product selection. Bertram Schoner constructed a stochastic model for the selection of applied research and development projects.[6] He attempts to represent mathematically a maximization process through utility theory which accounts for interaction between projects. Two important assumptions in this model limit its applicability to a given firm or industry situation:

1. Rapid obsolescence makes it unwise to consider sales from a product as extending further than five years beyond a product's introduction.

2. Contributions to profit are highest in the first year of a product's introduction and decline exponentially thereafter.[7]

Before any such model for the selection of research and development projects can be logically employed in any industrial situation, empirical research must test these underlying assumptions. Nevertheless, the acceptance of product life cycle theory within the firm is critical in the evaluation process if models are to be built around this concept with the expectation of having applicability in specific future product situations.

Basically this research seeks to:

1. Classify product life cycles of both sales and profits for new industrial chemicals.

2. Identify the important structural characteristics for new industrial chemicals.

3. Examine historical data of new chemical product histories for predictive content.

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[6]See Bertram Schoner, "The Selection of Research and Development Projects," (unpublished Ph.D. dissertation, Graduate School of Business, Stanford University, 1965).

[7]Ibid, p. 78.

Since chemical firms make large research and development outlays, historical performance should be closely scrutinized to find patterns that may lead to more refined inputs for better executive judgment in the future.

Significance of the Study

This research focuses on the relationships among product life cycle theory, financial planning, and the performance of selected new industrial chemical products. Admittedly, a juxtaposition of various product classes in the analysis could have proven valuable, although the research design required for such comparisons would be burdensome. A design of the present type could apply to other product groups, however, with few basic modifications. The basic groundwork has been laid.

Both financial and marketing planning vitally affect overall company performance, and will likely expand in the future. Corporate planning has broadened from its short term emphasis to include long-range planning. Even though sales have been rising in recent years, the chemical industry has shown declining profit margins and returns on investment.[8] Because of the rising trends expected in new capital outlays and research and development expenditures, then, operating personnel and management have an even greater responsibility to improve techniques in product analysis.

One purpose of this dissertation—to provide a suitable classification scheme for new industrial chemical product life cycles—requires that we identify representative sales and profit patterns (both their shape and timing), and numerous product relationships as well. This is important if one is going to provide adequate explanations of typical sales and profit patterns. The product life cycle itself provides a useful framework for noting changes in operating characteristics which affect the level of performance. A related goal of this study seeks to evaluate empirically specific financial and marketing concepts that are relevant to effective new product evaluations. The determination of the minimum appropriate

[8] Actual documentation is given in Chapter IV, Method of Data Collection.

time horizon, i.e., the shortest period of time required in any analysis to reasonably predict success, illustrates one useful output of such research.

Need for the Study

Since the product life cycle concept was first introduced years ago, many have examined and re-examined its implications. Most often it is proposed as the basis for long-range planning and market strategy. Yet before the concept may be operationally employed, many functional relationships between sales and time should be examined for various product classes. It may be conjectured that the sales and profit patterns and also the timing of the product life cycle vary on both a product and an industry basis. Yet few empirical studies have described existing patterns. No classification scheme exists for product life cycles in any product class. This research study seeks, then, to fill this void for new industrial chemical products.

Executives often feel intuitively that adequate explanations are available for most individual product life cycles. A noticeable decline in a firm's sales may be attributed to competitive product introductions. A product may be de-emphasized or completely withdrawn if customers integrate backward. Such explanations can further our fundamental understanding of product behavior. And documentation of structural characteristics will serve that end as well as providing a firm basis for input in statistical analysis, which can determine the extent of predictive content within the collected data on new industrial chemical products. As its ultimate contribution, this study will use structural characteristics to try to identify product life cycle distributions which in turn can be used as inputs in a capital budgeting model for new product proposal evaluations.

CHAPTER II

REVIEW OF SALIENT LITERATURE ON PRODUCT LIFE CYCLE THEORY

Introduction

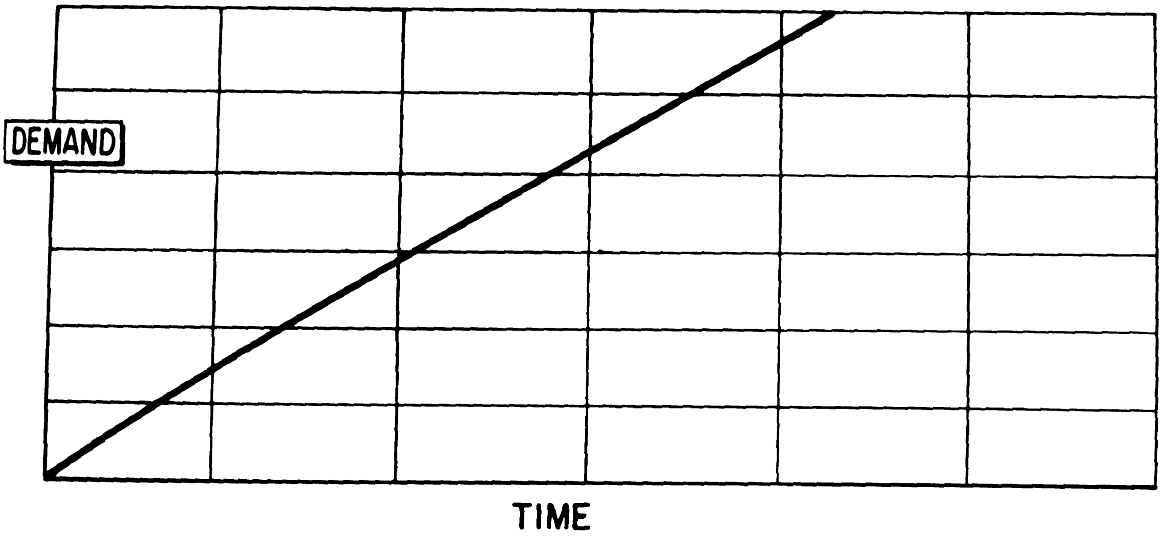
Actual efforts to develop mathematical expressions for demand patterns have been going on for decades. Because the ultimate results of product management often comprise some type of quantification, their interest may well surpass the simple exercise of fitting historical data to actual products. In measuring mathematical trends, any researcher looks for communal data suggesting an appropriate, representative trend. Ideally one examines the patterns of a product for phenomena which may be translated into possible shifts in future demand, if any, once all the developments which might affect the outcome are evaluated.

In forecasting, any mathematical expression of demand defined over time ends up with a projection of demand some time in the future. So we should examine some of the mathematical functions commonly employed in business applications to better understand why the product life cycle described in the literature has such widespread appeal today. In terms of prediction considerations, the problems center on forecasting technological change and market acceptance.

Linear Function

Aggregate demand assuming the form $Y = a + b(t)$, expressed in common units, defines a linear trend, the simplest method for fitting historical data on an industry-wide basis over time t, where a and b are calculable coefficients. When the time span is short enough, this technique can be quite useful for demand forecasting.

FIGURE 2-1
LINEAR MODEL

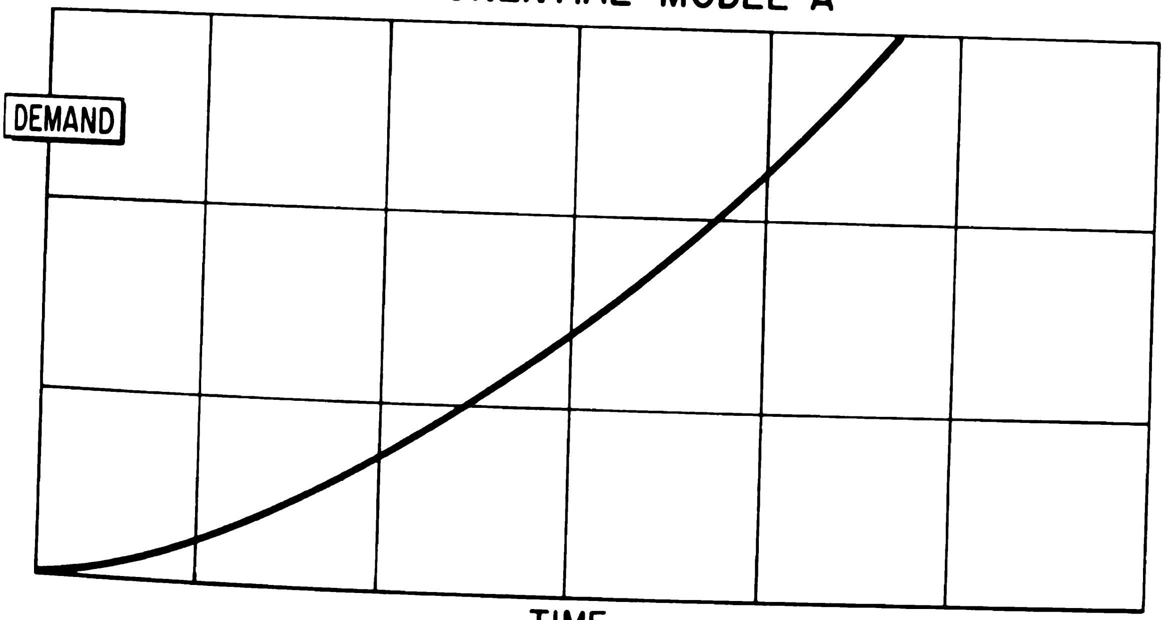


Although the graphical representation for this model is unquestionably linear over time, it actually suggests a declining but positive growth in demand over the projected life span of the industry, since the units in the base year are increasing through time. With marketing forces and technology influencing market development as much as they apparently do, demand fitted as a straight line for prolonged time periods may fail to represent actual behavior for long-range planning activities.

Exponential and Logarithmic Functions

In a number of business situations involving growth and decay the natural mathematical model assumes an exponential function: for example, interest rates continuously compounded. And the literature often describes long-range projections of basic economic data for specific industrial sectors in terms of annual growth rates. A graph of the mathematical function $Y = (Y_{t-1})\ (1 + r)$ easily demonstrates such non-linear growth, where r equals the calculated growth rate expressed as a fraction, as depicted in Figure 2-2.

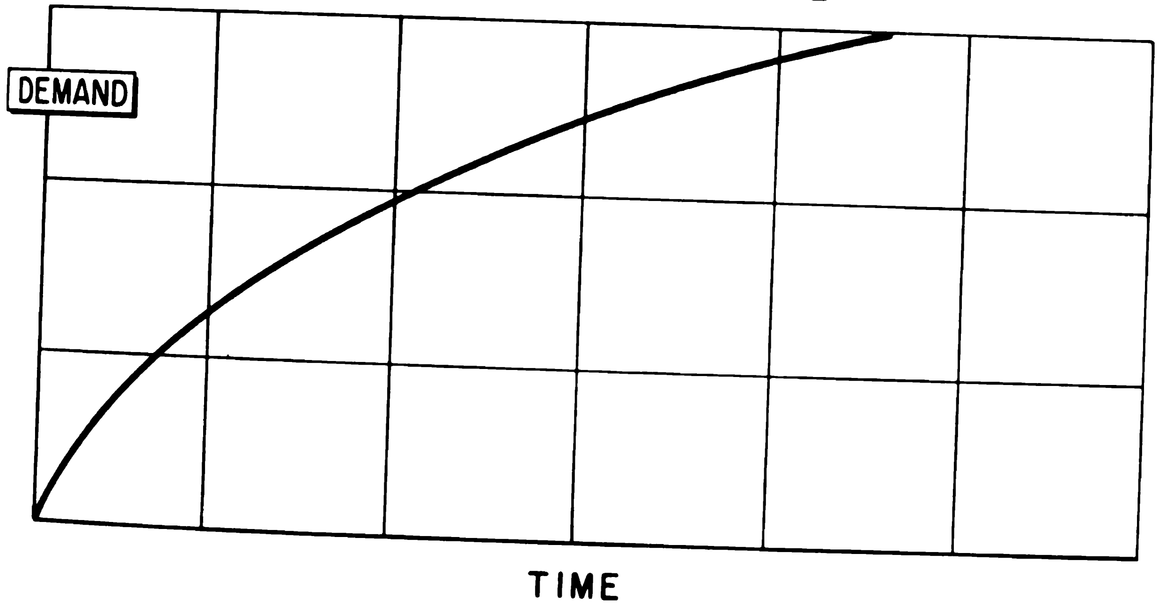
FIGURE 2-2
EXPONENTIAL MODEL "A"



The logarithmic form of the compound growth curve $\log Y_t = \log Y_{t-1} + \log (1 + r)$ becomes linear when graphed on semi-log paper, which permits the easy display and use of data having an underlying exponential trend, i.e., constancy of relative growth. Any researcher reporting long term annual growth rates assumes that demand is an increasing function over time. The particular case of continuous compounding over kt years is given by the equation $Y_t = Y_o e^{kt}$, and takes the same general shape of Figure 2-2 above. Since an equation of this type follows an exponential pattern, it too assumes a straight line on semi-log paper.

A product having a sizable pent-up demand can experience high initial acceptance and rapid growth immediately following its market introduction, particularly if the communications program is sufficiently effective and the firm has adequate production capabilities early in the product life cycle. This demand pattern, also an exponential function, assumes the form $Y_t = Y_{max} (1 - e^{Bt})$ as depicted in Figure 2-3.

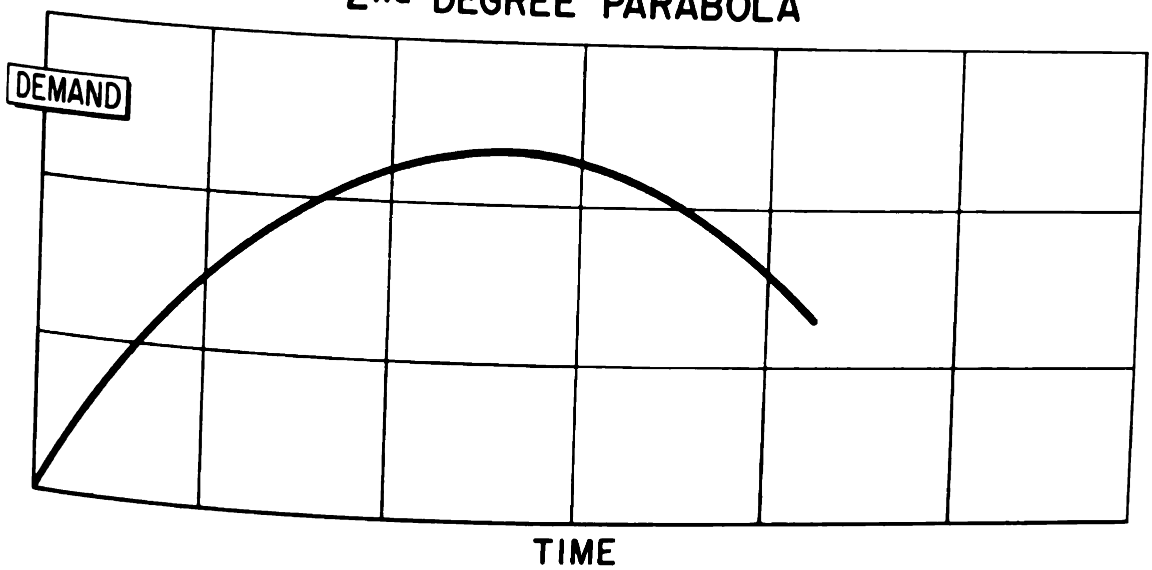
FIGURE 2-3
EXPONENTIAL MODEL "B"



The rate of increase for any product situation is determined by the term B.

The above equation may be supplemented, if a decline phase extends beyond the maximum demand level, by using a rotated parabola function. A second degree parabola fitted to data (given by $Y = a + bt + bt^2$) can assume the demand pattern graphed in Figure 2-4.

FIGURE 2-4
2nd DEGREE PARABOLA

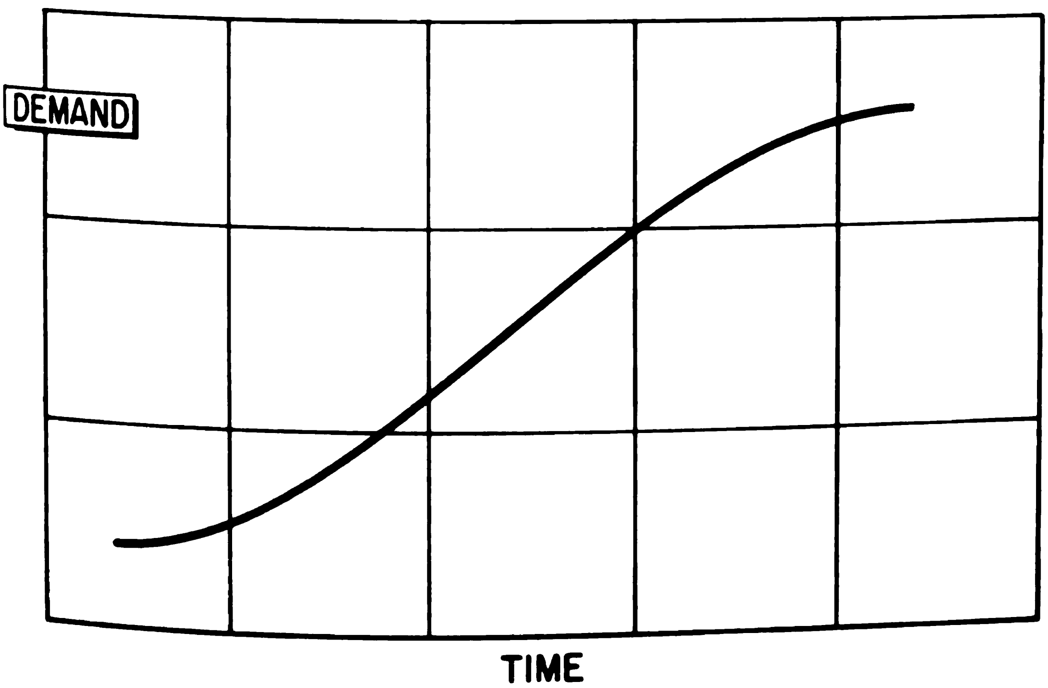


Even though higher order polynomial equations may be calculated to follow virtually every variation in data, such patterns seldom represent long term trends; such an approach for long-range planning purposes would likely meet questionable success.

Gompertz Curve

Also applied in actuarial science, the Gompertz curve is one growth pattern purported to be typical of industrial development. This type of growth is found in industries whose product uses are directly related to the growth of population, assuming that purchasing power is no obstacle to product movement. The natural form of the equation is $Y = ka^{-b^t}$, where a and -b are constants between zero and one; its logarithmic form is $\log Y = \log K + (\log a)\text{-}b^t$. The rate of growth over time is not constant, appearing instead as a decreasing quantity. The term log K is the logarithm of the maximum value approached by the function as it becomes asymptotic. Figure 2-5 approximates the pattern of the Gompertz curve.

FIGURE 2-5
GOMPERTZ MODEL



Because product movement is dynamic in nature, one expects demand to shift as the relative influences of demand determinants change. If a product demonstrates competitive strength, the growth phase may predominate in its life cycle; otherwise, its displacement by competitive products eventually imposes a declining pattern upon overall product demand. Many consumer and industrial product categories have experienced market displacement in the past, e.g., recent government statistics indicate decreased shipments for the following products during at least one reported year since 1955: canned fruits and vegetables, metal household furniture, primary zinc and explosives. Some products bounce back with renewed strength, while others sustain continued declines. Products displaying a satisfactory Gompertz trend historically seldom behave as the illustration indicates once the curve approaches the asymptote. The failure of this curve to describe eventual increasing or decreasing consumption as shifts in demand pinpoints its serious limitation for long-range forecasting.

Conventional Product Life Cycle

From our limited knowledge of published product behavior, we may describe a generalized aggregate industry product life cycle recognizing six distinct stages, as shown in the next exhibit. Although the number of stages presented in current references which describe the product life cycle concept differs, the traditional pattern of industry demand over time is very similar to that represented in this section.[1]

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[1] Actual reference will be cited later in the text.

DEFINITIONS OF TERMS USED IN FIGURE 2-6

Industry Sales: aggregate sales in dollars or standardized units of the product sold by all firms competing in the market in the time periods indicated.

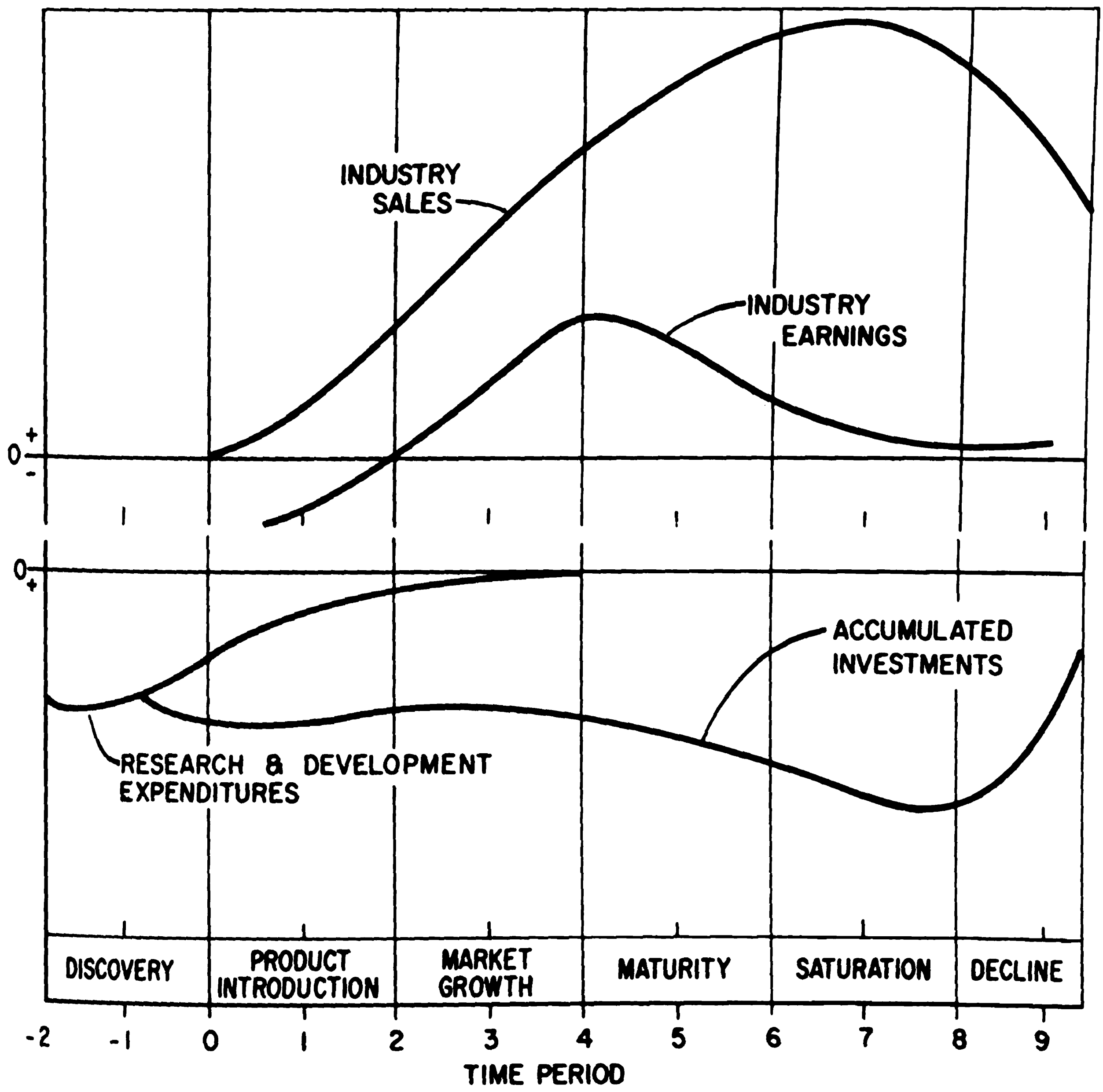
Industry Earnings: aggregate net profits after taxes in dollars or standardized units of the product resulting from its marketing by all firms competing in the market in the time periods indicated (assuming an acceptable, uniform treatment of all expensed items after the product's launching to derive the calculated figures).

Research and Development Expenditures: aggregate costs in dollars or standardized units for applied research and development work done by all competing firms and directed toward the commercialization of the product.

Accumulated Total Investments: accumulated investments through time in dollars or standardized units by all competing firms in new fixed assets, transferred fixed assets, rolled-back capital and working capital.

FIGURE 2-6

CONVENTIONAL PRODUCT LIFE CYCLE



Although these sales and profit patterns were envisioned for consumer products, they may not necessarily describe industrial products; certainly industrial goods usually have longer cycles.

Developed in order, these stages include:

1. Discovery

Any product succeeding in the marketplace can be traced to its origin as an idea. Developing any product from the idea inception through field studies is usually expensive, but essential if the firm is to effectively evaluate its potential. Innovative firms must obviously risk committing large expenditures in research and development characteristic of this stage. Once the product proposal survives a number of systematic management reviews, a decision must be made on its commercialization. Will the product cash flows be sufficient to recoup the investments required to market the product and still allow an adequate return on these investments? If indications are promising, funds may be committed to initiate production capability. Late in the discovery stage, the innovative firm makes the initially modest but vital investment in plant and equipment for the production of the hypothetical product. The key factor in the discovery stage is to organize a product development program resulting in the desired product.

2. Product Introduction

The product passing through a low volume introductory stage must create an awareness and garner subsequent demand. Consumer education may be required if the product has unique applications or physical properties, along with considerable expenditures in the promotional campaign for consumer products, if applicable. New industrial products must nearly always demonstrate technical superiority or cost reductions over competing products before users change their buying patterns.

3. Market Growth

During the so-called take-off stage, the product records rapid increases in consumer acceptance as a result of the firm's initial efforts to promote the product and its purchase, with adequate distributors and reliability in performance the two crucial factors. Where large potential markets develop, entries by competitors attracted by this potential often occur in the latter part of the growth stage.

4. Maturity

An increasingly competitive environment forces the firm to alter its market strategy to check its declining profits. Various forms of nonprice competition can be introduced to insure more effective coverage, or the firm may attempt to differentiate its product through quality changes. Repackaging may help make the product more appealing. Advertising programs can be altered to more effectively segment market types and to influence both other-brand purchasers and nonbuyers. By shortening distribution channels, the firm can gain greater control and broaden product exposure.

5. Saturation

Prices weaken in the early part of this stage because the industry's capability to supply exceeds consumption. Though price is one important element, other operating variables are affected by competitive pressures; for example, new distribution channels are often needed to provide greater economy. This stage calls for an even greater emphasis on developing more effective marketing programs.

6. Decline

Whenever demand declines, sales decline as well. Through product improvements and technology changes, old products become obsolete and are eventually displaced in the marketplace. Cost reductions forestall rapidly declining profits. The only alternative is to liquidate, consolidate, or diversify, and thus we might expect a trend toward concentration among producing firms.

The sales and profit patterns in the product life cycle of a firm can differ significantly from those of the industry, depending on the firm's time of entry into the market and its effectiveness in capturing a dominant market share. If the firm was the innovator, the shape of its curve in the early stages would be the same as the industry as long as it constitutes the industry; thereafter patterns of sales and profits are shared among competing members. Even when industry profits are increasing, the innovator could suffer declining profits if his position has been weakened. Many sales and profit patterns are available for firms that enter after the market develops. But after the market becomes saturated, it is far more difficult for an entering firm to succeed.

Product behavior is most likely to vary radically between firms for such reasons, regardless of industry trends. Even though a firm may produce a product having rapidly growing market acceptance, this gives no assurance of instant success: some products (and some firms) will fail. But all products have life cycles, though they may vary in length and magnitude. Eventually every marketed product will be displaced; and if business executives can remember this, they can prepare more readily for such transitions without their developing into real crises.

The analytical screening of new product proposals requires a multi-dimensional approach. No treatment in the literature adequately handles the selection process. So the search for methodologies to take into account all factors influencing new product performance continues.

Possible Applications of Product Life Cycle Theory

Identifying specific life cycle patterns of sales and profit contributions may dramatically further efforts to model new product behavior. But before such possibilities can be explored, we should review suggested applications of product life cycle theory and their implications to product management.

• As a management tool in launching a new product. Projections of the slope and duration of a product's life can be used in product planning to indicate possible marketing strategies that may be employed after market introduction to lengthen lead time over competition.[2]

• As an evaluation technique in directing research and development efforts. Any innovative firm having broad-based research and development capabilities can increase its new product success rate by examining the growth rates of various industries during several stages of market development. Research activities could then be limited to those product areas in which potential ideas can be transformed into marketable products at the time when rapid growths are expected. The timing of the research effort can easily affect eventual success, since it partially determines the timing of a new product's entry.

• For screening a firm's existing product mix. It is difficult to measure analytically the effect of one product's sales on the sales of other products within a given product line. Yet sometimes individual products become too costly to maintain on the market and should be eliminated. The product life cycle concept focuses on the relative profit contribution of any product in various stages of its development.[3]

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[2]Theodore Levitt, "Exploit the Product Life Cycle," Harvard Business Review, Vol. 43, No. 6 (November-December, 1965), p. 84.

[3]Philip Kotler, "Phasing Out Weak Products," Harvard Business Review, Vol. 43, No. 2 (March-April, 1965), p. 107.

• As a framework for extending the life cycle. The growth stage of a product may be stretched by any of the following strategies:[4]

1. Promoting more frequent usage among current users,
2. Developing more varied usage among current users,
3. Creating new users by market expansion, and
4. Finding new uses for the basic material.

• As a key for developing optimum marketing programs. The stage of market development may indicate the type of marketing effort that a specific new product requires. In a rapidly growing industry where consumer acceptance is spontaneous, for example, there is less need for firms to implement strong marketing programs.[5]

• As a basis for scheduling new product development programs. The profit cycle is important in timing research and development programs, especially if the firm sets its primary objective as earnings growth. Often profits begin to decline before sales, which is when additions coming from newer product offerings should seek at least to match expected profit declines.[6]

• For modeling various facets of industrial dynamic processes. The stage of product development at the firm level affects order rates, number of unfilled orders, delivery delays, capacity changes, and their interactions.[7]

• As a means of selecting advertising strategy. One research study indicates that advertising is far more effective in the earlier stages of the cycle in terms of impact and productivity, concluding that, in the decline stage, advertising cannot significantly lengthen the life cycle.[8]

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[4] Theodore Levitt, op. cit., p. 89.

[5] Frank J. Charvat and W. Tate Whitman, Marketing Management: A Quantitative Approach, (New York: Simmons-Boardman Publishing Corporation, 1964), p. 130.

[6] C. Wilson Randle, as reported in (no author), "Suggests Profit Cycle to Plan Product, R & D," Steel, Vol. 154, No. 20 (May 18, 1964), p. 31.

[7] Ole C. Nord, Growth of a New Product; Effects of Capacity-Acquisition Policies, (Cambridge, Mass.: M.I.T. Press, 1963), p. 3.

[8] C. Wilson Randle, as reported in (no author), "Key Ad Spending to Profit Cycle, Not Sales Cycle: Wilson," Advertising Age, Vol. 35, No. 17

In summary, the product life cycle concept should provide a useful instrument in marketing research and financial planning. But it is little used in industrial situations because we have lacked empirical documentation of its value. This research has been designed to investigate the feasibility of modeling product life cycles for one class of products, new industrial chemicals. If specific characteristics common to classification types of life cycles could be isolated, they would promote our understanding of the complex interrelationships in new product behavior. Once we establish any stable system of product performance, we can make a sound case for using the product life cycle concept in forecasting demand relationships in a capital budgeting model for screening new product proposals.

CHAPTER III

REVIEW OF SALIENT FINANCIAL CONCEPTS IN EVALUATING NEW PRODUCT PROPOSALS

Introduction

Most recently management has come to subject more and more decisions affecting corporate performance to critical review. Proposals should be screened for conformity with corporate objectives, requiring some quantitative evaluation of the impact such expenditures may have on corporate performance. Judging from past trends, we can assume a continued growth of quantitative techniques in finance and marketing, both in short- and in long-range planning.

Increasing Emphasis on Capital Budgeting

Capital budgeting techniques have principally been applied to the analysis of plant and equipment funds committed to major projects: they usually direct major corporate decisions on investment strategies. These basic techniques are process oriented, however, lacking specific product direction; and any attempt to expand their applicability to decisions regarding recognized market opportunities represents a new point of departure. The demand estimates required as inputs in capital budgeting models are often slighted because of the relative difficulty of estimating demand. The chemical industry has, in fact, been peculiarly limited to the process orientation, since in many cases intermediate processing steps are required before a finished chemical product results, and it has been traditional to roll up manufacturing costs around the processes involved. Any required process may produce economically important coproducts, in which case no single chemical product could be appropriately evaluated by itself.

Rapid technological change often renders products or processes obsolete. It is unreasonable to expect any product to find a future market niche because of past performance. So, the emphasis should be on filling market needs as they become known. Establishing profit centers at the product level seems one of the best ways to achieve the proper orientation, yet such a scheme requires that various functional personnel such as researchers and marketers have a voice in product management. Applying capital budgeting techniques can clearly promote an understanding of product behavior and aid in the selection of investment strategies at all operating levels.

Costs and Investments Considered

All applied resources, physical and human, have associated costs and, theoretically, these can be assigned on a direct or allocated basis to any given product or family of products. (Where coproducts are produced in any given chemical process—assuming all have economic value—we can evaluate the impact both on the individual products and on the total.) Research and development costs incurred prior to the decision to build plant capacity for a chemical product are sunk costs, so costs prior to the first sales year are usually charged against the associated corporate or divisional accounts. Management decides whether or not to provide production capacity by projecting future income streams; in this, it is logical to exclude all previous sunk costs. Any further research and development costs during the life of the product could be treated as part of the product evaluation process and amortized appropriately or, as the practice may become, expensed at the time of actual expenditure.

Expensed items and investments are conventionally distinguished on the basis of longevity in use. Current legislative interpretations delivered by Federal Government regulatory agencies determine the kinds of expenditures that can be charged off as costs to expense, and those that must be capitalized and written off through asset depreciation. The major expense items within the chemical process industries include raw material, labor, energy, quality control, insurance, start-up costs,

marketing, research and development, and general administrative charges. Investments, on the other hand, are basically applications of funds to a specific use over a longer time period. Since the products in the sample vary in the lengths of their investment and economic life expectancy, some attempt should be made to take these factors into account, both in accepting and rejecting new products, and in ranking established products by performance.

Even though the data contributed by the responding companies were as accurate as possible, varying accounting practices among firms in treating all the many fixed and variable costs associated with product behavior, including depreciation policies and development expenditures, make it unreasonable to draw exact comparisons. Having made every effort to standardize the treatment of accounting information for communality in experience, this writer believes the product histories here covered do indicate actual behavior, but only in an approximate sense.

Investment capital may be distinguished as fixed investments and working capital, with fixed capital conveniently divided into new, transferred, and carried-forward fixed investments. New fixed investments for plant (buildings and property) and equipment were valued at actual outlay prices. Transferred fixed investments for plant and equipment, evaluated at replacement cost, cover existing fixed capital shifted to the production of the new product under consideration. And carried-forward fixed investments include that existing fixed capital used in producing raw materials or chemical intermediates which are, in turn, used as inputs for chemical processes resulting in the production of the new product under study: these investments were valued at actual outlay prices or replacement values, depending upon whether the equipment was new or transferred. Working capital investments include raw materials inventory, work in process, finished goods inventory and credit allowances. Actual working capital requirements vary radically with the nature of the product and with established inventory and credit policies as well.

All initial product investments began one and one-half years before introduction, requiring 18 months on the average to establish a production capability within the chemical field. Whether or not the product was produced internally, first year sales marked time period one, with all subsequent changes in investments recorded on an annual basis to reflect increases or decreases in overall investment.

Depreciation Policies Considered

Non-cash depreciation directly affects the actual level of taxation in business operations. For various forms of accelerated depreciation (e.g., the sums of the years' digits method) act to reduce immediate tax payments and increase distant tax payments: their advantage lies only in the concept of the time value of money—a dollar today has more value than a dollar received any time in the future. Since depreciation figures affect net cash flows, they should be included in investment analysis.

Again, widely divergent forms of depreciation calculations among the contributing firms studied necessitated our developing a standardized approach to render product inclusions comparable. Though any technique would be more or less arbitrary, the method presented below at least takes the capitalization process into account. Seeking to rank products against various performance criteria, we may use any technique so long as it is applied consistently in all product analyses.

1. A straight line depreciation policy is used, assuming a ten year economic life for all fixed assets.

2. Whenever additional investments are made after the first year, the nondepreciated balance is released at the end of the analysis.

3. If the product remained stable in the marketplace at the end of the last time period in the study, and the number of recorded time periods for sales is less than the maximum possible of ten, future sales and investment requirements will be estimated by extrapolation to the final period by using its predetermined polynomial or other appropriate mathematical function.

4. If the product had been withdrawn at any time from the marketplace, all depreciable fixed assets not yet depreciated, which supported the production of the product, are credited to its cash flows as released assets.

Salient Financial Concepts

The many evaluation techniques suggested for investment analysis variously affect the measurement of immediate and, more importantly, long-range performance. Although pure survival matters a great deal, of course, the accelerating pace of market development and technological change make the relating of actions with pre-established objectives more essential. Each of the techniques here presented, then, should help in analyzing the performance of products included in the research.

As we have come to expect, investment accounting practices vary widely among major chemical manufacturers, sometimes even within a given divisional operation. So each product investment schedule was considered individually in an attempt to put all investment within a common framework. Book or net investment figures were avoided as purely accounting conveniences irrelevant to measures of performance.

1. Cost of Capital

Any discussion of evaluation techniques based on discounting procedures should consider the cost of capital concept, its meaning and calculation.[1] Actual costs of capital for select firms over specific time periods are measured as the first approximation of the discount factors that management must face in new product investment decisions. For many sources of funds can finance investment decisions, no one financing source necessarily funding product decisions for large manufacturing firms. Usually, in fact, a variety of capital funds support

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[1] One procedure for calculating the weighted cost of capital is suggested by J. Fred Weston, Managerial Finance, (New York: Holt, Rinehart and Winston, Inc., 1962), pp. 226-249.

a composite of new product proposals. Indeed, since major industrial chemical manufacturers typically face many new product decisions during any planning period, no single funding decision will grossly affect either the aggregate leverage position of the firm or its overall cost of capital. The marginal cost of capital constitutes the relevant discount factor in calculating present value measurements for proposed ventures. The average cost of capital is traditionally assumed to be constant over small incremental changes of leverage that a firm employs at any given time, thus, the marginal cost of capital equals the value of the average cost of capital.[2,3]

For our research purposes, a firm's relevant cost of capital shall take a weighted average of the costs of each type of capital, from all financing sources, with the basic model as follows:

$$K_0 = W_1 K_1 + W_2 K_2 + W_3 K_3$$

where K_0 = overall capitalization rate of operating earnings, reflecting both business and financial uncertainties.

W_i = weight of a given class of fund i based on the market value of that source relative to the market values of all financing sources for the firm.

K_1 = capitalization rate of short term liabilities.

K_2 = capitalization rate of long term debt.

K_3 = capitalization rate of equity capital.

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[2] See Myron Gordon, The Investment, Financing and Valuation of the Corporation, (Homewood, Ill.: R. D. Irwin, Inc., 1962).

[3] An excellent, controversial discussion of the firm's financial structure and its effect on the cost of capital can be found in F. Modigliani and M. Miller, "The Cost of Capital, Corporation Finance, and the Theory of Investment," American Economic Review, Vol. 48, No. 3 (June, 1958), pp. 261-297.

Largely a future oriented concept, the cost of capital should specifically consider what the firm is facing at the time the decision to reject or accept any new product proposal is considered as well as any changes the firm may face in the future. Any quantitative measure of the cost of capital may theoretically range from a low, equal to the prime rate of money, to infinity.

A. Cost of Current Liabilities

Short term debt, one source of capital available to firms and having an associated cost, is seldom included in any determination of cost of capital, perhaps from its relative unimportance in many situations. But, since it affects the utilization of all resources of the firm, it does affect the cost of capital and should be included; taxes payable, wages payable and other noninterest-bearing current liabilities are generally excluded from the calculation. For our purposes, the applicable rate of interest used for any year is the rate of commercial paper (4 to 6 months) at current rates deflated by the appropriate tax rate. Interest payments are tax deductible, so the effective cost of interest-bearing debt depends on the existing tax rate.

B. Cost of Long Term Debt

Dependent on the type of fund, long term debt is measured at current rates using market values and interest rates applicable to that type of financing for any given year. If market values are unobtainable, coupon or bank rates are substituted in the calculation. Again, all interest rates are deflated by the appropriate tax schedule.

C. Cost of Equity Capital

For our purposes, the capitalization rate associated with the equity portion for any period is based on market values of all types of stocks outstanding, assuming that current market prices reflect investors' evaluations of the firm's commitments and capabilities not only on an

immediate operating basis but for the distant future. Since retained earnings imply a cost to the firm, they are in fact regarded as a type of common stock investment; retained earnings contribute one source of funds and hence bear an opportunity cost. From an investor's viewpoint, of course, the source of funding is independent of expected returns; any normal returns from the use of retained earnings justify their use.

The rate used in assigning costs associated with preferred stock is the coupon rate, that is, the effective rate acceptable to preferred stockholders at the time of purchase. The appropriate discount rate for common stock probably should not be based on any current price-earnings relationship, especially for growth oriented firms (as many chemical manufacturers are). So, to provide a more realistic approximation to the true capitalization rate associated with common stock, the long term return on the common equity measurement is chosen because it reveals earnings growth yield on the common stock after risk valuation. It does not reflect the present situation, but measures expectation. The median return on common equity for the five year period after market introduction is actually used as the appropriate capitalization rate.[4] In terms of our information requirements, all common equity measurements are known, so no projections are necessary.

2. Payback Period

The number of years required to recover the initial depreciable fixed investment in plant and equipment, defined as the payback period, is probably the most widely used technique in ranking investment decisions in industrial situations. The simplest payback period—a lumped investment and averaged incremental cash flows—appears algebraically as:[5]

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[4]This approach includes an approximation of the impact of growth provided by retained earnings. The problems encountered in measuring the cost of equity capital are discussed by E. Solomon, The Theory of Financial Management, (New York: Columbia University Press, 1963), pp. 69-78.

[5]The equations defining those financial techniques actually used in the analysis of collected data are noted with an asterisk.

$$PP_T = \frac{I_L}{\dfrac{\sum_{j=0}^{n} OCF_j}{n}} \qquad (3.1)$$

where PP_T = payback period in years

I_L = lumped investments required before market introduction

$\dfrac{\sum_{j=0}^{n} OCF_j}{n}$ = mean operating cash flows (after taxes), i.e., average net profits after taxes plus depreciation, from time period 0 through n.

In nearly universal use whenever liquidity (rapid investment recovery) is a meaningful financial objective, this simplified technique does not involve entire economic lives and income streams, but only those parameters for the time period essential to recoup fixed investments.

This time concept ignores the temporal patterns of cash flows, however, as well as possible important contributions beyond the calculated time period, and thus fails to measure profitability properly. It seldom accounts for working capital requirements as investment inputs. Furthermore, the payback period may not provide a good indicator of risk. The risk of not getting production started on schedule due to technical difficulties in equipment design would all but be eliminated after the production system is tested and proven operational. The risk associated with competitors lowering traditional price levels at the time of product introduction would be resolved based on actual behavior. The risk of incorrectly assessing the impact of advertising media programs on product acceptance can be significantly reduced once checked against actual sales records after the product is launched. In many similar situations, some risks are reduced after the market introduction stage. So the payback technique

will demonstrate a bias toward investments that have disproportionately large cash flows early in the product life cycle.

The payback period concept may be redefined in situations where investments vary over time, especially important in chemical processes where investment totals are sensitive to varying levels of output because of carry-forward investments associated with raw materials. Working capital is generally ignored, with investments usually defined as fixed capital only. Where multipurpose equipment is used in the noncontinuous production of chemical products, investments can be distributed equitably to all products on a time-in-use basis. A modification of the simple payback equation incorporates a change in the definition of the investment variable.

$$PP_T = \frac{I_C}{\dfrac{\sum_{j=0}^{n} OCF_j}{n}} \qquad *(3.2)$$

where PP_T = payback period in years

I_C = maximum accumulated investment figures from time period 0 through n

OCF_j = yearly operating cash flow in time period j (after taxes), i.e., (Sales - cash charges - depreciation) (1 - TX) + depreciation, where TX = prevailing tax rate.

3. Accounting Rate of Return

This financial technique seeks to measure relative product profitability, though there is little apparent agreement about which of several alternate procedures is best. For products where investments only occur in time period -a, common definitions include:

$$ARR = \frac{EAT \Big|_{t=1}}{I \Big|_{t=-a}} \times 100 \tag{3.3}$$

$$ARR = \frac{\dfrac{\sum_{j=1}^{n} EAT_j}{n}}{I \Big|_{t=-a}} \times 100 \tag{3.4}$$

$$ARR = \frac{\dfrac{\sum_{j=1}^{n} EAT_j}{n}}{(0.5)\, I \Big|_{t=-a}} \times 100 \tag{3.5}$$

where ARR = accounting rate of return

EAT_j = earnings after taxes in time period j

$I \Big|_{t=-a}$ = required fixed investment at the time of initial authorization in time period -a

n = number of periods in the analysis

The first formula takes into consideration only book profits for the first period, ignoring the contribution of future income streams; and equations (3.4) and (3.5) ignore cash flows as well as the time value of money. In no case, here or below, are investment changes through time taken into account, again favoring products having relatively high initial earnings.

For products having distributed fixed investments, the denominator could be altered to define the period of maximum investment, though this does not change its limitations.

$$ARR = \frac{\dfrac{\sum_{j=1}^{n} EAT_j}{n}}{(0.5)\, I \Big|_{t=c}} \times 100 \qquad *(3.6)$$

where ARR = accounting rate of return

EAT_j = earnings after taxes in time period j

n = number of time periods in the analysis

$I \Big|_{t=c}$ = maximum investment in time period c

4. Return on Investment

Analysts within the chemical industry often employ the rate of return investment calculation, a limited concept by definition in the sense that it only measures a product's degree of profitability against its investment rate for a given time period. Its formula is shown typically as:

$$ROI_j = \frac{(EAT)_j}{I_j} \times 100 \qquad *(3.7)$$

where ROI = return on investment for time period j expressed as a percentage

$(EAT)_j$ = earnings after taxes in time period j

I_j = accumulated investment in time period j

Because cash flows vary widely throughout the life of a product, calculated ROI values may vary widely. As will be evidenced in the research findings, one cannot accurately project performance during the first several years in the case of industrial chemicals and expect it to be typical. Apparently one should really project demand and cost relationships far into the future when evaluating product proposals; in which case the most representative return on investment figure would be its median. But other financial techniques yet to be covered are more exacting and informative.

This measure obviously ignores the timing of cash flows, possibly a serious limitation. Such a subtle distinction may indeed be significant when one must examine a host of different attainable combinations in selecting a composite set of new product opportunities for market development based on profit optimization.

5. Internal Rate of Return

The internal rate of return, defined as that discount rate which will equate the discounted earnings cash flows and discounted investment cash flows over the product life cycle, can handle many of the limitations of other methods for evaluating product proposal work. It allows for varying product lives, taking into account the time value of money; and unlike the present value calculation (to be covered later), it makes no assumption about the exact cost of capital. Where the initial investment is fixed in size, the expression appears as:

$$I_{-a} - \sum_{j=0}^{n} \frac{(EAT + D)_j}{(1 + i)^j} = 0, \text{ and solve for } i \qquad (3.8)$$

where I_{-a} = lumped investment made in time period -a

D = depreciation charges

$(EAT + D)_j$ = total cash inflow in time period j

i = internal rate of return expressed as a fraction to the base 1

$j \leq n$

And where investment timings vary throughout the product life cycle from time period -a to n, the formula appears as:

$$\sum_{j=-a}^{n} \frac{\left[(EAT + D) - I\right]_j}{(1 + i)^j} = 0, \text{ and solve for } i \qquad (3.9)$$

where i = internal rate of return expressed as a fraction to the base 1

$\left[(EAT + D) - I\right]_j$ = net cash flow in time period j

$j \leq n$

Depreciation figures are necessary inputs in calculating the internal rate of return for they are used to determine tax liabilities. Any formula that considers the time value of money, such as the internal rate of return, includes with investments all fixed and working capital, so the timing of cash flows should be a relevant consideration. Marked changes in yearly investment totals are likely to occur through

time—which is where mathematical complications may arise. In general, two rates of return are possible whenever net cash flows shift from a positive to a negative figure during the analysis, whether this shift is due to an overall lack of profitability when investment expenditures for plant expansion exceed earnings, or to the release of any substantial amount of nondepreciated assets at the end of the product life cycle.[4]

Theoretically, any product can be accepted if its calculated internal rate of return exceeds the cost of capital for the firm, though naturally the cost of capital must be determined to use such a break-off point. In practice, many decision makers choose break-off points somewhat higher than the cost of capital to reflect possible marketing and related risks, depending on the nature of the product. This technique may not allow proper rankings of alternate product proposals having unequal product lives: a product with a 10% rate of return may not be better than one with an 8% rate of return. The internal rate of return method implicitly assumes that cash funds produced by any product are reinvested at the earned rate of that product. Occasionally this assumption is acceptable, as when a higher reinvestment rate pertains. But, in many situations, other discounted financial techniques evaluate and rank product proposals more effectively. All similar approaches still require estimates of performance over a significant portion of the product life history.

6. Present Worth Method

A promising discounted cash flow technique, the present worth method, explicitly handles the common situation facing chemical development decision makers where patterns of investment and earnings vary throughout the product life cycle. The earnings stream after taxes is discounted at an appropriate discount rate, and the investment stream similarly. Then if a product's net present worth is positive, that is, the algebraic sum

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[4]See John G. McLean, "How to Evaluate New Capital Investments," Harvard Business Review, Vol. 36, No. 6 (November-December, 1958), pp. 65-67.

of its discounted earnings exceeding the sum of its discounted investment figures, the product proposal is sound on the basis of financial data and may be accepted. This method also allows for ranking various new product proposals according to their calculated profitabilities as long as they have equal product lives. The net present value is expressed thus:

$$NPV = \sum_{j=0}^{n} \frac{(EAT + D)_j}{(1 + i)^j} - \sum_{j=-a}^{d} \frac{I_j}{(1 + i)^j} \qquad *(3.10)$$

where NPV = net present value

I_j = incremental investment required in time period j

$(EAT + D)_j$ = total cash inflow in time period j

$d \leq n$

$j \leq n$

i = predetermined discount rate

Most critical is the selection of the appropriate discount rate, though the cost of capital concept has been used. The exact meaning of any net present worth figure in dollars remains unknown. Yet despite this confusion the present value method does attempt to systematically quantify the important parameters in evaluating performance.

Problems arise when product lives differ. Taking the smallest common length of all product lives in a given set of attainable opportunities seems unreasonable for it favors higher net cash flows early in the product histories, overemphasizing liquidity. The simplest approach acceptable to the analyst involves converting present value totals to

annualized figures. The expected net profit contribution for any product on an annualized basis, in the present worth approach, would be simply:

$$\frac{\displaystyle\sum_{j=0}^{n} \frac{(EAT + D)_j}{(1+i)^j} - \sum_{j=-a}^{d} \frac{I_j}{(1+i)^j}}{n} \qquad *(3.11)$$

where n = time horizon in years considered

$d \leq n$

$j \leq n$

Associated financial and marketing risks can be accounted for in the evaluation process by adjusting the discount rate employed to arrive at present value figures. Product inclusions would be based on that combination of products which, over a given time horizon, maximize their sum of present values per year of market life, taking into account the usual resource limitation thwarting capital formation: this involves ranking yearly present values, and approximates an optimum selection of product combinations.

7. Equivalent Rate of Return

The equivalent rate of return is based on calculated present values of net earnings over investments in a specific time period, and makes the same assumptions regarding product lives and net cash flows. But the performance of a given product can here be related more meaningfully as a percentage return figure, the type of expression commonly used among people assigned the responsibility of evaluating product opportunities. Unlike the internal rate of return formula, this makes no assumption regarding reinvestment rates.

The formulation suggested by Herron is:[5]

$$\mathrm{ERR} = \frac{\displaystyle\sum_{j=0}^{n} \frac{(\mathrm{EAT} + \mathrm{D})_j}{(1+i)^j} - \sum_{j=-a}^{d} \frac{I_j}{(1+i)^j}}{\displaystyle\sum_{j=-a}^{d} \frac{I_j}{(1+i)^j}} \times 100 \qquad *(3.12)$$

where ERR = equivalent rate of return expressed as a percentage

$d \leq n$

$j \leq n$

This measure essentially defines the specific return made on cumulative discounted investments through time.

The equivalent rate of return inadequately evaluates differing product lives. And since it cannot appropriately rank projects by absolute profit contributions even where product lives are identical, it has its drawbacks. Nevertheless, accept or reject decisions based on the sign of the equivalent rate of return are accurate: that is, as long as the equivalent rate of return is positive in value, accepting the product would enhance earnings growth. Higher positive equivalent rate of return figures reflect greater returns on asset utilization, but they may not necessarily indicate optimum earnings per share results.

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[5] David P. Herron, "Comparing Investment Evaluation Methods," Chemical Engineering, Vol. 74, No. 3 (January 30, 1967), pp. 129-130.

8. Profitability Ratio

If one assumes a reinvestment capability for the summed net cash flows at the predetermined discount rate for those products in the analysis having economic lives shorter than the maximum, then net cash flows may be discounted out to the time period covered by the product with the longest economic life. Where multi-purpose equipment has use elsewhere, the released capital outflow is discounted in the fashion described previously. The resultant net discounted cash flow stream is expressed as a ratio to the discounted capital outlay stream.[6]

The formula relating discounted net cash flows to discounted investment flows for all products having market lives of e periods, but less than n periods, is shown as:

$$PI = \frac{\left[\sum_{j=0}^{e} \frac{(EAT + D)_j}{(1+i)^j} - \sum_{j=-a}^{d} \frac{I_j}{(1+i)^j}\right] + \left[\frac{\dfrac{\sum_{j=0}^{e} (EAT + D)_j - \sum_{j=-a}^{d} I_j}{(1+i)^j}}{(1+i)^n}\right]}{\left[\sum_{j=-a}^{d} \frac{I_j}{(1+i)^j} + \frac{\sum_{j=-a}^{d} \frac{I_j}{(1+i)^j}}{(1+i)^n}\right]} \qquad *(3.13)$$

where PI = profitability ratio

$j \leq e$

$d \leq n$

$e \leq n$

[6]Such methodology is adapted from Edgar A. Pessemier, New Product Decisions, (New York: McGraw-Hill Book Company, 1966), pp. 77-78.

The ratio for products having market lives of n periods is merely the ratio of the conventionally calculated discounted net cash flows to discounted investment flows, using the formula:

$$PI = \frac{\sum_{j=0}^{n} \frac{(EAT + D)_j}{(1 + i)^j} - \sum_{j=-a}^{d} \frac{I_j}{(1 + i)^j}}{\sum_{j=-a}^{d} \frac{I_j}{(1 + i)^j}} \qquad *(3.14)$$

where PI = profitability ratio

$d \leq n$

Positive ratios on profitability indexes indicate acceptable product proposals in terms of financial performance, with profitability being a relative function of asset size, after all nondepreciated assets are released. The larger the ratio, the higher the relative profit contribution, in terms of more efficient utilization of capital equipment.

9. Performance Index

It is quite possible to combine a number of these financial definitions and to devise analytical formulas tailoring product selection to specific corporate objectives. For example, management may desire to weigh equally the effects of present value and liquidity. One such performance index, PIN, takes into account both of these concepts in the form:

$$PIN = \frac{\sum_{j=0}^{e} \frac{(EAT + D)_j}{(1+i)^j} - \sum_{j=-a}^{d} \frac{I_j}{(1+i)^j} + \frac{\sum_{j=-a}^{n} (EAT + D - I)_j}{(1+i)^n}}{\sum_{j=-a}^{d} \frac{I_j}{(1+i)^j} + \frac{\sum_{j=-a}^{d} I_j}{(1+i)^n}} \quad *(3.15)$$

where PIN = performance index

n = longest time horizon in the set of projects being evaluated

$d \leq n$

$e \leq n$

$j \leq n$

Here products are ranked not only according to their net cash flows but to the extent of total cash generated throughout their market lives as well. The equal weighting scheme in this case was obviously arbitrary and could be altered to suit individual needs.

Summary

No one financial technique for evaluating product proposals can be considered clearly superior; each has distinct advantages and disadvantages. It is most important to compare product proposals using many different and combined financial techniques for a better understanding of expected performances. Nevertheless, the annualized discounted present value model seems to be most suitable when one desires to rank proposals and select alternatives on the basis of only one relationship, net discounted cash flows. The empirical portion of this thesis will investigate the similarities and dissimilarities among these described techniques; then, perhaps more appropriate recommendations can be made.

CHAPTER IV

METHOD OF DATA COLLECTION

Selection of Industry

The industry to be studied was selected partly according to its apparent level of emphasis on new product development activity: presumably management would respond more readily to this study if it was already stressing new product development as an industrial strategy. And expecially since contributing firms would have to retrieve the underlying data—an expensive, time consuming process—only those industries having adequate staff and informational capabilities could be expected to cooperate. Certainly the research and development branch of the chemical industry has always been heavily involved in new product development. Furthermore, wherever long-range planning received considerable attention, the capabilities required for internal coordination of this programmed study usually appeared as well. Once the study was underway, we found in fact that respondents of the participating firms indeed felt that their efforts were contributing to a more comprehensive documentation of product behavior in their own field, generally concluding that such work was indeed worthwhile. As an expression of gratitude for their participation, the respondents were offered a copy of the research findings.

Definition of New Product

Predictably, the firms in the industry differed over what constitutes a new product, since different people had different orientations and responsibilities to one or another specialized facet of operation associated with new product work. Nevertheless, establishing a definition of a new product was necessary to allow consistent interpretations among responding firms. We shall define a new product as differentiable from existing products on the basis of composition, structure, form or shape, including adaptive products introduced by firms who did not previously offer them as an integral part of their product mix (where the product is actually new to the firm, though not to the marketplace).

All products added to existing product offerings as a result of acquisition, merger or combination are excluded, because in many of these cases, product programs continue to be implemented by the same basic line management, even after an integration of capital structures has been completed. The products in question may be new to the parent company, but not to the elements within the company having operational control and primary responsibility over product development work or the marketplace. The fruits of purchased technology may, however, be included. Since we desire to investigate the progress of only significant new products within the basic chemical industry, we have arbitrarily set a minimum annual sales level of $50,000 for this study. And any new product so qualified retains its classification for five years, another arbitrary limit insuring relative consistency in information, and allowing relative comparability of new product development experiences across all firms included in the sample. Any product included must have reached this minimum for the first time between the years 1955 and 1960.

Most accounting data are considered for reporting purposes at the end of the fiscal year (the end of the calendar year for most major chemical firms). Again to render statistical comparison meaningful, a new product must have been introduced for five complete fiscal periods; any partially completed introductory period preceding the start of a complete fiscal period for a given product will be adjusted to reflect annualized patterns when analyzing life cycle data. Such a procedure allows for meaningful comparisons without introducing any built-in bias.

As new products must be distinguishable from existing products on the basis of composition, structure, form or shape, formulations are generally excluded unless they prove to have been unique either from a marketing or a technological standpoint. Internal consumption must be less than 10%, for if large amounts of the product were captively consumed, the make or buy decision would be made primarily from cost considerations.

Technological breakthroughs in synthetic fibers and plastics have spurred unusual expansions into new fields within the chemical industry. Yet much underlying growth has stemmed from basic chemical products:

> ". . . it must be emphasized that the dramatic growth rate of the industrial chemical industry has reflected and has been made possible by the large flow of new products. The volume of older products has increased as our national economy has grown in size. But it has been the sales derived from the new organics, particularly synthetic materials, which has made the difference between an about average growth rate and one which is twice as rapid as that recorded by the national economy. However, a continuation of past trends will depend upon the continued high rate of innovation which has contributed so significantly to the brilliant record achieved by industrial chemicals."[1]

Thus it was that only industrial organic and inorganic chemicals were included in the defined population.

The Standard Industrial Classification system devised by governmental sources was used to identify specific products, thus protecting the vital interests of contributing firms from disclosure of confidential information. The major group, chemicals and allied products (SIC 28), includes three general classes: (1) basic chemicals, such as acids, alkalies, salts and organic chemicals; (2) chemical products used in upgrading processes, such as synthetic fibers, plastic materials, and pigments; and (3) finished chemical products for ultimate consumption, such as drugs, cosmetics and soaps, or for use in other industries, such as paints, fertilizers, and explosives. The SIC 281 group is a further subdivision of the chemicals and allied products group and includes industrial inorganic and organic chemicals. Any products included in this study, then, can be coded as follows:

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[1] Jules Backman, Chemicals in the National Economy, (Washington, D.C.: Manufacturing Chemists' Association, Inc., December, 1964), p. 3.

Standard Industrial Classification Number	Inclusions
2812	Alkalies and Chlorine: sodium hydroxide, potassium hydroxide, sodium carbonate, potassium carbonate, sodium bicarbonate, chlorine, and the like.
2813	Industrial Gases: gases in liquid, solid, and compressed forms, as acetylene, nitrogen, and hydrogen.
2814	Cyclic (Coal Tar) Crudes: coal tar crudes, coal tar acids, medium and heavy oil products as creosote oil, naphthalene, anthracene, and their homologues (coal tar crudes produced in recovery ovens and petroleum refineries not included).
2815	Intermediate Coal Tar Products: cyclic organic intermediates, dyes, color lakes, and color toners.
2816	Industrial Inorganic Pigments: all inorganic pigments, as black, white, and color pigments.
2818	Industrial Organic Chemicals, N.E.C.: noncyclic acids, aldehydes, amines, solvents, polyhydric alcohols, synthetic perfume and flavoring materials, rubber processing chemicals, cyclic and acyclic plasticizers, synthetic tanning agents, and chemical warfare gases.
2819	Industrial Inorganic Chemicals, N.E.C.: salts, alums, calcium carbide, hydrogen peroxide, phosphate, sodium silicate, ammonia compounds, anhydrous ammonia, fertilizer materials as muriate and sulfate of potash, rare earth metals (alkali) and metal salts.

In summary, all new products included in this research design:

1. Must possess SIC Codes 281X.

2. Must have attained minimum sales volume of $50,000 annually for at least one year, reaching this volume for the first time between the years 1955 and 1960.

3. Must consume less than ten percent internally.

4. Must be differentiable from existing products in composition, structure, form or shape.

5. May not be a formulation.

6. Must be new to the firm, though not necessarily to the marketplace.

Selection of Population

This dissertation takes major chemical manufacturers for its population. Since an estimated 850 chemical firms sell over $50 million annually, a speculative listing in any event, each major chemical firm must be listed:

1. In the top 500 largest industrial firms (ranked by sales) as compiled by the editors of Fortune magazine.[2]

2. In the directory of companies filing annual reports under the Securities Exchange Act of 1934 as of 1963 under SIC Codes 281 and 289.[3,4]

3. On available Compustat tape of Standard Statistics, Inc., at the Computer Center, Michigan State University, East Lansing, Michigan, under SIC Codes 2800 Chemicals, 2823 Synthetic Fibers, or 2899 Chemicals and Chemical Preparations (1966 edition).

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[2] "The Fortune Directory of the 500 Largest U.S. Industrial Corporations," Fortune, Vol. 74, No. 2 (July 16, 1966), pp. 230-251.

[3] Securities and Exchange Commission, Directory of Companies Filing Annual Reports with the Securities and Exchange Commission under the Securities Exchange Act of 1934, (Washington, D.C.: Office of Statistical Studies, Division of Trading and Markets, 1963), pp. 117-121.

[4] The Securities and Exchange Commission has chosen to include product offerings conventionally listed as 282 under the 281 code. We thus see plastic materials, synthetic resins, synthetic rubber and other man-made fibers included. Each industrial firm was placed in one selected category after a determination was made of its major line of business.

The final alphabetical tabulation of major chemical firms, henceforth identified as the population for the study, is as follows:[5]

	Firm	Corporate Address
1.	Air Products and Chemicals, Incorporated	P. O. Box 538 Allentown, Pennsylvania 18100
2.	Air Reduction Company, Inc.	150 E. 42nd Street New York, New York 10017
3.	Allied Chemical Corporation	61 Broadway New York, New York 10006
4.	American Cyanamid Company	Wayne, New Jersey 07470
5.	Celanese Corporation of America	522 Fifth Avenue New York, New York 10016
6.	Chemetron Corporation	201 E. 42nd Street New York, New York 10017
7.	Diamond Alkali Company	300 Union Commerce Building 9th and Euclid Cleveland, Ohio 44114
8.	The Dow Chemical Company	Midland, Michigan 48640
9.	E. I. duPont de Nemours & Company	Wilmington, Delaware 19898
10.	Eagle-Picher Company	American Building Cincinnati, Ohio 45202
11.	Ethyl Corporation	100 Park Avenue New York, New York 10017
12.	FMC Corporation	633 Third Avenue New York, New York 10017
13.	W. R. Grace and Company	7 Hanover Square New York, New York 10005
14.	Hercules, Inc.	Wilmington, Delaware 19898

[5] Two corporations, American Enka and International Minerals and Chemicals, were not included because they either had no SIC 281 Code production or had introduced no new products (as defined by the aforementioned criteria) within the time period specified.

Firm	Corporate Address
15. Hooker Chemical Corporation	Niagara Falls, New York 14302
16. Koppers Company, Inc.	Koppers Building Pittsburgh, Pennsylvania 15219
17. Monsanto Chemical Company	1800 North Lindbergh St. Louis, Missouri 63166
18. Olin Mathieson Chemical Corporation	460 Park Avenue New York, New York 10022
19. Pennsalt Chemical Corp.	3 Penn Center Philadelphia, Pennsylvania 19102
20. Reichhold Chemicals, Inc.	525 N. Broadway White Plains, New York 10603
21. Rohm and Haas Company	Washington Square Philadelphia, Pennsylvania 19105
22. Stauffer Chemical Company	380 Madison Avenue New York, New York 10017
23. Union Carbide Corporation	270 Park Avenue New York, New York 10017
24. Witco Chemical Company, Incorporated	277 Park Avenue New York, New York 10017
25. Wyandotte Chemicals Corp.	Box 111 Wyandotte, Michigan 48192

Performance Record of Major Chemical Companies

The chemical industry as a whole has made substantial gains in physical output and dollar shipments during the last two decades. More progressive domestic chemical manufacturers have successfully broadened marketing participation in above average growth areas, particularly through integration movements, both forward toward final markets and backward toward sources of lower cost raw materials. Balancing the promotion of profitable upgraded chemical products against the support of commodity type chemicals helped generate above average gains, both endeavors requiring considerable funding in research and development. Naturally merger activities and other factors aided this historical growth as well.

Chemical companies with smaller asset and sales structures have typically been able to grow at above average rates during the 1955-66 period (see Tables 4-1 and 4-2). Reference is made here to the compounded rates of change, not generalizing with respect to absolute dollar changes for revenues. Ranking fourteenth in 1966 sales among the 25 major chemical companies, Ethyl Corporation has shown the most aggressive sales growth history during 1955-66 with an annual growth rate of 30.6%, primarily due to its profitable bid for petroleum additive and industrial chemicals business.[6] National concern over possible pollution hazards caused by gasoline emissions involving tetraethyl lead anti-knock additives has forced Ethyl to re-examine its long-range position in this field. The company continues to diversify through both internal development and acquisition to include biodegradable detergents, plastics and paper products.

Since only three companies ranking in sales among the top ten in 1966 had above average sales growth rates in the 1955-66 period, it appears that large asset firms have not dominated long term relationships in rapidly growing market areas, although the evidence remains inconclusive. Other companies showing exceptional annual growth rates include Air Products and Chemicals, Inc., with major expansions in industrial gases (23.8%); Witco Chemical Company, enjoying a strengthened position as a specialty chemicals producer through the acquisition and new product routes (20.0%); and Celanese Corporation, with primary emphasis on the marketing of synthetic fibers, organic chemicals, and plastic products (17.1%).

Those chemical firms having above average growth of net sales over the 1955-66 period also tended to have higher earnings growth (see Tables 4-2 and 4-3). In fact the comparative rankings between these two performance characteristics did not begin to differ prior to the sixth rank position, the most notable exception being Air Reduction who ranked ninth in sales growth over the 1955-66 period but dropped to

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[6] Prospectus, (Richmond, Virginia: Ethyl Corporation, October 7, 1964), pp. 7-14; Special Meeting of Stockholders, (Richmond, Virginia: Ethyl Corporation, June 27, 1967), pp. 16-18.

eighteenth in changes of net profit to common stock over the same time period. With the emergence of strong demand for industrial gases, Airco has benefited from its regionalized production capabilities in developing specific users. But its competitive cost position was disrupted in the long run because of a management decision to limit production to relatively small scale operations. Although the company had a broad marketing and distribution network, it has recently had to switch to larger production units in order to establish a more favorable cost position. Such policies did limit earnings over the time period under study.[7]

There were two companies, Diamond Alkali Company (now Diamond Shamrock) and Hooker Chemical Corporation (acquisition completed by Occidental Petroleum), whose experiences on changes in earnings per share and net profit to common substantially differed once ranked (see Tables 4-4 and 4-5). Diamond Alkali significantly improved its relative position on a per share basis, while Hooker Chemical slipped in the rankings as its number of shares outstanding increased through time at a faster rate than that of other chemical firms relative to their earnings.

Among these companies we note a tendency to have a relative dilution of earnings on a per share basis, i.e., the propensity to increase the number of shares outstanding was greater than that of overall earnings growth. Thus the annual growth rates of earnings per share typically fell below that of net profits to common stockholders, often due partly to securing additional capital through equity financing for needed plant expansions. The Rohm and Haas Company was the only exception, since its 8.7% annual growth rate on net profit to common was less than that on a per share basis. In this case, there was no real earnings dilution over the 1955-66 period.

It is difficult to generalize about cash flow patterns of major chemical companies over the 1955-66 period since interfirm accounting practices have varied so widely. For many firms, capital investment

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[7] "A New Airco Diversifies for Growth," Chemical and Engineering News, Vol. 41, No. 44 (October 14, 1963), pp. 44, 46.

requirements have increased faster than the earnings record on a share basis over the long run, pinpointing their willingness to accept deferred cash benefits far in the future (see Tables 4-4 and 4-5). Part of the explanation may lie with changes in firms' depreciation policies during the time period under study. Since it was strongly expansionistic-minded relative to its current earnings position, Reichhold Chemical Corporation stood out, seeking in many ways to broaden its product mix and earnings base. When compared with the historical earnings patterns of other major chemical producers, Reichhold has managed to improve its relative ranking some twelve positions in the listing of growth rates for cash flow figures.

Industry-wide relative market valuations of stock have fallen during the 1955-66 period (see Tables 4-4 and 4-6); in fact, 56% of the companies found that price movements of their common stocks during this time period did not even keep pace with changes in their respective earnings records. For the long term investor, the chemical group has fallen into disfavor, the investment community apparently concluded that the long term growth potential of the industry generally warranted more conservative stock valuations. Mean price-earnings ratios of the major chemical firms under study between 1955 and 1966 ranged from a low of 12.02 for Eagle-Picher Company to a high of 27.38 for The Dow Chemical Company (see Table 4-7). Diversified chemical companies probably attract capital on the basis of long term growth rather than on expectation of immediate earnings. Many companies have been accorded rather liberal price-earnings ratios. For example, Dow Chemical has a strong, broad position in basic chemical commodities, its large scale operations being instrumental in maintaining favorable production economics. Dow Chemical also is a manufacturer of many upgraded products, having diversified activities in animal and human health areas, plastics, metals and packaging. Its commitments in overseas activities are expanding rapidly to meet the needs of growing foreign markets.[8]

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[8] The Dow Chemical Company, 1965 Annual Report, pp. 2-7.

Record capital expansion programs budgeted by the chemical industry have required the use of funded debt. Many firms would simply not have been able to add new capacity in established product areas to meet the growing market needs if they were limited to internally generated cash sources. In terms of the population, seventeen firms out of the 25 had mean long term debt positions exceeding 20% of total capital (see Table 4-8). The favorable provisions of the Revenue Act of 1964 were quite a stimulus to increased plant investment activities, with its allowance for a 7% investment tax credit resulting in an effective reduction in corporate taxation rates. Not only did this measure have an immediate impact on profitability, but it provided worthwhile investment incentives for growth. Most firms now have considerably higher leverage capital structures than the long term positions of major chemical firms shown in Table 4-8 covering the 1955-66 period.

Profits before taxes as a percent of sales for basic chemicals began to dip in 1958, recovering well the following year, though they have never since managed to surpass the 17.5% high of 1959.[9] In recent years chemical firms have been unable to keep rising costs in line with a more stabilized price structure. Part of this deteriorating profitability is due to significant increases in capital expenditures and expensive start-up costs of new facilities.

Return on common stockholders' equity has improved significantly for the chemical industry since 1961, though continued pressure on profit margins after 1965 has forced a reversal in this trend.[10] During the 1955-66 period, the mean return on common stockholders' equity in the population ranged from a low of 6.0% for Koppers Company, Inc., to a high of 22.0% for Ethyl Corporation (see Table 4-9). Koppers Company, however, has depended fairly heavily on less profitable nonchemical fields for earnings, including highly cyclical engineering and construction activities. Coupled with less aggressive marketing efforts in chemicals and plastics, inefficient producing plants and price attrition account

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[9] Federal Trade Commission - Securities and Exchange Commission, Quarterly Financial Report for Manufacturing Corporations, various issues, 1955-1968.

[10] Ibid, various issues, 1961-1968.

for its poor showing on the return measure relative to other major chemical manufacturers.[11] On the other hand, Ethyl has managed to sustain a very aggressive expansion program, capitalizing on patent protected positions in a select number of profitable upgraded chemical products.

Whenever investment opportunities exist within any operating firm, executive management must select capital sources if authorizations are to be granted. Within the defined population, six companies have had mean retention rates in excess of 60% (see Table 4-10). All except Reichhold Chemicals, Inc., had above average earnings growth, with the retention of earnings important in achieving these performance records in the 1955-66 period under study. The duPont situation is peculiar: since this company requires a high cut-off return on investment rate before proposed projects are acceptable to management, the number of new investment opportunities did not far outpace that which could be funded from current operations. The company has paid out in dividends the value of its net income earned during the entire twelve year period, plus some more. Yet the company's earnings from its investment in General Motors common stock, before its forced divesture in January, 1965, were sizable. In actuality, the aggregate of preferred and common stock dividends paid from duPont sources was 71 percent of earnings for the ten year period 1957 through 1966.[12] It is interesting to note that duPont had no long term debt obligations outstanding before 1965.

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[11] "Koppers Prepares for the Good Years," Chemical and Engineering News, Vol. 42, No. 42 (September 28, 1964), pp. 33-37.

[12] E. I. duPont de Nemours & Company, Annual Report for the Year 1966, p. 41.

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TABLE 4-1

PERFORMANCE PROFILE OF MAJOR CHEMICAL FIRMS IN STUDY[1]: 1966

Company	(Millions of dollars) Net Sales	Net Income	Ranking[2]
E. I. duPont de Nemours & Company	3,185.1	389.1	1
Union Carbide Corporation	2,224.0	231.0	2
Monsanto Company	1,611.9	112.4	3
The Dow Chemical Company	1,309.7	121.7	4
W. R. Grace & Company	1,278.7	58.6	5
Allied Chemical Corporation	1,245.6	89.2	6
Olin Mathieson Chemical Company	1,117.1	66.8	7
Celanese Corporation of America	1,019.9	66.7	8
FMC Corporation	1,009.7	62.9	9
American Cyanamid Company	952.6	94.4	10
Hercules, Inc.	601.0	52.3	11
Koppers Company, Inc.	430.0	11.4	12
Air Reduction Company, Inc.	423.0	28.8	13
Ethyl Corporation	384.2	29.2	14
Rohm & Haas Company	371.2	35.5	15
Stauffer Chemical Company	360.4	32.6	16
Hooker Chemical Company	284.1	25.8	17
Diamond Alkali Company	233.0	19.0	18
Chemetron Corporation	232.7	16.1	19
Pennsalt Chemicals Corporation	222.5	12.7	20
Witco Chemical Company	195.9	9.3	21
Eagle-Picher Company	170.9	7.4	22
Air Products & Chemicals, Inc.	146.9	9.2	23
Reichhold Chemicals, Inc.	136.7	5.7	24
Wyandotte Chemicals Corporation	126.3	8.0	25

[1]Source: Basic data listed on Compustat magnetic tapes compiled by Standard Statistics Company, Incorporated, New York, New York, and made available to Michigan State University.

[2]Ranked by net sales in descending order.

TABLE 4-2

PERFORMANCE OF MAJOR CHEMICAL FIRMS IN STUDY ON NET SALES[1]: 1955-1966

Company	Annual Growth Rate of Net Sales As A Percent[2]	Ranking in Descending Order	Correlation Coefficient Through Time[3]
Air Products & Chemicals, Inc.	23.81	2	0.9544
Air Reduction Company, Inc.	9.77	9	0.9776
Allied Chemical Corporation	6.41	17	0.9577
American Cyanamid Company	6.37	18	0.9771
Celanese Corporation of America	17.06	4	0.9350
Chemetron Corporation	5.45	19	0.8526
Diamond Alkali Company	6.47	16	0.9610
The Dow Chemical Company	7.53	15	0.9954
E. I. duPont de Nemours & Company	4.99	23	0.9571
Eagle-Picher Company	3.15	25	0.7043
Ethyl Corporation	30.57	1	0.9509
FMC Corporation	13.49	5	0.9646
W. R. Grace & Company	9.24	11	0.9133
Hercules, Inc.	10.48	7	0.9797
Hooker Chemical Corporation	9.69	10	0.9848
Koppers Company, Inc.	3.58	24	0.7148
Monsanto Chemical Company	12.25	6	0.9776
Olin Mathieson Chemical Company	5.28	21	0.9440
Pennsalt Chemicals Corporation	10.08	8	0.9572
Reichhold Chemicals, Inc.	8.55	12	0.9667
Rohm & Haas Company	8.44	13	0.9908
Stauffer Chemical Company	8.39	14	0.9698
Union Carbide Corporation	5.18	22	0.9654
Witco Chemical Company	19.96	3	0.9719
Wyandotte Chemicals Corporation	5.42	20	0.9554

[1]Source: Basic data listed on Compustat magnetic tapes compiled by Standard Statistics Company, Incorporated, New York, New York, and made available to Michigan State University.

[2]Based on the slope of the regression line that best fits the logarithms of the data and indicates the compounded annual change for the statistic.

[3]Indicates the goodness of fit for the data and the association of the actual and predicted values through time.

TABLE 4-3

PERFORMANCE OF MAJOR CHEMICAL FIRMS IN STUDY ON NET PROFIT TO COMMON[1]: 1955-1966

Company	Annual Growth Rate of Net Profit to Common As A Percent[2]	Ranking in Descending Order	Correlation Coefficient Through Time[3]
Air Products & Chemicals, Inc.	24.76	2	0.9526
Air Reduction Company, Inc.	6.41	18	0.8060
Allied Chemical Corporation	7.13	17	0.8278
American Cyanamid Company	8.39	14	0.9332
Celanese Corporation of America	18.90	4	0.9466
Chemetron Corporation	8.16	15	0.4584
Diamond Alkali Company	6.34	19	0.7621
The Dow Chemical Company	7.32	16	0.8657
E. I. duPont de Nemours & Company	0.92	25	0.3392
Eagle-Picher Company	1.63	23	0.1749
Ethyl Corporation	34.49	1	0.8893
FMC Corporation	14.95	5	0.9641
W. R. Grace & Company	12.09	8	0.8014
Hercules, Inc.	10.22	9	0.9631
Hooker Chemical Corporation	8.75	11	0.9179
Koppers Company, Inc.	0.97	24	0.1274
Monsanto Chemical Company	13.01	7	0.9480
Olin Mathieson Chemical Company	4.50	20	0.3723
Pennsalt Chemicals Corporation	13.44	6	0.9723
Reichhold Chemicals Corporation	4.44	22	0.1577
Rohm & Haas Company	8.72	12	0.9190
Stauffer Chemical Company	8.40	13	0.9215
Union Carbide Corporation	4.46	21	0.7959
Witco Chemical Company	22.65	3	0.9935
Wyandotte Chemicals Corporation	9.85	10	0.5872

[1]Source: Basic data listed on Compustat magnetic tapes compiled by Standard Statistics Company, Incorporated, New York, New York, and made available to Michigan State University.

[2]Based on the slope of the regression line that best fits the logarithms of the data and indicates the compounded annual change for the statistic.

[3]Indicates the goodness of fit for the data and the associatio-

TABLE 4-4

PERFORMANCE OF MAJOR CHEMICAL FIRMS IN STUDY ON EARNINGS PER SHARE[1]: 1955-1966

Company	Annual Growth Rate of Earnings Per Share As A Percent[2]	Ranking in Descending Order	Correlation Coefficient Through Time[3]
Air Products & Chemicals, Inc.	14.82	2	0.8933
Air Reduction Company, Inc.	1.99	22	0.3768
Allied Chemical Corporation	3.47	20	0.6475
American Cyanamid Company	7.13	11	0.9078
Celanese Corporation of America	12.69	5	0.9621
Chemetron Corporation	4.77	17	0.2843
Diamond Alkali Company	5.55	14	0.7120
The Dow Chemical Company	6.09	13	0.7927
E. I. duPont de Nemours & Company	0.80	24	0.2992
Eagle-Picher Company	1.57	23	0.1666
Ethyl Corporation	27.11	1	0.8598
FMC Corporation	13.26	4	0.9519
W. R. Grace & Company	6.38	12	0.6865
Hercules, Inc.	8.33	10	0.9506
Hooker Chemical Corporation	5.25	16	0.8102
Koppers Company, Inc.	0.53	25	0.0674
Monsanto Chemical Company	10.04	7	0.9357
Olin Mathieson Chemical Company	4.47	18	0.3687
Pennsalt Chemicals Corporation	11.02	6	0.9684
Reichhold Chemicals Corporation	3.26	21	0.1152
Rohm & Haas Company	8.97	9	0.9208
Stauffer Chemical Company	5.41	15	0.8348
Union Carbide Corporation	4.29	19	0.7794
Witco Chemical Company	13.36	3	0.9855
Wyandotte Chemicals Corporation	9.30	8	0.5755

[1] Source: Basic data listed on Compustat magnetic tapes compiled by Standard Statistics Company, Incorporated, New York, New York, and made available to Michigan State University.

[2] Based on the slope of the regression line that best fits the logarithms of the data and indicates the compounded annual change for the statistic.

[3] Indicates the goodness of fit for the data and the association of the actual and predicted values through time.

TABLE 4-5

PERFORMANCE OF MAJOR CHEMICAL FIRMS IN STUDY ON CASH FLOW PER SHARE[1]: 1955-1966

Company	Growth Rate of Cash Flow Per Share Per Annum As A Percent[2]	Ranking in Descending Order	Correlation Coefficient Through Time[3]
Air Products & Chemicals, Inc.	20.88	2	0.9712
Air Reduction Company, Inc.	2.31	23	0.5824
Allied Chemical Corporation	3.61	21	0.8419
American Cyanamid Company	5.10	16	0.9506
Celanese Corporation of America	10.54	6	0.9446
Chemetron Corporation	4.61	17	0.5045
Diamond Alkali Company	5.35	14	0.8838
The Dow Chemical Company	4.38	19	0.8944
E. I. duPont de Nemours & Company	2.91	22	0.8343
Eagle-Picher Company	1.62	24	0.2604
Ethyl Corporation	27.35	1	0.9032
FMC Corporation	12.98	4	0.9606
W. R. Grace & Company	5.91	11	0.9478
Hercules, Inc.	8.23	8	0.9738
Hooker Chemical Corporation	5.29	15	0.8952
Koppers Company, Inc.	0.52	25	0.1740
Monsanto Chemical Company	11.36	5	0.9784
Olin Mathieson Chemical Company	4.34	20	0.6991
Pennsalt Chemicals Corporation	5.44	13	0.9804
Reichhold Chemicals Corporation	8.17	9	0.7875
Rohm & Haas Company	9.26	7	0.9794
Stauffer Chemical Company	5.45	12	0.9215
Union Carbide Corporation	4.60	18	0.9240
Witco Chemical Company	14.84	3	0.9882
Wyandotte Chemicals Corporation	6.74	10	0.8530

[1] Source: Basic data listed on Compustat magnetic tapes compiled by Standard Statistics Company, Incorporated, New York, New York, and made available to Michigan State University.

[2] Based on the slope of the regression line that best fits the logarithms of the data and indicates the compounded annual change for the statistic.

[3] Indicates the goodness of fit for the data and the association

TABLE 4-6

PERFORMANCE OF MAJOR CHEMICAL FIRMS IN STUDY ON AVERAGE MARKET PRICE[1]: 1955-1966 OR OTHERWISE INDICATED

Company	Growth Rate of Average Market Price Per Annum As A Percent[2]	Ranking in Descending Order	Correlation Coefficient Through Time[3]
Air Products & Chemicals, Inc.	16.41	4	0.8922
Air Reduction Company, Inc.	3.17	17	0.4764
Allied Chemical Corporation	0.15	24	0.0490
American Cyanamid Company	7.57	11	0.8880
Celanese Corporation of America	18.56	3	0.9436
Chemetron Corporation	2.78	18	0.3346
Diamond Alkali Company	4.95	14	0.8016
The Dow Chemical Company	2.17	19	0.4385
E. I. duPont de Nemours & Company	1.02	22	0.3889
Eagle-Picher Company	4.37	15	0.8338
Ethyl Corporation	32.65	1	0.9321
FMC Corporation	18.59	2	0.9837
W. R. Grace & Company	10.41	5	0.8653
Hercules, Inc.	8.41	8	0.9035
Hooker Chemical Corporation	1.97	20	0.4910
Koppers Company, Inc.	0.52	23	0.1087
Monsanto Chemical Company	8.39	9	0.8752
Olin Mathieson Chemical Company	-1.07	25	-0.2384
Pennsalt Chemicals Corporation	10.37	6	0.9633
Reichhold Chemicals Corporation	7.92[4]	10	N.C.
Rohm & Haas Company	6.65	12	0.7667
Stauffer Chemical Company	4.32	16	0.5428
Union Carbide Corporation	1.21	21	0.3942
Witco Chemical Company	8.97[5]	7	N.C.
Wyandotte Chemicals Corporation	5.91[4]	13	N.C.

N.C. = Not Calculated

[1]Source: Basic data listed on Compustat magnetic tapes compiled by Standard Statistics Company, Incorporated, New York, New York, and made available to Michigan State University.

[2]Based on the slope of the regression line that best fits the logarithms of the data and indicates the compounded annual change for the statistic.

[3]Indicates the goodness of fit for the data and the association of the actual and predicted values through time.

[4]Calculated in time period 1956-1966.

TABLE 4-7

PERFORMANCE OF MAJOR CHEMICAL FIRMS IN STUDY ON PRICE-EARNINGS RATIO[1]: 1956-1966 OR OTHERWISE INDICATED

Company	Mean Price-Earnings Ratio (Times)[2]	Ranking in Descending Order
Air Products & Chemicals, Inc.	22.94	4
Air Reduction Company, Inc.	16.58	17
Allied Chemical Corporation	19.96	10
American Cyanamid Company	18.95	12
Celanese Corporation of America	12.43	23
Chemetron Corporation	15.80	19
Diamond Alkali Company	15.05	20
The Dow Chemical Company	27.38	1
E. I. duPont de Nemours & Company	24.65	3
Eagle-Picher Company	12.02	25
Ethyl Corporation	12.03	24
FMC Corporation	17.56	16
W. R. Grace & Company	16.36	18
Hercules, Inc.	22.66	5
Hooker Chemical Corporation	20.69	8
Koppers Company, Inc.	13.78	22
Monsanto Chemical Company	20.30	9
Olin Mathieson Chemical Company	17.99	15
Pennsalt Chemicals Corporation	21.97	7
Reichhold Chemicals Corporation	18.93[3]	13
Rohm & Haas Company	26.17	2
Stauffer Chemical Company	19.23	11
Union Carbide Corporation	22.20	6
Witco Chemical Company	14.87[4]	21
Wyandotte Chemicals Corporation	18.58	14

[1]Source: Basic data listed on Compustat magnetic tapes compiled by Standard Statistics Company, Incorporated, New York, New York, and made available to Michigan State University.

[2]Price-earnings ratio defined as adjusted average price divided by adjusted earnings per share (adjustments are made for stock splits and stock dividends).

[3]Median selected to eliminate distortion caused by abnormal earnings recorded in at least one year of operation.

[4]Calculated in time period 1955-1966.

TABLE 4-8

PERFORMANCE OF MAJOR CHEMICAL FIRMS IN STUDY
ON LONG TERM DEBT TO TOTAL CAPITAL[1]: 1956-1966

Company	Mean Long Term Debt to Total Capital As A Percent[2,3,4]	Ranking in Descending Order
Air Products & Chemicals, Inc.	47.05	2
Air Reduction Company, Inc.	31.20	8
Allied Chemical Corporation	29.73	12
American Cyanamid Company	16.73	18
Celanese Corporation of America	34.87	5
Chemetron Corporation	32.17	7
Diamond Alkali Company	25.73	14
The Dow Chemical Company	25.11	15
E. I. duPont de Nemours & Company	0.36	25
Eagle-Picher Company	23.80	16
Ethyl Corporation	53.65	1
FMC Corporation	30.07	11
W. R. Grace & Company	41.29	4
Hercules, Inc.	2.36	23
Hooker Chemical Corporation	32.63	6
Koppers Company, Inc.	16.18	20
Monsanto Chemical Company	30.74	10
Olin Mathieson Chemical Company	42.56	3
Pennsalt Chemicals Corporation	21.17	17
Reichhold Chemicals Corporation	26.85	13
Rohm & Haas Company	1.22	24
Stauffer Chemical Company	16.49	19
Union Carbide Corporation	31.17	9
Witco Chemical Corporation	16.15	21
Wyandotte Chemicals Corporation	5.76	22

[1]Source: Basic data listed on Compustat magnetic tapes compiled by Standard Statistics Company, Incorporated, New York, New York, and made available to Michigan State University.

[2]Long term debt defined as debt obligations due beyond one fiscal period with purchase obligations and liabilities to offers excluded as well as subsidiary preferred stock.

[3]The value of total capital was found by summing the values of long term debt, preferred stock valuation, and common equity.

[4]The long term debt to equity valuation position is one per-

TABLE 4-9

PERFORMANCE OF MAJOR CHEMICAL FIRMS IN STUDY ON SELECTED PROFITABILITY RATIOS[1]: 1956-1966

Company	Mean Return on Total Capital As A Percent[2,4]	Mean Return on Common Stock Equity As A Percent[3]	Ranking of Return on Common Stock Equity in Descending Order
Air Products & Chemicals, Inc.	9.87	13.65	8
Air Reduction Company, Inc.	9.43	11.67	15
Allied Chemical Corporation	9.28	11.52	17
American Cyanamid Company	11.79	13.42	9
Celanese Corporation of America	7.94	12.50	12
Chemetron Corporation	9.05	10.43	18
Diamond Alkali Company	9.46	12.58	11
The Dow Chemical Company	10.43	12.22	14
E. I. duPont de Nemours & Company	17.29	18.83	2
Eagle-Picher Company	8.14	9.80	19
Ethyl Corporation	10.40	21.99	1
FMC Corporation	10.59	13.82	7
W. R. Grace & Company	7.90	8.73	22
Hercules, Inc.	14.40	15.40	4
Hooker Chemical Corporation	10.78	14.42	6
Koppers Company, Inc.	5.54	5.97	25
Monsanto Chemical Company	9.34	11.57	16
Olin Mathieson Chemical Company	7.33	9.51	20
Pennsalt Chemicals Corporation	8.30	9.41	21
Reichhold Chemicals Corporation	7.37	7.92	23
Rohm & Haas Company	14.56	15.08	5
Stauffer Chemical Company	11.67	13.36	10

(Continued)

TABLE 4-9

PERFORMANCE OF MAJOR CHEMICAL FIRMS IN STUDY ON SELECTED PROFITABILITY RATIOS[1]: 1956-1966

(Continued)

Company	Mean Return on Total Capital As A Percent[2,4]	Mean Return on Common Stock Equity As A Percent[3]	Ranking of Return on Common Stock Equity in Descending Order
Union Carbide Corporation	12.32	16.25	3
Witco Chemical Corporation	11.02	12.23	13
Wyandotte Chemicals Corporation	6.39	6.57	24

[1]Source: Basic data listed on Compustat magnetic tapes compiled by Standard Statistics Company, Incorporated, New York, New York, and made available to Michigan State University.

[2]Return on capital for any year is defined as net income and fixed charges divided by average annual total capital, i.e.,

$$\frac{(\text{net income}_t + \text{fixed charges}_t)}{\dfrac{(\text{total capital}_{t-1} + \text{total capital}_t)}{2}}$$

[3]Return on common stock equity is defined as net income minus preferred dividends divided by average annual common stock equity, i.e.,

$$\frac{(\text{net income}_t - \text{preferred dividends}_t)}{\dfrac{(\text{common stock equity}_{t-1} + \text{common stock equity}_t)}{2}}$$

[4]The value of total capital was found by summing the values of long term debt, preferred stock valuation, and common equity.

TABLE 4-10

PERFORMANCE OF MAJOR CHEMICAL FIRMS IN STUDY ON RETENTION RATES[1]: 1955-1966

Company	Mean Retention Rate of Net Earnings on Common Stock As A Percent	Ranking in Descending Order
Air Products & Chemicals, Inc.	89.13	1
Air Reduction Company, Inc.	35.47	22
Allied Chemical Corporation	31.84	24
American Cyanamid Company	36.68	21
Celanese Corporation of America	56.61	7
Chemetron Corporation	37.43	19
Diamond Alkali Company	48.08	13
The Dow Chemical Company	42.31	17
E. I. duPont de Nemours & Company	-5.01	25
Eagle-Picher Company	39.41	18
Ethyl Corporation	82.58	2
FMC Corporation	60.74	6
W. R. Grace & Company	49.51	12
Hercules, Inc.	52.80	9
Hooker Chemical Corporation	42.45	16
Koppers Company, Inc.	36.81	20
Monsanto Chemical Company	55.14	8
Olin Mathieson Chemical Company	44.61	14
Pennsalt Chemicals Corporation	44.58	15
Reichhold Chemicals Corporation	78.48[2]	4
Rohm & Haas Company	82.12	3
Stauffer Chemical Company	50.72	11
Union Carbide Corporation	32.30	23
Witco Chemical Company	64.20	5
Wyandotte Chemicals Corporation	51.88	10

[1]Source: Basic data listed on Compustat magnetic tapes compiled by Standard Statistics Company, Incorporated, New York, New York, and made available to Michigan State University.

[2]Median selected to eliminate distortion caused by an abnormal dividend payout in at least one year of operation.

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CHAPTER V

FUNDAMENTAL POSTULATES BEHIND THE RESEARCH EFFORT

Any research study of this scope requires a thorough investigation into numerous traditions directly influencing the research findings, into those postulates incorporated into the fabric of this thesis on the basis of widespread practice and not assessed empirically.

Postulate No. 1

New products are basic to the growth of any firm.

The chemical industry's fine growth during the present decade has been largely based on technological progress, unfulfilled demand (running ahead of supply capabilities), and favorable economic conditions, with one key strategy employed to achieve these results being a strong emphasis on new product development activity. Chapter II has already discussed the product life cycle concept. Certainly product cycles in any given industry have specific patterns for both sales and profits. This thesis, therefore, seeks common patterns relating these two factors within one product class, industrial chemicals.

Chemical firms have adopted many planning orientations with varying levels of success: e.g., projections based on historical sales records of specific territories may be made to indicate future performance, or divisional performance records may be set against one another to illustrate comparative results. Yet firms stressing anything but a product orientation to business planning may lack the product data necessary to make those strategic decisions seriously altering eventual outcomes. Obviously one needs technological research and new product development activity. But management still must ask the right product questions, get the right information, and then act on that information.

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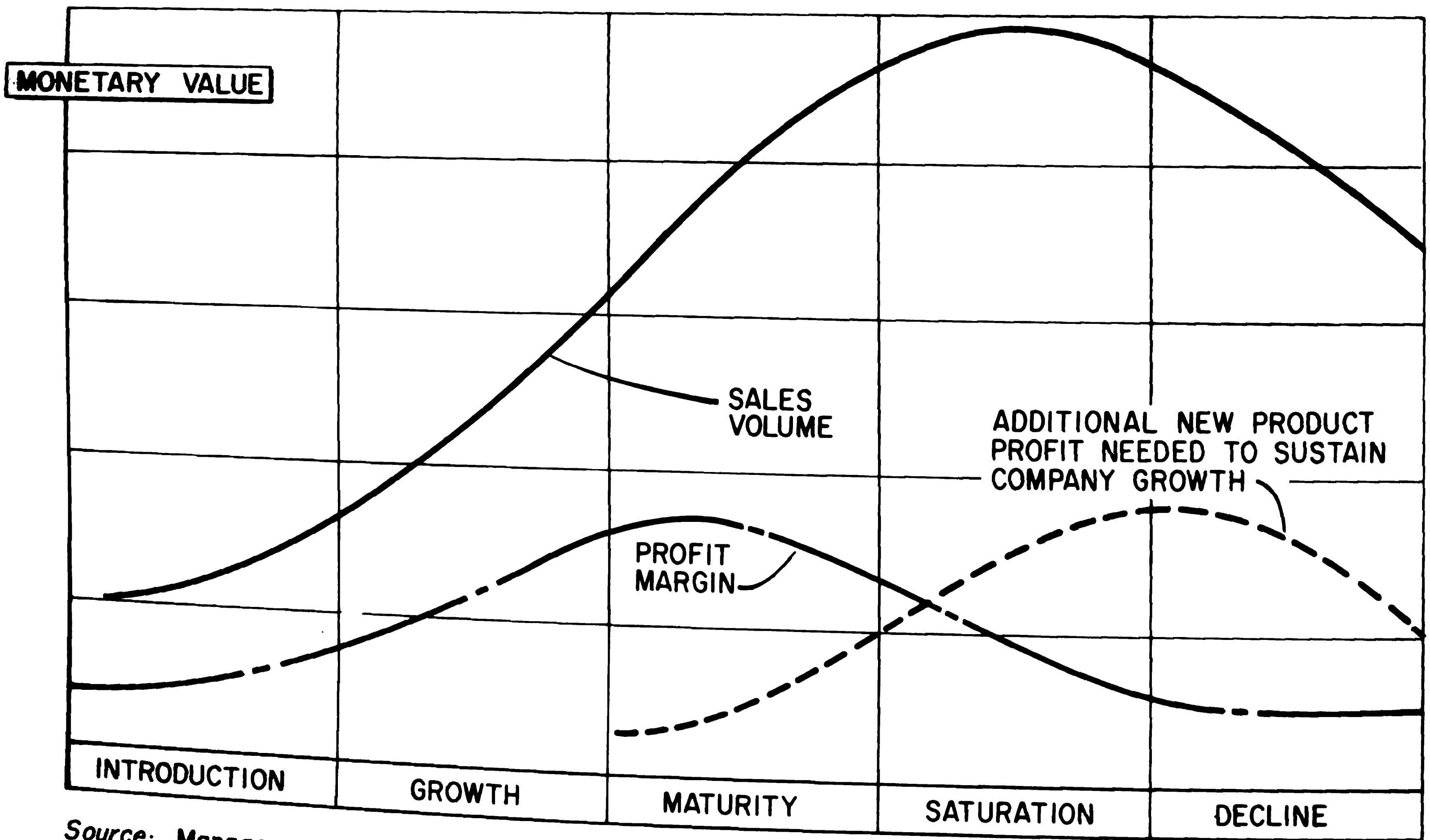
Sales and profit patterns assume finite shapes for any product, a fundamental concept in business development. Various linear and curvilinear models have been proposed to depict the product life cycle. Choice depends on the variables considered relevant and their patterns of influence. If revenue and profit are examined over time, these might vary as depicted by the model for new products posited by Booz•Allen and Hamilton, Inc., and shown in Figure 5-1. The two cycles (sales and profits) are analyzed separately. As sales begin to grow substantially in the growth phase, profitability also begins to demonstrate significant growth, so long as there is an unfilled demand for the product. Recognizing this demand, management provides the necessary production facilities which, along with economies of scale reflected in higher levels of plant utilization, generate increasing unit profit margins. But as sales growth tapers off in the maturity stage, both aggregate and unit profit margins decline under the pressure of competitive forces (including price erosion). As obsolescence eventually sets in, both aggregate profits and sales decline, and either the buyer need for the product may disappear or substitutions may win out on the basis of product improvement and the tactical superiority of competitors.

BASIC LIFE CYCLE OF PRODUCTS

FIGURE 5-1
BASIC LIFE CYCLE OF PRODUCTS



Source: Management Research Department, Booz, Allen & Hamilton, Inc.

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Marketing dynamics enhance the importance of the product life cycle concept in preparing for possible eventualities. Most viable business organizations are growth-conscious. And given this corporate objective, the product life cycle concept supports assigning new product development activities high priorities: as Figure 5-1 demonstrates, any firm that is going to sustain growth while one existing product faces decreasing aggregate profit contributions must introduce additional products to fill the developing void. This reasoning applies even to well-diversified firms in which any one product may contribute a relatively small percentage of the total earnings.

The Booz·Allen and Hamilton study showed that sales growth for major industries stems from two sources: existing products and new products. Growth from new products ranged between 46% and 100% for major industries, with a mean of 75%.[1] Obviously product planning is the key to achieving growth expectations, especially with new products. Thus we may assume that aggregate profits grow only as a continuing stream of new products gain market acceptance. Evidence in current literature substantiates the importance of new products to growth for manufacturing firms, as shown in Figure 5-2 for eleven selected industries.

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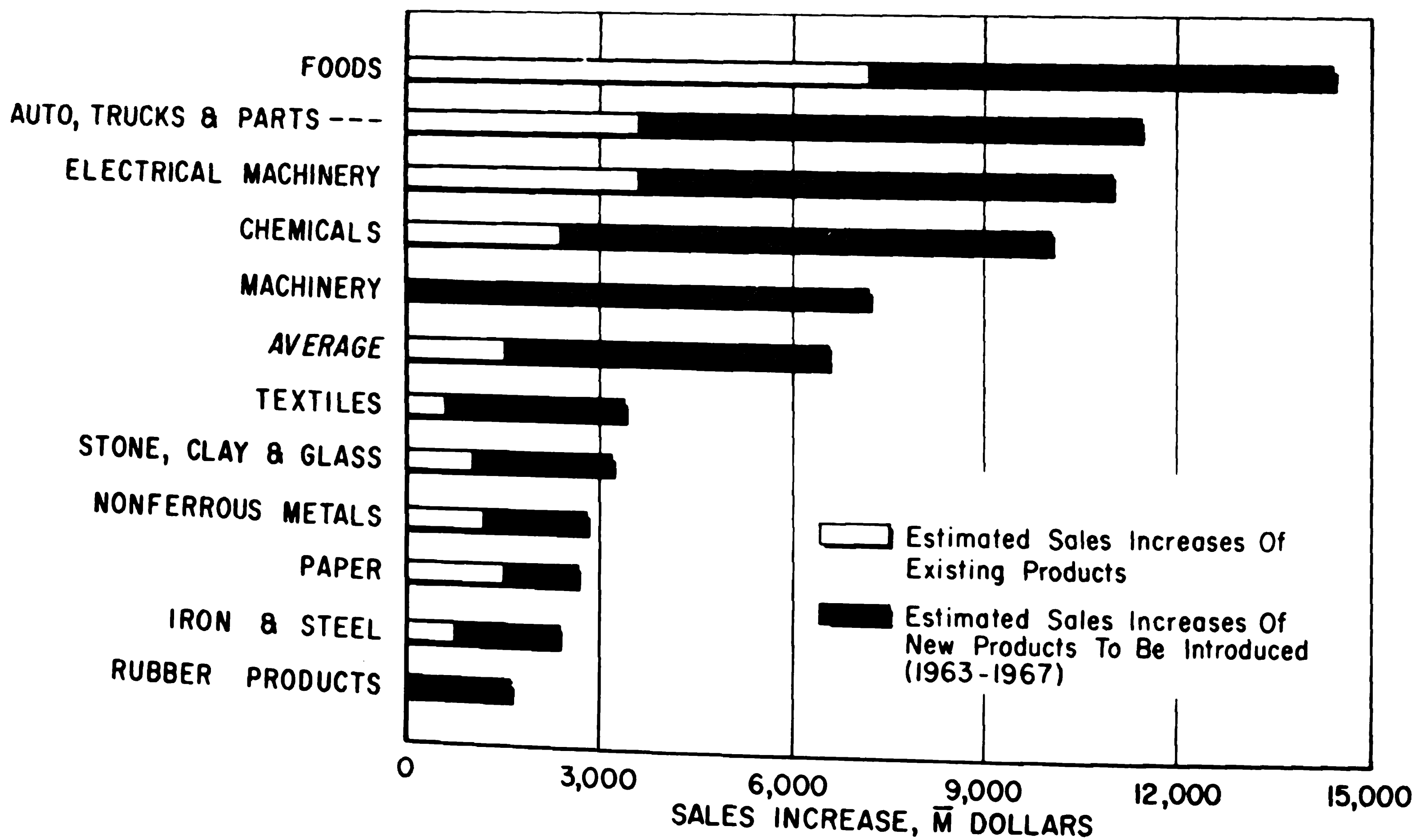
[1] Booz·Allen and Hamilton, Inc., op. cit., p. 6.

CONTRIBUTION OF NEW PRODUCTS TO EXPECTED SALES GROWTH, 1963 - 1967

FIGURE 5-2

CONTRIBUTION OF NEW PRODUCTS TO EXPECTED SALES GROWTH, 1963 - 1967



<u>SOURCES</u>: Federal Trade Commission & Mc Graw Hill As Reported In Booz, Allen & Hamilton, Inc., <u>Management Of New Products</u> (4th Edition, New York: Booz, Allen & Hamilton, Inc., 1965), p.5

Postulate No. 2

> The projections of demand estimates incorporated in new product evaluation proposals are the most uncertain inputs, and their uncertainty increases with time.

Few empirical studies in the literature demonstrate the actual behavior of estimates used as inputs in any quantitative model for new product evaluations. Our understanding of the new product decision process hinges on an understanding of the estimates incorporated in the model, always a source of implicit error due to the lack of perfect knowledge. The error in any given situation may be reduced through the estimator's experience, his learning process being a vital factor. But the worth of any retrieved information that may be used to make better estimates must be constantly weighed against the cost of retrieving the information.[2]

One empirical study estimating time and cost for developmental projects, by Marshall and Meckling, revealed that estimates improve as any project progresses, i.e., error is reduced through the learning process.[3] (They studied aircraft and missiles of various sorts where technological changes have influenced cost behavior.)

Another study by Brandenburg, on a sample of 42 cost reduction projects in a major corporation's research and development for a manufacturing division, weighed estimated (before project implementation) versus actual data for five parameters: financial savings, development costs, associated costs, plant expenditures, and completion time. Although these were not new product development projects, the inputs are comparable. For example, financial savings might correspond to modified demand estimates—in tracing the economic effect of changing chemical

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[2] Frank M. Bass considers such an evaluation for the determination of maximum allowable marketing research expenditures in evaluating research proposals within a Bayesian framework in the article, "Marketing Research Expenditures: A Decision Model," The Journal of Business, Vol. 36, No. 1 (January, 1963), pp. 77-90.

[3] A. W. Marshall and W. H. Meckling, "Predictability of the Costs, Time, and Success of Development," in National Bureau of Economic Research, The Rate and Direction of Inventive Activity; Economic and Social Factors, (Princeton, N.J.: Princeton University Press, 1962), pp. 461-476.

processes in the production of a specific industrial chemical. For if a breakthrough in engineering process allows significant price reductions, one would have to determine the effects of greater resource efficiencies on supply and subsequent demand shifts. Brandenburg's cost categories correspond to accounting variables normally incorporated in economic evaluations of new products. And determining completion time resembles the problem of predicting product life expectancy or, at best, meaningful time horizons associated with product acceptances. Evaluating industrial chemical products is harder whenever the applicable time periods exceed those associated with cost reduction studies, as is usually the case.

Brandenburg expressed the ratios of actual outcomes to estimated outcomes as follows:

TABLE 5-1

ESTIMATION OF OUTCOMES: A CASE STUDY

	(ratio of actual/estimate)	
	Mean	Standard Deviation
Savings	1.62	1.62
Development Cost	1.45	1.32
Associated Cost	0.75	0.81
Plant Expenditures	0.75	0.63
Completion Time	2.98	2.15

SOURCE: Richard George Brandenburg, Research and Development Project Selection: A Descriptive Analysis of R and D Management Decision Processes, (unpublished Ph.D. dissertation, Cornell University, 1964), p. 209.

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Note particularly the relative difficulty in estimating the variables of savings, development cost and completion time. Seven of the projects involved were reviewed more than once after the projects began, and revised estimates made. Actual estimates were then closer to results and dispersions lessened, which shows that a learning process existed with this type of work, and that errors in estimation were reduced significantly as projects approached completion. Hence there is value in documenting the predictive capabilities in estimating demand for specific new and existing products.

Tull and Rutemiller recently studied the relationships of actual and predicted sales and profits in new product introductions, based on data collected from sixty-three new product case histories.[4] In addition to other models, they solved the general regression model of the form:

$$\text{Forecast}_i = \alpha + \beta\,(\text{Actual}_i) \qquad (5.1)$$

$$\text{Variance}_i = \left[\gamma + \delta\,(\text{Actual}_i)^{1/2}\right]^2 \qquad (5.2)$$

With the forecasts as the dependent variable and actual sales or profit data as the independent variable, they adopted a maximum likelihood approach in estimating the regression coefficients (α, β, γ, and δ), assuming heteroscedasticity, i.e., that each population does not have the same variance. The authors found that the variance model (5.2) cited here had the highest likelihood of occurrence and concluded that variance in forecasting both sales and profits increased at a decreasing rate as a function of the level of actual product behavior. Though they detected no bias in the case of profit forecasting, sales revenue forecasts for new products tended to be optimistic.

[4]Donald S. Tull and Herbert C. Rutemiller, "A Note on the Relationship of Actual and Predicted Sales and Profits in New-Product Introductions," The Journal of Business, Vol. 41, No. 3 (July, 1968), pp. 385-387.

Postulate No. 3

> The cost of capital concept aids in effectively evaluating the degree of financial uncertainty associated with new product decisions.

The cost of capital, a significant issue facing the decision maker in his investment strategy, implies the effective utilization of capital assets, and can take into consideration the leverage position of the firm and the expectations of investors. The cost of capital is that discount rate applied to estimated streams of operating and investment cash flows which reflect risks in project evaluation. Theorists have traditionally limited the concept to financial risks facing the firm, arguing that all business risks eventually influence the financial structure of the firm. Such a definition suggests, of course, that all projects with positive net present values (i.e., discounted operating cash flows greater than investment cash flows required to undertake the projects) are desirable.

How does one select the proper discount rate? Theoretical costs of capital range from the rate associated with riskless investments (the pure interest rate, if not higher) to near infinity. Though the cost of capital is fixed at any specific moment in time, it changes with changes in factors affecting business outcomes and subsequent performance. Basically the cost of capital is a "futurity" concept. Any attempt to determine the cost of capital empirically should rest on the expected capital structure as a composite of past decisions, especially since most large investment decisions seriously affect future debt requirements, stockholders' expectations of earnings growth, and the changes in risk associated with new and existing business ventures (particularly the product mix).

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Certainly the minimum acceptable rate of return for any project would be the actual aggregate cost of capital of the firm, regardless of the business risks in any new product situation. Nonfinancial risks are seldom measured explicitly in the cost of capital calculation because they pertain uniquely to specific investment decisions. The decisions facing management today are the very ones that would largely affect the financial performance of the firm in the future. Since stockholders by and large lack any inside information on intimate details, one cannot expect their judgment to suitably reflect changes in company operations in the short run. To offset this peculiar position, many decision makers, in evaluating individual product proposals, select a somewhat higher discount rate than the cost of capital to reflect the risks in expected cash flows; this tends to reduce actual calculated present values for proposed products than would otherwise occur.

Chapter III has already presented the exact model used for calculating the cost of capital in this dissertation. A concept with certain limitations, it does not adequately analyze projects with varying levels of risk nor venture interdependencies. But even if the cost of capital concept does not give ideal information in risk analysis, it remains a crucial variable in evaluating new product results.

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CHAPTER VI

POSSIBLE INFLUENCES
DETERMINING NEW PRODUCT BEHAVIOR

In order to approach field investigative work methodically, a number of hypotheses were formulated as the general framework upon which to build the study. This chapter discusses operating influences originally thought to be important in describing new product behavior. Whenever statistical tests would be meaningful in the analysis of data, the statement delineating the particular postulated influence is presented as a testable hypothesis in alternate form.

We shall first discuss several general hypotheses concerning the product life structure of new industrial chemical products, and add a premise considering the time horizon appropriate to use in evaluating new product proposals. Then, after presenting the classification schemes used as indicators of performance, we turn to describing factors thought to relate to the performance of new industrial chemical products.

General Hypothesis No. 1

> No single representative nth order polynomial function best describes the sales patterns of new industrial chemical products.

A function which is the sum of a finite number of monomial terms, i.e., of the form cx^n where c is a constant and n is zero or a positive integer, is called a polynomial of x. Extensions of the simple linear form $y = a + bx$, employing higher powers of x, give polynomial expressions of the type

$$y = a + bx + cx^2 + dx^3 + \ldots + mx^n$$

where y = the dependent variable

a,b,c,d ... m = constant terms

n = the nth order of the polynomial expression

x = the dependent variable

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Here we have a polynomial in one variable: y is a function of x alone. In a relationship of this type, a specific value of y is given by the sum of a finite number of terms, each of which consists of a specific power of x multiplied by a constant. This form will be applied in the research study, with sales as the dependent variable and time the independent variable.

We shall attempt to identify the specific types of sales patterns, i.e., the general shape and timing, for new industrial chemical products included in the sample in order to provide one classification scheme for historical product behavior. The implications of such an identification were discussed in Chapter II. As long as any nth order explains variation in the dependent variable above that accounted for by the remainder of the orders and the overall mean of the dependent variable, it will be retained in the polynomial expression. The significance level used for any standard error of the beta weight associated with a given order, i.e., a decision criterion to retain or delete any nth order expression, is set at the .05 level. Otherwise, orders will be dropped one at a time (with new least squares equations calculated on the remaining variables), starting with the variable contributing the least towards variance reduction until the significance criterion is met on an individual variable basis.

<u>General Hypothesis No. 2</u>

> The profit cycle for new industrial chemical products does not typically fit a declining exponential curve.

The class of functions suggested by Bertram Schoner[1] for inclusion in his developed stochastic model for the selection of research and development projects was of the type $y = ab^x$

where y = the dependent variable

a,b = constants

x = the independent variable having a negative sign

The industry for which he constructed his model sells highly technical products to other industries, not to the consumer. Certainly new chemical

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[1]Bertram Schoner, op. cit., p. 78.

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products in the chemical specialty class should qualify for inclusion under his classification scheme. For this is where the bulk of the emphasis on research and development work has been in the recent past within the chemical industry. We particularly desire not only to pinpoint general shapes of profit data through time, but relate these experiences with those of sales histories.

General Hypothesis No. 3

> The profit cycle of new industrial chemical products does not typically descend while the sales curve is still rising in the maturity phase of the product life cycle.

The timing of the profit cycle is another research issue facing a critical test. As previously stated, many researchers have suggested that the profit cycle reaches its peak before the sales cycle, implying that peaking of profits signals future weakness. We need to determine how extensive leading profit cycles are part of the product experiences of industrial chemical products.

General Premise No. 1

> The time horizon necessary to consider sales and profit contributions for new industrial chemical products exceeds five years beyond product introduction.

The full economic life of a product would be an ideal time horizon for any financial and marketing analysis of a new product proposal. Yet few industrial chemical firms attempt to use the economic life quantitatively as the time horizon. For among other drawbacks, the element of uncertainty is felt to be an increasing function of time. Naturally, executives hope that many new products will remain viable for decades, yet analysts are presently unable to predict with reasonable accuracy what that period of time actually is. In many cases where highly profitable new products remain viable, it serves no useful purpose to extend an analysis that far in the future.

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Recent literature often seems to suggest that the obsolescence rate of existing products is high and continually increasing. If this is true, any attempt to project cash flows beyond the period during which the product is actually displaced in the market may fault the decision in regard to commercialization.

Emphasizing the management of working capital and liquidity may obstruct the selection of many potential new product proposals. Under such a policy, some minimum cumulative contribution to profits is imposed as a budgetary constraint for a set of projects. This is not to say that major industrial chemical manufacturers face such a prescriptive policy within the context of individual product evaluation; it only becomes a significant factor when various new product proposals are consolidated at the corporate level, especially when retained earnings fail to supply the funds required for its operation, thus creating a dependence on outside financing.

Classification Schemes Used to Describe Performance Identified

The following classification schemes will be used as indicators of performance in the evaluation of new product behavior:

1. Total Sales: annual and aggregate
2. Total Profits: annual and aggregate
3. Rate of Growth (Decay) of Sales: annual
4. Rate of Growth (Decay) of Profits: annual
5. Rate of Growth (Decay) of Losses: annual
6. Timing of Sales: years
7. Timing of Profits: years
8. Payback Period for Recovering Plant and Capital Equipment Expenditures: years
9. Accounting Rate of Return: as a percentage
10. Return on Investment: as a percentage
11. Discounted Present Value Sum: annual, aggregate, and critical turning point

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12. Equivalent Rate of Return: as a percentage
13. Profitability Ratio: as a ratio
14. Performance Index: as a ratio
15. Structure of Sales Patterns: distribution and timing

Variables (8) through (14) are defined separately in Chapter III; the remainder are discussed with the research findings disclosed in Chapter VIII.

Possible Factors Relating to the Performance of New Industrial Chemical Products

Screening based on statistically determined probabilities will seek to isolate the factors which relate to performance. Potential influences on new product behavior are grouped into four broad categories for ease of treatment: those associated with market structure, buyer behavior, product characteristics, and related intrafirm experiences. Standardized testing procedures will be used. Of course, few of the relevant factors can be related in any simple fashion. These relationships are usually highly complex and obscure, which is why previous efforts to model product behavior have met with such limited success.

If a stated hypothesis is supported at an appropriate confidence level, we may infer a conclusion. But on the other hand, however, failure to support a hypothesis does not preclude any relationship, defined or otherwise; evidence is simply lacking. This apparently subtle difference becomes important when the research process seeks to reduce the number of variables involved in product structures to a manageable number.

Since many factors were either judgmental or subjective, respondents for individual product histories were selected on the basis of their product knowledge or their access to those possessing such knowledge. The compilation of data involved the efforts of many different executives and analysts having diverse responsibilities. One can only hope that, in this process, the right questions were directed to the right people.

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1. Market Structure

A. Degree of Patent Protection

Performance should correlate with the effect of any patent in protecting the product from external competition.

B. Demand Trends in Derived Demand Situations

Performance of chemical intermediates should relate to the relative growth (decay) rates of specific product markets upon which the derived demands depend. Ignoring the cyclic, delayed effects of inventory balances within distribution channels, two forces essentially determine commodity product demand at the market level: demand for finished products that utilize the chemical product in some fashion in their manufacture and the rate of materials displacement via technological change. The faster the growth rates of finished products and the more the tendency of the product to displace others, the faster will the product be pulled through the distribution channel (assuming adequate marketing coverage). This variable should be measurable in the performance records of the products under study.

C. Duplication Difficulties by Competitors

Patent rights and technological obstacles often thwart the attempts of any competitor to make important inroads in marketing an identical product. Yet the difficulty of overcoming these barriers should be unrelated to achieved performance results.

D. Extent of Capacity Utilization at Industry Level

Levels of plant utilization must relate directly to demand levels only when all producing firms are operating at full capacities; then profitability is determined by various managerial actions and process efficiencies. Unit product costs usually reflect changes in plant

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utilization; and they in turn directly affect the profit contribution of any given product. Those products with abnormally high idle capacity percentages on an industry basis should show price attrition to such an extent that it could damage existing average profit positions. This is most true when the demand for a product is inelastic, as long as relative price changes do not cause a shift in demand toward the product.

E. Import Patterns

Since imports are not sizable, particularly for new chemical specialties, the performance of new industrial chemical products is probably unrelated to the percentage of total imports to domestic sales of all producing firms.

F. Market Share

Where firms have commanding market shares, we expect to find generally better performance because of their controlling positions over critical decisions, such as prices, existing capacities and sources of supply.

G. Market Trends

The timing of new product introductions in relation to the capacity to supply demand appears to be a critical operating factor. One expects superior performance from those chemical products in which the specific markets were experiencing strong increases in growth rates, assuming the firms have capacities sufficient to fill market requirements.

H. Minimum Corporate Asset Size of Competitors Required to Compete Effectively

Since the capability to commercialize many new industrial chemical products often involves large research and development and plant and equipment expenditures, some chemical processors may not become competitors because of the lack of needed capital or adequate financing. Thus, those

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few firms having the capability should be in a better position to offer the product in the marketplace more profitably, especially in early periods of commercialization when demand may be somewhat limited. This consideration reinforces the barriers of entry stemming from the technology required.

I. Number of Consuming Industries

The development of additional end-uses, one marketing strategy for expanding the total market for industrial chemicals, should generate greater returns.

J. Number of Significant Competitors

Performance should correlate inversely with the number of competitors. Competition does not necessarily have to take the form of price attrition, although this form has prevailed historically. If a high level of promotional activity is the only alternative open to get product recognition, this expensive route may necessitate a relative loss in performance. The relationship hypothesized should even hold true for varying demand levels, for products with high attainable sales potentials will probably attract other entrants.

K. Supply Characteristics of Factors

Since we assume a direct relationship between raw material purchasing experiences and the prices of raw materials through time, profitability should decrease with shortages and difficulties of access to existing supplies of raw materials.

2. Buyer Behavior

A. Degree of Backward Integration

Large volume purchasers of specific chemical products pose the constant threat of backward integration (if they have the technical and legal capabilities), for they seek greater economies in operation. Chemical manufacturers facing such a threat should experience an accelerated rate of coalescence wh

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obsolescence which limits their expected returns, particularly when these moves are quite pronounced.

B. Degree of Required Deliberation

One expects no particular correlation between performance and the extent that the initial purchase requires deliberation.

C. Dependence on Field Contact Work

Performance and the extent to which the final sale depends on personal company contacts should be correlated in most instances. Personal contacts by the field representative may be necessary to generate the interest required to complete a sale. And the technical and informational support which so many new industrial chemical products require may be supplied only by the company representative, often to the point that lost opportunities with inadequate field coverage are costly to the firm. If this is true, then, we should find higher performance in products requiring personal contacts by field representatives, assuming adequate field coverage has been provided. The incremental costs of field coverage for any new chemical decrease if the product is either related to other product offerings presently being detailed in some way or the consuming markets overlap those being detailed for other product lines.

D. Effect of Industrial Advertising on Source Selection

Even though one expects improved performance with effective industrial advertising, such effects are possible over any range of performance records. The critical issue is determining the optimum level of advertising expenditure. Experimental advertising programs may be valuable for firms who desire to better utilize their advertising resources.

E. Effect of Product Quality on Source Selection

Although the quality of new chemicals is an important consideration in selecting product sources, we have reason to believe that performance will not be a correlate of product quality.

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F. Effect on Sales of Related Products

Since performance records used in this study do not reflect changes in profit contributions of related products, no relationship should appear between performance and the effect of a new product on the sales of related products.

G. Extent of User Laboratory Evaluation

Performance should vary directly with the percentage of potential users that evaluate a new chemical product in their own laboratories using experimental quantities.

H. Level of Product Loyalty

Where their product loyalty is high, one generally expects higher returns from industrial chemical products (other factors being held constant) because buyer behavior is more stable and predictable. The producer would expect to receive the increase in purchase orders from buyers when their input requirements increase. Where these patterns are lacking, however, the producer must compete just as vigorously for growth from these buyers as well as from potential buyers.

I. Number of Contacts Required by Marketing and Technical Personnel

Contact work presents a distinct challenge in product promotion since typical industrial marketing situations are field intensive. The extent of field commitment should correlate directly with most performance measures.

J. Number of Product Sources

An industrial buyer often finds it convenient to have more than one continuous source of supply for industrial chemical products. For

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this insures a continual supply when a producer may be unable to meet the buyer's needs, and it places constant pressure on individual producers to provide technical support and other needed services. On the other hand, such behavior stimulates price fluctuation through competitive action. Multiple sources thus tend to depress returns for those products that operate within this type of competitive situation.

K. Number of Purchasers

We expect superior performance from products with large numbers of existing purchasers.

L. Number of Annual Purchases by Buyers

Since purchasing patterns typically reflect inventory policies as well as extent of material usage by buyers, we cannot expect performance to vary on the basis of purchasing records, although large existing demand levels often necessitate high frequency purchase behavior.

M. Recognition Experiences of Product Advantages by Users

Any new industrial chemical product has advantages which may be more or less easily recognized by industrial users. Relative ease of recognition can spur product evaluation and eventual acceptance, and thus should relate directly to performance.

N. Reputation and Image of Manufacturer

A manufacturer's established reputation and image are thought to influence a user in selecting his source of supply, thus directly affecting product acceptance.

O. Time to Educate the User

The average time required for marketing personnel to communicate product characteristics to potential buyers varies with the extent of

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deliberation and the complexity of the evaluation process; it should be inversely correlated with performance.

P. Trade Relations With Users

Valuable information on user expectations for future requirements and other pertinent data can often be obtained from users and incorporated in product plans. The ease of access to this information, better where trade relations are established and favorable, can enhance performance.

3. Product Characteristics

A. Cyclical Patterns

We expect cyclical patterns to adversely affect the performance of new industrial chemical products.

B. Degree of Marketing Innovativeness

The selection of unique distribution channels, the alteration of existing advertising strategies, or a change in normal technical support illustrate a type of marketing innovation which may improve the market position of the firm. Such factors are expected to affect performance levels decisively.

C. Degree of Matching Between Technological Characteristics and Market Requirements

Performance should be directly related to the degree to which technical characteristics of a new product match the market requirements. One expects superior performance from chemical products where these two factors are extremely well matched, assuming that the product's full potential was estimated accurately and that timely programs were developed to effectively meet the marketing opportunities.

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D. End-Use Patterns

All levels of performance are possible in most end-use classifications.

E. Level of Technological Innovativeness

Technological innovation in new chemical products (whether process or production oriented) should generate above average performance, which in turn reinforces continued emphasis on technological improvements.

F. Price Movements

Price declines are warranted in those cases where induced demand shifts result in net gains, even though these effects are often lagged.

G. Product Differentiation Strategy

Many have questioned the value of product proliferation within the marketplace for products serving the same general end-uses. While some insist such a move represents economic waste, others argue that it serves to thwart product declines and to stimulate primary demand as well. In this study, we can assess the net effect of such activities, where present, on the behavior of new industrial chemical products.

H. Research and Development Harnessing Experiences

Performance is probably independent of the degree of difficulty of harnessing the research and development program in commercializing any new industrial chemical product.

I. Seasonal Patterns

Where the demand for a new industrial chemical product is highly seasonal, inventory requirements and production scheduling become more

difficult to plan. If single-purpose equipment is used which cannot be adapted to any other chemical process, production inefficiencies usually result.

J. Specificity of Use

The more specific its uses, the less likely a new industrial chemical product is to find wide industrial application.

K. Standard Industrial Classification (SIC) Code

Attainable performance levels of specific products are often thought to be directly correlated with the overall economic behavior of their respective broad classification groups.

L. Technical Service Requirement

Chemical products vary widely on how much technical service support is needed in the field, according to the nature of the product and the degree of technical sophistication acquired by users. Still, one expects no particular pattern between performance and the amount of technical service support required to insure user satisfaction.

M. Trends in Gross Margins

Gross margin trends often signal changes in profitability, although it is the absolute level of the earnings stream that affects performance most directly.

N. Type of Product

Recovering economic byproducts and coproducts may generate significant revenue. Still, there is no reason to believe that chemical products having byproducts or coproducts outperform those without, and no relationship should exist between the type of product and performance.

Any normative evaluation technique should, of course, take into account the economic contributions of byproducts and coproducts.

O. Type of Product Demand

As long as the manufacturer estimated market potentials adequately and designed the new product program accordingly, we should expect a superior return, regardless of the product's purported demand type.

4. Related Intrafirm Experiences

A. Effectiveness of Product Flows in the Distribution Channel

If product movement through distribution channels is irregular and burdensome, both the level and profitability of operations should be seriously limited.

B. Export Patterns

Foreign markets in many cases may provide excellent opportunities to utilize any existing idle capacity on a profitable basis.

C. Extent of Plant Utilization at Firm Level

Since unit production costs change markedly with changes in plant utilization, we normally expect better performance with optimum levels of plant utilization.

D. Intensity of the Selling Effort

In cases where profitable demand may not be fully tapped, marketing can provide broader market coverage in the field by altering the sales-call ratios for given prospects.

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E. Investment Patterns

Since both marketing and financial risks are generally unrelated to investment levels on a product basis, we would not expect performance to be correlated with the size of the investment commitment in fixed assets and working capital, with the exception of absolute sales and profit data. A firm's investments in one single product are usually not sufficiently large to represent a significant portion of its total capital stock.

F. Length and Number of Production Runs

Performance relates directly to production run experiences, since profitability is thought to be sensitive to effective production planning.

G. Level of Clarity of Product Demand

Performance should vary directly with the degree of clarity of demand for a new industrial chemical product, since those firms which can size up potential market demands well can also gauge their various operations more effectively. Any sizing-up process would necessitate a fundamental understanding of what comprises current and future needs of industrial users.

H. Level of Research and Development Expenditures

Products with high research and development requirements represent greater risks, and must generally have higher expected returns to compensate the firms for bearing those risks.

I. Licensing Experiences

Although licensing arrangements are profitable ventures themselves, especially in securing foreign operations, there is no reason to expect the likelihood of licensing arrangements to differ with performance.

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Licensing arrangements represent the sale of technology. Usual accounting practices assign these proceeds to corporate accounts only, not reallocating them on a product basis.

J. Management Evaluation of Relative Success

The performance of an industrial chemical may be evaluated through time using many criteria. Some argue that product performance should be measured against pre-established marketing objectives to determine progress toward these goals. In matching actual outcomes with the subjective evaluations of performance, we may infer which measures of performance are used by respondents in determining the relative success of new products.

K. Marketing Costs

Economies of scale associated with higher output levels should allow for the spread of marketing costs on a unit basis over a larger base, which should then reflect in the performance records of new products.

L. Merger Activities

Since the analysis does not consider profit contributions on an institutional basis (it is product oriented), performance should not correlate with merger activities.

M. Mode of Production

Any marked underutilization of unique plant and equipment in the production of an exclusive chemical product should produce inefficiencies limiting profitability. On the other hand, products produced in common production facilities give management a great deal more flexibility in scheduling production more efficiently.

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N. Orientation of Research and Development Program

Research-based products are said to be developed as a result of pure scientific investigation, with end-use applications detected through numerous screening programs. Many compounds coming out of research laboratories have unique physical characteristics, but little or no commercial value. But marketing-based products are developed through applied scientific investigation only after particular user requirements become known. Superior performance, then, should come with marketing-based products, which reflect the efficiency gained by knowing in advance the existence of specific product demand.

O. Output of Research Activities

Performance should relate to the number of products uncovered and commercialized, each usually absorbing its fair share of the originally budgeted research and development costs associated with the research project. Then, if joint production is possible, further economies of scale are usually realizable.

P. Product Concept Acceptance

Performance should be directly related to the marketer's general ability to communicate the characteristics and benefits of the product to industrial users.

Q. Product Improvement Efforts

Once a new chemical is marketed, the firm can collect evidence to evaluate its performance characteristics against its end-use applications. If deficiencies appear in the investigation, product improvement programs can be scheduled whenever economically justifiable. Presumably those products having product improvements recorded at least once in the product life cycle under study will show a lower rate of product acceptance before the product changes are incorporated. Future sales behavior is ffected by

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affected by the ability of the firm to overcome the technical problems. The fact that problems did arise, however, should in itself limit future growth seriously, regardless of the actions taken to correct performance deficiencies. In other words, the sales structure can be effectively related to the degree to which a product does meet desired performance characteristics.

R. Promotional Media Strategy

Industrial products differ in the extent to which they are tailored to specific markets. Advertising should be focused on those media in which the resources of the firm are utilized optimally in reaching stated objectives and intended markets; horizontal mass media are unlikely to provide the most efficient approach.

S. Promotional Outlay Trends

Advertising can help create interest in investigational evaluations and application studies, although promotional programs are seldom critical in the success of new chemical introductions. If promotional outlays are important in demand creation, however, promotional outlay trends should relate directly to performance.

T. Source of Product Discovery

Many new products can still be very profitable to a particular firm even if they are mere duplications of existing chemical products.

U. Suitability of Marketing Capabilities

Marketers generally find that an experienced, viable selling organization is prerequisite to a successful new product development program. It is damaging to undertake the marketing of a new product without the immediate capability to do so. Integrating a large number of new personnel, for example, might disrupt uniform market development until their overall productivity reaches normal levels.

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V. Supply Capabilities in Developmental Sampling Programs

Developmental sampling programs can be useful in gaining product acceptance and subsequent usage. Most potential buyers of industrial chemicals work closely with field representatives in evaluating user requirements. But the firm's capability to supply significant amounts of product to meet estimated user needs at the time samples are distributed is probably an important factor in overcoming any resistance in having the new product evaluated.

W. Technological Specialty Experiences

It seems reasonable that chemical manufacturers would concentrate on research and development programs in selective areas in which they have existing expertise. But since major chemical manufacturers so limit themselves generally, performance should not vary with technological specialty requirements.

X. Type of Distribution Channel Used

Major chemical manufacturers have most often chosen direct sale to users, allowing distributors to handle small lot purchases. Frequently used distributors are probably complementary to the traditional channel and economically justifiable. Early in market development, many firms attempt to develop the markets directly for they can thus better control the destiny of new product programs. Product management generally feels that the technical and sales support needed must be sensitive to market needs, even when information on potential end usage is incomplete. On the average, we expect superior performance from those firms using the combined direct and indirect sales approach, as long as they handle the profitable large volume business on a direct basis.

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Y. Type of Fixed Capital Employed

Given fixed levels of capital investment and noncontinuous production, we expect superior performance from more desirable forms of capital equipment, such as all multipurpose equipment, where capital expenditures may be allocated to the various products being produced on the basis of actual output or time in use. And greater production efficiencies result too, as long as changeover and start-up costs are reasonable.

Z. Type of Marketing Representation Used

The marketing function is often handled by special marketing development people, at least in the introductory stage of a new chemical product. The technically trained people working on development programs are most qualified to handle the technical aspects of product usage, so many feel that they are in a unique position to handle the selling effort as well. Others argue, on the other hand, that the selling function can best be handled by the regular sales force, which knows and understands its assigned markets and business opportunities within those markets; if technical problems arise, they contend, the regular sales force can easily handle them through referrals. We hypothesize that superior product performance relates to assigning the marketing function to the regular sales force. We have the opportunity to evaluate these general approaches to market development and their outcomes using empirical support.

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CHAPTER VII

METHODS EMPLOYED IN DATA ANALYSIS

Introduction

Various mathematical and statistical techniques will be employed in the analysis of collected field data. However, this effort involves more than the reporting of statistical data. Our inquiry is directed toward whatever specific conclusions emerge from the analysis of empirical data, a quest leading ultimately toward a better understanding of new product behavior.

Polynomial Determination

A methodological approach based on curve fitting has obvious advantages, expecially since this is an approximation problem involving a search for a function which can be defined on a number of preselected variables, but whose parameters are unknown. Approximation problems most often fit polynomial, trigonometric and exponential curves. Polynomial and exponential expressions are typically involved in nonlinear systems. Because a polynomial expression can be generated for any arbitrary continuous function in a finite, closed interval, an approximation of any system, linear or nonlinear, based on a polynomial determination can best fit the empirical data associated with product behavior.

The approximation criterion for generating parameters in the function $y(g,t)$, defined on sales or profit data over time, is the minimization of the sum of squares of absolute deviations. The following depicts this:

where

$$\hat{Y} = g_0 + g_1 t_{1q} + g_2 t_{2q}^{\;2} + \ldots g_k t_{kq}^{\;v} + e \tag{7.1}$$

where $\hat{Y}$ = predicted dependent variable

$g_0, g_1, \ldots g_k$ = estimation coefficients

t = time in years, starting with the first year equal to the value one

q = number of observations, 1,2, . . . N

$v \leq N - 1$, the vth order of polynomial

e = disturbance

The sum of the squared residuals is to be a minimum, i.e.,

$$\sum_{q=1}^{N} (Y_q - \hat{Y}_q)^2 \text{ is a minimum} \tag{7.2}$$

The least-squares parameters, $g_0, g_1, \ldots g_k$, are found by matrix algebra.[1] We need make no distribution assumptions regarding the dependent variable and the independent variables while calculating the least-squares coefficients, although the independent variables are assumed to be fixed variables. The dependent variable is a normally distributed random variable with a mean based on the values of the independent variables for each observation in the population. A constant variance is assumed to exist over all observations in this model, with independence among observations. The amount of squared error accounted for by the independent variables is measured by the coefficient of multiple determination R^2, which is expressed statistically as follows:

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[1]See Carl F. Christ, Econometric Models and Methods, (New York: John Wiley & Sons, Inc., 1966), pp. 380-395.

$$R^2 = 1 - \frac{\sum_{q=1}^{N} (Y_q - \hat{Y}_q)^2}{\sum_{q=1}^{N} (Y_q - \bar{Y}_q)^2} \qquad (7.3)$$

An initial least-squares equation is obtained using N - 1 independent variables defined over time for sales or profit data representing an individual product situation. Through a general stepwise procedure, we delete from the equation each order of independent variables that is unable to account for the variation in the dependent variable above that accounted for by the overall mean of the dependent variable and the remainder of the independent variables.

The F statistic for each least-squares coefficient in any given equation is examined to test its significance level. The minimum level of significance accepted for inclusion is .05. In other words, a least-squares equation is calculated after each deletion until the significance probability of each Fg_i statistic left in the equation exceeds the established minimum. The F statistic for the regression weight g_i is defined as beta weight "i" squared divided by the square of its corresponding standard error. The end result is the maximum-order polynomial expression for sales or profit data of a new product that is justified statistically, and comparisons between product histories can be made on the basis of their determined polynomial expressions. No independent variable erroneously included in the regression equation will bias estimates of the other parameters even if multicollinearity (a problem of high covariance between a number of independent variables that are highly correlated) exists between the variable in question and one or more other independent variables. We must pay particular attention to any covariance because the sample size is quite small.

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The real purpose in this exercise is not to estimate parameters in the equation but instead to best fit data historically for classification purposes and to forecast the values of the dependent variable for predictive purposes. Forecasting procedures are not likely impeded so long as the joint distribution of the independent variables is not altered in the forecasting period, even though the separate influences of the independent variables may remain unknown.

An Approach to New Product Evaluation

There is no substitute for an analytical approach in evaluating new product decisions. The characteristic problem of a new product not producing a satisfactory return once introduced in the marketplace can be offset if adequate resources are allocated to a comprehensive study of the entire marketing situation. A decision to curtail a project based on conclusions drawn from unfavorable empirical evidence could conceivably save the firm from serious loss.

A number of analytical approaches find use in the evaluation of new products. However, whatever specific approach is adopted, an incorporation of uncertainty in the process appears to be mandatory. Figure 7-1 details the information required to quantify the impact of expected new product behavior. The next section contains an explanation of how uncertainty is introduced as an evaluative factor.

SUMMARY TABLE FOR NEW PRODUCT EVALUATION FORM

ITEM DESCRIPTION	CALCULATION		VALUE
Cumulative Operating Cash Flows	$\sum_{t=-\frac{1}{2}}^{m} (19)_m$	where $m \leq n$	
Cumulative Investment Requirements	$\sum_{t=-\frac{1}{2}}^{m} (25)_m$	where $m \leq n$	
Discounted Operating Cash Flow Sum	$\sum_{t=-\frac{1}{2}}^{m} (27)_m x (19)_m$	where $m \leq n$	
Discounted Investment Sum	$\sum_{t=-\frac{1}{2}}^{m} (27) x (25)_m$	where $m \leq n$	
Present Value Sum	$\sum_{t=-\frac{1}{2}}^{m} (28)_m$	where $m \leq n$	

Figure 7-1

NEW PRODUCT EVALUATION FORM

Product Development No.__________ Date of Evaluation__________

Projected Product Life: Mean__________ Variance__________

Item Description	Item Number	Calculation	Year -5		Year 0		Year 1		→	Year N	
			Mean	Variance	Mean	Variance	Mean	Variance		Mean	Variance
Unit Selling Price	1										
Demand in Units at Assumed Mean Unit Selling	2										
Total Estimated Revenues	3	(1)x(2)									
Unit Material Costs	4										
Unit Labor Expenses	5										
Unit Energy Costs	6										
Other Unit Manufacturing Expenses	7										
Total Unit Manufacturing Expenses	8	(4)+(5)+(6)+(7)									
Production Start-Up Expenses	9										
Depreciation Charges	10										
Cost of Goods Sold	11	[(2)x(8)] + [(9)+(10)]									
Gross Profits	12	(3)-(11)									
Research & Development Charges	13										
Marketing Expenses	14										
Administrative Expenses	15										
Net Profits (Losses) Before Taxes	16	(12)-[(13)+(14)+(15)]									
Taxes	17										
Net Profits (Losses) After Taxes	18	(16)-(17)									
Operating Cash Flows	19	(18)+(10)									
Incremental New Fixed Capital Requirements	20										
Incremental Transferred Fixed Capital Requirements	21										
Incremental Carry Forward Fixed Capital Requirements	22										
Total Incremental Fixed Capital Requirements	23	(20)+(21)+(22)									
Incremental Working Capital Requirements	24										
Total Incremental Investment Requirements	25	(23)+(24)									
Net Cash Flows	26	(19)-(25)									
Discount Factor	27										
Present Value	28	(26)x(27)									

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Program Analysis

A computer program titled PROGRAM ANALYSIS is available for performing the mathematical calculations under uncertainty for all economic and associated data required in the evaluation of new products, written in Fortran IV for CDC 3600 computer equipment.[2]

One subroutine in the program calculates the appropriate discount factor to be used in deflating cash flow values during a specific time period. The formula for continuous discounting in an instant at the end of a given time period may be represented as:

$$(DF)_i = \frac{1}{e^{rt_i}} \tag{7.4}$$

where $(DF)_i$ = discount factor in time period i expressed as a fraction

e = 2.7182818

r = selected cost of capital or risk factor expressed as a decimal

t_i = time period i expressed in years

The reference point is time period zero, which for most new product situations within the chemical industry was eighteen months after approval of a given capital expenditure.

The underlying assumption for all estimates of parameters is that the associated estimated error terms are normally distributed. There is a random deviate generator within the program. Any estimated parameter is calculated such that a sequence of random numbers is generated which has a normal distribution with a mean equal to zero and a variance of one. In other words, values for estimated parameters are randomly selected around their predetermined average values. A unit normal sampling

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[2] A listing of the source deck can be found in the appendix.

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distribution results after a large number of passes is made over a set of product data. A definite pattern for each performance statistic can then be delineated. If one wishes to evaluate new products on the basis of any other type of error distribution assumption, the program must first be altered to reflect this change. An empirical study of actual estimation processes should offer the most rigorous way of establishing a basis for selecting specific error distribution assumptions. This computer program may quite easily be employed as a deterministic model of new product performance by setting all variance terms equal to zero. This, in effect, implies perfect measurement and prediction.

Parametric Versus Nonparametric Methods

Since the statistical technique chosen may critically influence the outcome of research findings, any statistical test is selected on the basis of the sampling distribution of the statistic employed. Since the sampling distribution is a theoretical distribution, it can be characterized if its exact distribution is known. And once the sampling distribution of a statistic is known, we can make statements about the probability of occurrence of certain numerical values of that statistic.

Parametric tests are based on specific assumptions with regard to the type of population from which the sample is drawn. The parametric approach is appropriate if the variables studied are continuous and normally distributed. Unfortunately, there is no simple way to determine whether or not the collected field data in this study meet the assumptions of normality. And it is quite difficult to estimate the extent of error introduced if these conditions are not met, particularly with small samples as in the present case.

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Many research problems are encountered in the evaluation of new products whose solutions suggest the use of nonparametric techniques. Siegel makes a clear and concise comparison between these two statistical approaches, suggesting under what conditions they are employed appropriately.

> "A parametric statistical test is a test whose model specifies certain conditions . . . about the parameters of the population from which the research sample was drawn. Since these conditions are not ordinarily tested, they are assumed to hold. The meaningfulness of the results of a parametric test depends on the validity of these assumptions. Parametric tests also require that the scores under analysis result from measurement in the strength of at least an interval scale.
>
> "A nonparametric statistical test is a test whose model does not specify conditions about the parameters of the population from which the sample was drawn. Certain assumptions are associated with most nonparametric statistical tests, i.e., that the observations are independent and that the variable under study has underlying continuity, but these assumptions are fewer and much weaker than those associated with parametric tests. Moreover, nonparametric tests do not require measurement so strong as that required for the parametric tests; most nonparametric tests apply to data in an ordinal scale, and some apply also to data in a nominal scale."[3]

Even when samples are drawn from different populations, nonparametric tests can be applied to determine whether or not given population estimates differ on a statistical basis.

A number of statistical tests will be used for inferential purposes in the analysis of new product behavior; the indicated scale will determine the test to be chosen. In situations where any statistical model includes two or more types of scales, the test that allows the usage of the lowest desirable scale in terms of power efficiencies will be used. The significance level reported for any k-sample test in the research findings is the probability of the calculated value of the statistic or any larger value given no relationship. In the case of rank correlation measures, the stated probabilities apply to one-tailed tests. After statistical relationships have been firmly established by

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[3] Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences, (New York: McGraw-Hill Book Company, 1956), pp. 30-31.

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the use of nonparametric approaches, several forms of multivariate analysis will be employed to evaluate how feasible it may be to relate proven determinants of product behavior with specific performance characteristics for predictive purposes.

The following specific statistical techniques are used in the research data analysis phase of the dissertation. For reference purposes, a consolidated listing covering each calculating formula appears in the appendix.

Kolmogorov-Smirnov Two Sample Test

This nonparametric test, to determine whether two independent samples have been drawn from the same parent population, is sensitive to any characteristic difference in distribution types: such differences as location, dispersion, skewness, or kurtosis. Whenever the two samples have been drawn from the same parent population and the values are at least ordinally scaled, any difference between two cumulative proportion sampling distributions would be due to sampling error and represent random deviations from the parent distribution. But unreasonably large differences between cumulative proportion sampling distributions strongly suggest real differences between the two distributions.

Data from both samples are combined into the largest feasible number of common intervals so as not to lose valuable information. A search is then made of all intervals to detect the largest difference in the noted proportions. The probability associated with any observed value of the statistic D can be found by computing the chi-square statistic and referring to its density function. Critical values for the Kolmogorov-Smirnov test (when $n_1 = n_2 \leq 40$) may be found tabled in a number of literature sources.[4]

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[4] One such source is William Beyer (ed.), CRC Handbook of Tables for Probability and Statistics, (Cleveland, Ohio: The Chemical Rubber Company, 1966), p. 324.

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Kruskal-Wallis One-Way Analysis of Variance

This nonparametric ranking technique, used for deciding whether independent samples are from different populations, requires at least an ordinal measurement for any given variable. All data of the k-samples are ranked by size in a single series from largest negative values to largest positive values. In the case of ties, the mean of the tied ranks is assigned. The calculating formula for the statistic H is distributed as a chi-square distribution with df = k - 1, as long as each n_j is sufficiently large.

Kiefer K-Sample Analogue Test

The Kiefer test, a nonparametric extension of the Kolmogorov-Smirnov test to k-samples, tests whether all of the k-samples have been drawn from the same population. Data measured on at least an ordinal basis are first pooled for all samples. It is possible to specify the population on an a priori basis although, if this capability does not exist, an estimate of the cumulative distribution function may be made from the collected sampling information. Probabilities of the statistic can be found by using a tabulated routine established by its author for $k \leq 5$.[5]

Bhapkar K-Sample Analogue Test

The Bhapkar statistical test, another k-sample analogue, uses the null hypothesis to test whether all of the k-samples have been drawn from the same population. When the observations are independent and the cumulative distribution functions for all samples are continuous and equal, the V statistic is asymptotically distributed as a chi-square statistic with k - 1 degrees of freedom. This approximation is said to be relatively close for sample sizes of moderate size or larger.[6]

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[5] J. Kiefer, "K-Sample Analogues of the Kolmogorov-Smirnov and Cramer-V. Mises Tests," Annals of Mathematical Statistics, Vol. 30 (1959), pp. 434-445.

[6] V. P. Bhapkar, "A Nonparametric Test for the Problem of Several Samples," Annals of Mathematical Statistics, Vol. 32 (1961), p. 1109.

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Spearman Rank Correlation Coefficient

This nonparametric measure of association based on rank differences, requiring at least an ordinal scale for measurement, tests the independence of ranks. The procedure is particularly useful when the sample sizes are relatively small. Ranks are assigned separately to any two samples one wishes to compare in order of decreasing size. For every pair of ranks, the difference in ranks is calculated. If a perfect correlation exists for any two sets of data, we would expect to find each $X_i = Z_i$. As long as the observations have been randomly drawn, one can calculate the probability that the observed statistic in the predicted direction is significantly different from zero. When $N \geq 10$, the Spearman rank correlation statistic is distributed as a Student's t distribution with $df = N - 2$.

Multiple Regression

When considering a number of predetermined predictor variables, it is possible to combine their effects in a single equation by estimating relationships between a dependent variable and a set of independent variables. Based on a linear combination of calculated coefficient values, the least-squares estimation approach, one multivariate statistical procedure commonly employed in research methodology, is capable of handling both linear and nonlinear systems in terms of the spread for dependent variable data. The least-squares equation with a constant term and no restrictions takes on the following form.

$$\hat{Y}_i = b_o + \sum_{j=1}^{k-1} b_j X_i^j + e \quad (i = 1,2, \ldots N) \qquad (7.5)$$

where $\hat{Y}$ = dependent variable

b_o = constant term

b_j = jth parameter (regression coefficient)

X_i^j = ith observation for independent variable X^j

e = error term (disturbance)

Multiple regression makes three basic assumptions if and only if relationships between the dependent variable and the independent variables are to be statistically tested.

1. The expected value of the dependent variable is based on the values of the independent variables for each observation, i.e., a linear relationship exists between the dependent variable and any independent variable.

2. The error distribution is homoscedastic over all observations.

3. There is independence between observations.

Since high covariance caused by a corresponding high correlation between two independent variables will bias the estimates of their parameters, it is necessary to examine the covariance matrix of any run to detect the existence of multicollinearity. Whenever an independent variable does not belong in a given equation and is erroneously included, there is no bias in the estimates of other parameter values. Thus all independent variables which were thought to relate to a specific performance characteristic are included in the original calculation. One at a time, the independent variables with the highest significance probabilities of the F statistic associated with their calculated coefficients are deleted and new equations calculated. The deletion process continues until the minimum significance probability of the Fb_i statistic for each of the remaining independent variables is less than or equal to .05.

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The deletion process is an equivalent test in determining whether any given independent variable accounts for any of the variance in the dependent variable above that accounted for by the remainder of the independent variables, the constant term, and the mean of the dependent variable.

Linear Programming Regression

Many research issues can be logically defined so as to specify the signs of coefficients for a number of predictor variables a priori on the basis of reasoning. For example, one marketing theory in buyer behavior might specify that demand for a class of new consumer products is an increasing function of allocated shelf space and promotional expenditures over a common time horizon. A least-squares multiple regression solution of the collected experimental data could show a negative coefficient for the allocated shelf space variable. But such a relationship does not make sense in terms of accepted marketing behavior.

Whenever side inequality restrictions are imposed on parameter values, the least-squares regression approach loses its linear identity and can only be solved through the use of complicated mathematical procedures, such as quadratic programming. It is also possible to solve such a problem by the analytical method of linear programming regression.

A linear programming regression run concerns itself with estimating parameter values for independent variables in the equation

$$\hat{Y}_i = b_o + \sum_{j=i}^{k-1} b_j \, x_i{}^j + \delta_i \qquad (1 = 1,2, \ldots N) \qquad (7.6)$$

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where $\hat{Y}_i$ = dependent variable

b_o = constant term

b_j = regression coefficient for jth parameter

X_i^j = the ith observation for independent variable X^j

δ = deviation term

A number of objective functions can be used in the linear programming regression run. Choice depends on the application of the model and the actual values in the observational data. For example, one may wish to minimize the absolute sum of deviations when the spread in data points for the predictors is not large. Our objective function then becomes

$$Z = \min. \left(\sum_{i=1}^{N} |\delta_i| \right) \tag{7.7}$$

It is also possible to place constraints on any coefficient if desired. The regression problem can be solved by generating a basic algorithm and searching after inversion for possible solutions until the established criteria are first met.

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CHAPTER VIII

RESEARCH FINDINGS

Introduction

Since this study sought to isolate the determinants of not only demand but eventual product performance as well, the subsequent field work necessitated a highly organized approach from the start, particularly in presenting the rationale of the thesis clearly to all potential data sources and in screening product inclusions according to some standardized procedure. The writer recognized the likely sensitivity of respondents in providing the information sought. Consequently, special care was taken in presenting the safeguards that would be used in reporting data.

Participants were asked to expend a great deal of time in responding; indeed the availability of retrieval facilities at the time of submitting the request might have augmented the response considerably. As it was, however, the response was gratifying, since sixteen of the twenty-five chemical manufacturers comprising the population contributed at least some information in the data collection effort.

A number of submitted product histories had to be deleted because of irregularities or gaps in the data. The screening process finally yielded twenty-seven new industrial chemical product histories reflecting the unique experiences of six large chemical manufacturing firms. Sampling controls sought to insure that the data were reasonably representative, though nothing in routine investigative sessions with industry respondents suggested that any inputs were particularly atypical.

The organization of this chapter closely parallels that of Chapter VI. First it presents the results of fitting polynomial functions to sales and profit data over time of new industrial chemical products included in the sample. This chapter then recapitulates the study over the time

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horizon necessary for examining sales and profit contributions empirically. The final two sections explore the complex relationships between performance and possible determinants of product behavior.

General Hypothesis No. 1

> No single representative nth order polynomial function best describes the sales patterns of new industrial chemical products.

Orthogonal polynomial functions were generated by fitting a linear components model to sales data defined as a function of time. The least-squares estimators of regression coefficients were tested for statistical significance at the .05 level under the assumption that they were independent normal variates. Only those orders of polynomials for which the statistical evidence was conclusive were retained in Table 8-1.

The data supported the rejection of our alternate hypothesis, one polynomial function can best describe the sales patterns of new industrial chemical products. Since there were only two cases (Products 10700 and 11300) in which the polynomial expressions for actual retained orders matched by having nonzero regression coefficient values, the statistical routine of polynomial determination did not provide a useful classification technique. This conclusion held true even when one grouped products having identical exposure times. So of necessity, the general configuration of sales patterns ascertained for individual product histories remained a matter of judgment.

Based on iterative fitting, the higher order polynomial expressions—beyond quadratic—defined on time literally exploded when attempts were made to use the estimated parameters in forecasting the dependent variable in future time periods. The limited number of time periods involved was part of the problem. Without presenting specific evidence, complicated mathematical descriptions of sales defined on time simply did not capture the true genesis of future trends.

TABLE 8-1

POLYNOMIAL DETERMINATION OF INDUSTRIAL CHEMICAL PRODUCT SALES DATA

Product Code Number	Minimum Exposure[1] (in years)	Coefficient of Multiple Determination	Durbin-Watson Statistic	nth Order of Polynomial Retained 1	2	3	4	5	6	7	8	9	10
10100	10	0.9833	3.1849			X	X			X			-
10200	7	0.9999	3.7121	X	X	X	X	X		-	-	-	-
10300	10	0.9994	3.8176	X			X	X	X	X	X	X	-
10400	10	0.9999	3.6758	X	X			X	X	X	X	X	-
10500	6	0.9999	3.6587	X		X	X	X	-	-	-	-	-
10600	10	0.8968	2.9597		X			X					-
10700	7	0.9481	2.0529	X						-	-	-	-
10800	10	0.9942	3.5877		X	X	X	X	X	X			-
10900	10	0.9597	2.3468		X	X							-
11000	7	0.8144	2.4234				X	X		-	-	-	-
11100	9	0.9999	3.5300	X	X			X	X	X	X	-	-
11200	7	0.8422	1.1536			X				-	-	-	-
11300	7	0.6099	2.9492	X						-	-	-	-
11400	8	0.9994	3.6176	X			X	X	X	X	-	-	-
11500	8	0.9999	0.1847	X	X	X	X	X	X		-	-	-
11600	9	0.9986	3.7612	X			X	X	X			-	-
11700	8	0.9514	2.7493				X	X	X		-	-	-
11800	8	0.9447	2.5334			X	X	X			-	-	-
11900	10	0.9409	2.3910						X	X	X	X	-
12000	7	0.9699	3.0003			X	X			-	-	-	-
12100	11	0.9952	3.3747						X	X	X	X	X
12200	9	0.2292	1.2631						*			-	-
12300	6	0.1900	2.0181		*				-	-	-	-	-
12400	9	0.9828	2.9149		X	X			X	X		-	-
12500	10	0.9167	2.6224			X			X	X	X		-
12600	10	0.2932	1.6772		*								-
12700	8	0.9318	3.3019		X	X	X	X			-	-	-

[1]Defined as the number of years included in the analysis whether or not the product had been withdrawn from the marketplace.

*The remaining variable was not significant at the 0.05 level, but retained for reporting purposes.

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General Hypothesis No. 2

> The profit cycle for new industrial chemical products does not typically fit a declining exponential curve.

It required no sophisticated mathematical runs to suggest that the profit data seldom generated a declining exponential curve through time, a suspicion quickly confirmed by examining the empirical results presented in Table 8-2. As the residuals of entrepreneurial action, profit data need exhibit no consistent pattern among products, even those with similar end-use patterns. The decisive managerial strategies involved were far too idiosyncratic. Also, new industrial chemical products were generally high risk ventures having volatile performance records. Polynomial determination runs on profit data typically displayed irregular mathematical patterns. In fact, only two product situations (Products 11700 and 12700) achieved identical nth order functions having nonzero regression coefficient values defined over the independent time variable (see Table 8-3).

General Hypothesis No. 3

> The profit cycle of new industrial chemical products does not typically descend while the sales curve is still rising in the maturity phase of the product life cycle.

Twice as many products experienced coincident or lagging profit life cycle structures as experienced leading profit cycle patterns, though a number of product histories, too brief to permit accurate statements on the timings of profit cycles in relation to sales behavior, were considered indeterminant. Table 8-4 presents a breakdown of the profit cycle timings included in the research sample.


Year

TABLE 8-2

PROFIT INDEXES FOR NEW INDUSTRIAL CHEMICAL PRODUCTS

Product Code Number	Base Year[1]	Year									
		1	2	3	4	5	6	7	8	9	10
10100	6	(1.6)	(0.8)	(0.7)	5.7	6.5	11.3	4.5	5.6	3.2	5.1
10200	10	(0.4)	(0.3)	0.1	0.3	0.9	(0.4)	(0.6)	--	--	--
10300	8	1.9	1.5	2.6	6.8	8.6	8.4	10.9	16.2	9.1	8.8
10400	10	(2.5)	0.1	1.6	3.2	3.6	1.8	1.7	7.1	9.6	12.3
10500	2	0.7	2.7	1.7	3.4	6.8	6.1	--	--	--	--
10600	2	7.2	11.7	8.2	9.7	5.1	5.1	0.0	0.0	0.0	0.0
10700	10	1.1	4.0	4.6	6.9	9.5	10.7	11.2	--	--	--
10800	5	(1.0)	(6.5)	3.3	10.8	13.0	6.5	0.0	0.0	0.0	0.0
10900	1	(193.6)	(131.4)	(64.0)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11000	6	5.0	5.9	8.9	8.2	10.0	17.1	10.7	--	--	--
11100	10	(1.0)	1.6	3.7	4.8	9.4	9.0	11.5	12.3	13.8	--
11200	10	3.2	5.3	2.5	10.1	10.3	12.2	14.1	--	--	--
11300	10	3.1	2.0	9.9	10.0	8.9	8.9	9.5	--	--	--
11400	10	(0.2)	2.3	4.3	5.6	7.8	11.2	14.4	13.8	--	--
11500	10	1.4	2.2	4.0	4.8	4.2	4.2	4.1	3.3	--	--
11600	9	0.7	0.1	0.5	(6.5)	(1.6)	(2.9)	(0.6)	(7.1)	4.9	--
11700	5	(2.3)	(0.9)	6.7	10.3	13.7	7.6	8.0	7.0	--	--
11800	10	(65.2)	(78.2)	(69.5)	(48.9)	(57.6)	(26.4)	(6.2)	(6.8)	--	--
11900	10	(1.7)	(1.4)	0.5	0.9	2.7	2.5	3.2	(0.3)	2.5	4.2
12000	7	(2.8)	0.8	0.8	0.4	1.3	4.6	6.8	--	--	--
12100[2]	6	0.1	1.4	4.7	11.9	17.0	15.1	11.2	15.1	15.3	15.9
12200	10	(0.5)	0.7	(1.9)	(1.3)	(2.2)	(1.0)	(0.5)	(1.9)	(17.1)	--
12300	10	0.6	0.9	4.0	1.6	1.7	4.9	--	--	--	--
12400	3	9.6	13.8	16.7	16.2	10.4	5.0	6.6	4.4	4.1	--
12500	9	(8.3)	(6.1)	(4.9)	(2.2)	1.6	8.0	8.4	6.7	6.7	6.4
12600	8	(11.2)	(16.6)	(8.0)	(11.5)	2.3	16.4	11.2	19.8	11.0	12.8
12700	10	1.3	2.7	2.8	0.1	(1.1)	5.9	8.6	4.1	--	--

NOTE: Negative values are shown in parenthesis

[1]The profit index is calculated for a given product in any year by dividing maximum annual sales over the product life cycle under study into the net profits after taxes and multiplying the quotient by 100.

[2]A negligible quantity of product was sold in year 0 resulting in a net profit index of 0.0.

TABLE 8-3

POLYNOMIAL DETERMINATION OF INDUSTRIAL CHEMICAL PRODUCT PROFIT DATA

Product Code Number	Minimum Exposure[1] (in years)	Coefficient of Multiple Determination	Durbin-Watson Statistic	nth Order of Polynomial Retained 1	2	3	4	5	6	7	8	9	10
10100	10	0.6726	2.3179					X	X	X			-
10200	7	0.1863	1.3973					*		-	-	-	-
10300	10	0.9998	3.8022	X	X	X			X	X	X	X	-
10400	10	0.9999	3.8037	X	X	X		X	X	X	X	X	-
10500	6	0.9994	3.6587	X	X	X	X		-	-	-	-	-
10600	10	0.9196	3.6062	X	X	X							-
10700	7	0.9691	2.0535	X						-	-	-	-
10800	10	0.9963	3.5962	X	X	X			X	X			-
10900	10	0.9977	3.6339			X	X	X					-
11000	7	0.9999	3.7113	X	X	X	X		X	-	-	-	-
11100	9	0.9627	2.8395		X	X						-	-
11200	7	0.7684	2.2850			X				-	-	-	-
11300	7	0.3787	1.4652		*					-	-	-	-
11400	8	0.9998	3.1375		X	X	X	X			-	-	-
11500	8	0.9806	3.1169			X	X	X	X		-	-	-
11600	9	0.1157	2.3964						*			-	-
11700	8	0.8509	2.7215				X	X	X		-	-	-
11800	8	0.9376	2.9554					X	X		-	-	-
11900	10	0.8940	3.2987				X			X	X	X	-
12000	7	0.9995	3.3002	X	X	X			X	-	-	-	-
12100	11	0.9999	3.8196	X	X	X			X	X	X	X	X
12200	9	0.9808	2.9875		X			X	X			-	-
12300	6	0.4443	2.3363				*		-	-	-	-	-
12400	9	0.9941	3.3489				X	X	X	X	X	-	-
12500	10	0.9975	3.7898			X	X	X	X	X	X		-
12600	10	0.9325	2.9827			X			X	X			-
12700	8	0.8409	2.2977				X	X	X		-	-	-

[1] Defined as the number of years included in the analysis whether or not the product had been withdrawn from the marketplace.

*The remaining variable was not significant at the 0.05 level, but retained for reporting purposes.

TABLE 8-4

TIMING OF PROFIT CYCLE
IN RELATION TO SALES PATTERNS

Timing	Frequency	Percentage
Leading	7	25.93
Coincident	12	44.44
Lagging	2	7.41
Contra-cyclical	1	3.70
Indeterminant	5	18.52
	27	100.0

No empirical evidence suggests that new products typically display leading profit cycles. In twelve new product histories analyzed, declining profit contributions began at the very time there was a turnabout in demand when aggregate revenues for the product started a downward course. (See Table 8-4). Leading profit cycles, in fact, were limited to just seven out of the twenty-seven new product situations studied. This appears to be quite a significant finding, since any early warning system used for detecting demand weakness based on the examination of the profit cycle would not operate consistently for new industrial chemicals.

<u>General Premise No. 1</u>

> The time horizon necessary to consider sales and profit contributions for new industrial chemical products exceeds five years beyond their introduction.

The normative approach in recommending a time horizon for product analysis implies a strong analytical approach in describing product experiences. It seeks to lessen dependence on executive intuition, or at least to challenge an established position if contrary judgment is held by one or more of the decision makers involved in the evaluation. To introduce such a criterion into the decision making process of necessity involves specific inputs, many having future orientations, e.g., price-volume relationships, market trends, and competitive behavior.

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In the case of new industrial chemical products, many experienced analysts have long realized that a time horizon equal to the product life is unrealistic, particularly for industrial commodities. Any time horizon which appeared in the course of research, furthermore, reflected just an arbitrary policy rather than an empirically determined interval. Sales forecasts were typically limited to five years or less, as revealed in the many informal discussions held with industry respondents.

The number of established viewpoints on investment behavior complicates matters considerably, as the objective selected influences the technique chosen for analyzing the worth of product proposals. For example, the investor may elect to look only at the earnings stream with a cut-off rate established on the basis of a projected divisional performance record; a go/no-go decision would then be based on the results expected of the considered product opportunity relative to overall performance.

Another accepted approach, mainly financial, incorporates the time value of money in the analysis. Here discounted dollar flows ultimately determine the relative success of new product decisions. A number of other techniques, as the return on investment formula, places product decisions in a financial framework, each having its own unique features.

Even though the ultimate desirability of an optimum time horizon remains to be established, existing statistical evidence casts doubt on the validity of the present practice of limiting product analysis up to a five-year period. Trends of profit and sales data are inadequate to discriminate new product performance because initial conditions are usually minuscule in absolute terms, so all changes over initial conditions appear quite inflated.

In order to accurately evaluate the performance of at least 75% of all products included in our sample, a time horizon of between eight and eighteen years would have been necessary, depending of course upon the criterion selected (see Tables 8-5 through 8-8). The ratio of net income

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TABLE 8-5

MINIMUM NUMBER OF YEARS REQUIRED FOR NET INCOME ON PRODUCT AS A PERCENTAGE OF NET SALES TO MATCH OR EXCEED ITS CORPORATE PERFORMANCE RECORD[1]

Minimum Number of Years	Frequency	Percentage	Cumulative Percentage
One	6	22.22	22.22
Two	2	7.41	29.63
Three	4	14.81	44.44
Four	3	11.11	55.55
Five	0	0.00	55.55
Six	4	14.81	70.36
Seven	0	0.00	70.36
Eight	1	3.70	74.06
Nine	1	3.70	77.76
Ten or more years	5	18.52	96.28
Indeterminant	1	3.70	100.0
Total	27	100.0	

[1]The mean rates for corporate performance were established by a historical analysis of responding company data in the 1955-64 period.

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TABLE 8-6

SAMPLING DISTRIBUTION OF PAYBACK PERIOD

Payback Period[1]	Frequency	Percentage	Cumulative Percentage
Less than 3 years	0	0.00	0.00
3 years, but less than 5 years	4	14.81	14.81
5 years, but less than 7 years	3	11.11	25.92
7 years, but less than 9 years	5	18.52	44.44
9 years, but less than 11 years	2	7.41	51.85
11 years, but less than 13 years	3	11.11	62.96
13 years, but less than 15 years	2	7.41	70.37
15 years and over	5	18.52	88.89
Indeterminant	3	11.11	100.0
Total	27	100.0	

[1]No forecasted information was utilized in the calculation of the payback period.

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TABLE 8-7

MINIMUM NUMBER OF YEARS FOR RETURN ON INVESTMENT MEASURE TO MATCH OR EXCEED ITS COMPANY'S COST OF CAPITAL AT THE TIME OF MARKET INTRODUCTION[1]

Minimum Number of Years	Frequency	Percentage	Cumulative Percentage
One	7	25.93	25.93
Two	2	7.41	33.34
Three	1	3.70	37.04
Four	2	7.41	44.45
Five	0	0.00	44.45
Six	1	3.70	48.15
Seven	1	3.70	51.85
Eight	0	0.00	51.85
Nine	0	0.00	51.85
Ten	0	0.00	51.85
Eleven or more years	11	40.74	92.59
Indeterminant	2	7.41	100.0
Total	27	100.0	

[1]See Chapter III for an outline of the procedure used in measuring the cost of capital; forecasted data were used in the determination of the cut-off points, but they excluded possible salvage values of fixed assets.

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TABLE 8-8

CRITICAL TURNING POINT IN DOLLAR FLOWS

Critical Turning Point[1]	Frequency	Percentage	Cumulative Percentage
Less than 5 years	2	7.41	7.41
5 years, but less than 7 years	3	11.11	18.52
7 years, but less than 9 years	3	11.11	29.63
9 years, but less than 11 years	3	11.11	40.74
11 years, but less than 13 years	2	7.41	48.15
13 years, but less than 15 years	2	7.41	55.56
15 years, but less than 17 years	3	11.11	66.67
17 years, but less than 19 years	2	7.41	74.08
19 years and over	4	14.81	88.89
Indeterminant	3	11.11	100.0
Total	27	100.0	

[1]Defined as the minimum number of years required before the present value sum becomes a positive figure for the first time; forecasted data were used in the estimation process.

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to sales is ascertainable much more quickly, but its usefulness as a criterion is limited by its failure to relate the income stream to the investment stream. In other words, it is difficult to allocate efficiently resources among investment alternatives unless asset information is used directly in the evaluation process.

From what we know of product behavior, then, it is safe to conclude that a time horizon of longer than five years is essential for the appropriate evaluation of new industrial chemical products, though an awareness of different product life cycle patterns may assist the analyst in evaluating product opportunities. A specific recommendation on an appropriate time horizon in evaluating new product proposals for industrial chemicals will be presented later in the dissertation.

Discussion of Performance Variable Outcomes

1. Sales Structure

Even though the sample distribution of aggregate sales dollars is skewed toward lower values, the peculiarities of sampling inclusions preclude our generalizing accurately about the shape of the parent population. The samples were drawn randomly, but varying allowable market introductory dates could have theoretically biased a number of observations. Even so, it remains a useful exercise to examine the sales data since we wish to identify those relevant operating characteristics which differentiate high and low sales levels. Since the analysis of all product data covered at least five years of history, we might expect to base a reasonable ranking of products on annualized sales figures, which reflect the adjustment made to partial out the major effect of varying sales time periods allowed in the research.

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TABLE 8-9

SALES STRUCTURE ON ANNUALIZED NET SALES[1]

Class Interval	Frequency	Percentage
Between $34,933 and $474,429	9	33.33
Between $474,429 and $1,147,556	9	33.33
Between $1,147,556 and $6,300,000	9	33.33
	27	100.0
Median	$ 660,444.0	
Mean	$1,385,978.6	
Standard Deviation	$1,633,489.7	

[1]Found by dividing the number of time periods covered in the analysis into the aggregate present value sum.

Absolute dollar totals confirm empirically one fact so often stressed in the literature, that new industrial chemical products are important revenue producers: eleven of the twenty-seven products had accrued sales totals exceeding $10 million over the time span covered in the study.

Sales and profit data, according to the rank correlation statistic presented in Table 8-10, are clearly interrelated. Though this association might appear to prove that "volume cures all evils," the maxim seems unwarranted since no statistical relationship appeared between attained sales levels and accrued discounted earnings. Annualized present value sums are apparently independent of sales results, since the rank correlation statistic for these two performance measures was 0.1032 and not significant at the .05 level (see Table 8-10). The timing and coordination of investment decisions are critical to the outcome.

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Industrialists are generally not accepting lower returns for larger volume business on a product basis. There was no apparent relationship between sales and return data, since their rank correlations were not significant at the 0.05 level (see Table 8-10). In fact, the median equivalent rate of return for the top five revenue producing products in the study was a negative 0.7%. Pricing policies seemed to be based on what the market will bear. To summarize other important relationships, products having higher sales performance records tended to have a larger number of firms competing for the business, a lower percentage of potential users evaluating the product in their own laboratories, higher promotional outlay trends, faster growing markets, a demand characterized as slight necessity or desire type, larger number of active participating accounts, an increased sensitivity to macroeconomic conditions, and a dependence on expanding marketing horizons to include international sectors.

As with the other performance variables, this report can only highlight significant findings in the present section. Table 8-11 documents the statistical outcomes on the nonparametric tests of sales data against the group variables cited above. The mean ranks of all grouped data are summarized in the appendix as further evidence for all the simple relationships between variables editorially drawn throughout this chapter. A more detailed analysis of the results can be found in the next section which treats the group variable listings separately.

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TABLE 8-10

SPEARMAN RANK CORRELATION TESTS OF ANNUALIZED NET SALES (RESEARCH CODE VARIABLE 152) AGAINST SELECTED VARIABLE MEASUREMENTS

Research Code Variable Number	Variable	Rank Correlation	Significance[1] (one-tail)
2	Accounting Rate of Return	0.2753	0.0823
3	Aggregate Net Sales	0.9872	<0.0001
5	Rate of Growth of Net Sales	-0.0165	0.4675
6	Rate of Growth of Net Profits	-0.1993	0.1869
7	Rate of Growth of Net Losses	-0.8000	0.1000
8	Timing of Sales Cycle	0.3686	0.0293
9	Timing of Profit Cycle	0.5383	0.0019
10	Payback Period	-0.3309	0.0459
11	Equivalent Rate of Return	0.2149	0.1409
12	Profitability Ratio	0.2070	0.1502
13	Return on Investment	0.2485	0.1057
19	Cost of Capital	-0.1666	0.2031
20	Market Share Statistics	0.0230	0.4546
21	Aggregate Research & Development Expenditures	0.1711	0.1968
118	Mean Cumulative Investment Requirements	0.9237	<0.0001
126	Extent of Plant Capacity Utilization	-0.0044	0.4914
147	Annualized Discounted Present Value Sum	0.1032	0.3043
149	Performance Index	0.1990	0.1598
153	Annualized Net Profits (Losses) After Taxes	0.8468	<0.0001
154	Critical Turning Point for Present Value Calculations	-0.3050	0.0609

[1] In testing the significance of the Spearman rank coefficient, the one-tail calculation lists the probability of the observed value in the direction shown given no relationship.

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TABLE 8-11

NONPARAMETRIC STATISTICAL TESTS OF ANNUALIZED NET SALES (RESEARCH CODE VARIABLE 152) AGAINST SELECTED GROUP VARIABLES

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
27	Direct Competitive Situation (5)	Kruskal-Wallis H 10.3619	0.0348
76	Percentage of User Laboratory Evaluation (3)	Kruskal-Wallis H 6.8098	0.0332
88	Outlay Trends for Product Promotion (4)	Kruskal-Wallis H 9.8027	0.0203
95	Market Trends (3)	Kruskal-Wallis H 6.5911	0.0370
97	Type of Product Demand (4)	Bhapkar V 14.1611	0.0027
101	Number of Purchasers (5)	Bhapkar V 11.3047	0.0233
103	Cyclical Patterns (2)	Kruskal-Wallis H 4.9304	0.0264
116	Export Patterns (3)	Bhapkar V 13.4473	0.0012
120	Trends in Gross Margins (3)	Kruskal-Wallis H 9.7058	0.0078

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2. Length of Sales Pattern

The sampling of the minimum number of years new industrial chemical products were sold in the marketplace displayed a nearly normal distribution. Three products were withdrawn from the marketplace, and these product life cycles were considered complete. For the other products under study, the life cycle reflected only the minimum length of the sales structure.

Whether or not product behavior across selected characteristics differs with the length of product cycles is of vital interest to product management.

TABLE 8-12

TIMING OF IDENTIFIED PRODUCT SALES CYCLES

Minimum Number of Years Sold in the Marketplace	Frequency	Percentage
Three	1	3.70
Six	3	11.11
Seven	6	22.22
Eight	6	22.22
Nine	4	14.81
Ten	5	18.52
Eleven	2	7.41
	27	100.0
Median	8.0000	
Mean	8.1111	
Standard Deviation	1.8046	

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Quite predictably, as the length of the sales cycle increased, both aggregate and annualized sales tended to increase, as did the length of profit cycles and investment requirements as well (see Table 8-13).

This research confirmed that industrial users attach more importance to quality standards as the sales cycle lengthens. However, it is likely a new product's technical performance must at least match existing products it intends to replace in the marketplace. Other notable variables were related to the length of the sales cycle: the number of purchasers and export patterns. As products become more entrenched in the marketplace, the number of purchasing accounts tended to increase. And there was a greater dependence on the export market to take up possible slack in production capacity later in a product life history (see Table 8-14).

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TABLE 8-13

SPEARMAN RANK CORRELATION TESTS OF TIMING OF SALES CYCLE (RESEARCH CODE VARIABLE 8) AGAINST SELECTED VARIABLE MEASUREMENTS

Research Code Variable Number	Variable	Rank Correlation	Significance (one-tail)
2	Accounting Rate of Return	-0.0394	0.4226
5	Rate of Growth of Net Sales	0.1297	0.2596
6	Rate of Growth of Net Profits	-0.1393	0.2683
7	Rate of Growth of Net Losses	0.1054	0.4473
9	Timing of Profit Cycle	0.4465	0.0098
10	Payback Period	0.0906	0.3266
11	Equivalent Rate of Return	-0.0465	0.4088
12	Profitability Ratio	-0.0400	0.4214
13	Return on Investment	-0.0149	0.4706
19	Cost of Capital	0.3368	0.0429
20	Market Share Statistics	-0.0552	0.3923
21	Aggregate Research & Development Expenditures	0.1073	0.2972
118	Mean Cumulative Investment Requirements	0.3521	0.0358
126	Extent of Plant Capacity Utilization	0.2150	0.1407
147	Annualized Discounted Present Value Sum	-0.0475	0.4071
149	Performance Index	-0.0726	0.3595
152	Annualized Net Sales	0.3686	0.0293
153	Annualized Net Profits (Losses) After Taxes	0.2253	0.1293
154	Critical Turning Point for Present Value Calculations	-0.0673	0.3693

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TABLE 8-14

NONPARAMETRIC STATISTICAL TESTS OF TIMING OF SALES CYCLE (RESEARCH CODE VARIABLE 8) AGAINST SELECTED GROUP VARIABLES

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
86	Effect of Product Quality on Source Selection (3)	Kruskal-Wallis H 6.4564	0.0396
101	Number of Purchasers (5)	Kruskal-Wallis H 12.6918	0.0129
116	Export Patterns (3)	Kruskal-Wallis H 9.8179	0.0074

3. Profit Structure

A surprising percentage of new products actually generated no earnings over those portions of their life cycles under study. Of the products reviewed, 18.5% had aggregate losses totaling over $1.8 million, the result of product situations with obviously uncertain outcomes. Most of these products were thoroughly screened on numerous occasions in an attempt to weed out proposals not meeting minimum standards of performance; but such precautions could not counteract serious miscalculations in market behavior. Judging from the evidence, then, an across-the-board 9% risk factor over certain profit outcomes should be incorporated in all product evaluation work covering new industrial chemical products just to recover expected losses that will ultimately arise (assuming that this loss parameter has not shifted since the data were taken).

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TABLE 8-15

PROFIT STRUCTURE ON ANNUALIZED NET PROFITS (LOSSES) AFTER TAXES[1]

Class Interval	Frequency	Percentage
Between $-198,150 and $23,466	9	33.33
Between $23,466 and $99,387	9	33.33
Between $99,387 and $1,159,600	9	33.33
	27	100.0
Median	$ 43,600.0	
Mean	$148,343.2	
Standard Deviation	$290,229.6	

[1]Found by dividing the number of time periods covered in the analysis into the aggregate net profits (losses) after taxes results.

TABLE 8-16

TIMING OF PROFIT CYCLE

Minimum Number of Years Showing Actual Profit Results	Frequency	Percentage
Zero	2	7.41
One	1	3.70
Three	1	3.70
Four	2	7.41
Six	7	25.93
Seven	8	29.63
Eight	2	7.41
Nine	2	7.41
Ten	2	7.41
	27	100.0
Median	7.0	
Mean	6.1	
Standard Deviation	2.6	

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Annualized net sales correlated highly with net profit results, having a calculated Spearman rank correlation value of 0.8468 (see Table 8-17). Firms tended to select as key targets for market development those industrial chemical products that were above average in profitability in terms of their absolute dollar contributions. Whenever a product had a persistent loss position early in its life history, management usually sought to improve the problem in order to reverse the situation quickly or withdrew that product from the marketplace.

As one would expect, return on investment calculations correlated with profit figures. Since they were not time-discounted, the patterns of change in profit figures were more closely linked with return on investment data than those indicators discounting cash flows through time, e.g., the present value sum and the performance index.

Even though investment patterns were associated with achieved profit structures, the decision to invest or divest was more than likely based on sales, not profit expectations. Evidence indicated that decision makers may have overemphasized the sales contributions of new products in their development activities, at least in the stages prior to maturity.

Other determinants of product behavior statistically related to the various levels of profitability included the degree of challenge facing the scientific community in supporting commercial development, the thrust of promotional outlays, effect of industrial advertising on manufacturer selection, and the type of fixed capital equipment employed in the production process. The nonparametric test results are summarized in Table 8-18.

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TABLE 8-17

SPEARMAN RANK CORRELATION TESTS OF ANNUALIZED PROFITS (LOSSES) AFTER TAXES (RESEARCH CODE VARIABLE 153) AGAINST SELECTED VARIABLES

Research Code Variable Number	Variable	Rank Correlation	Significance (one-tail)
2	Accounting Rate of Return	0.6435	0.0001
4	Aggregate Net Profits (Losses) After Taxes	0.9878	<0.0001
5	Rate of Growth of Net Sales	-0.0446	0.4127
6	Rate of Growth of Net Profits	-0.0570	0.4005
7	Rate of Growth of Net Losses	0.2000	0.4000
8	Timing of Sales Cycle	0.2253	0.1293
9	Timing of Profit Cycle	0.7356	<0.0001
10	Payback Period	-0.6740	0.0001
11	Equivalent Rate of Return	0.6026	0.0004
12	Profitability Ratio	0.5800	0.0008
13	Return on Investment	0.6062	0.0004
19	Cost of Capital	-0.4573	0.0082
20	Market Share Statistics	0.1745	0.1920
21	Aggregate Research & Development Expenditures	0.0177	0.4651
54	Median Yearly Incremental Investments	0.2772	0.0808
118	Mean Cumulative Investment Requirements	0.6667	0.0001
126	Extent of Plant Capacity Utilization	-0.1735	0.1934
147	Annualized Discounted Present Value Sum	0.4921	0.0046
149	Performance Index	0.5702	0.0010
152	Annualized Net Sales	0.8468	<0.0001
154	Critical Turning Point for Present Value Calculations	-0.6085	0.0004

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Research Code Variable Number
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TABLE 8-18

NONPARAMETRIC STATISTICAL TESTS OF ANNUALIZED NET PROFITS (LOSSES) AFTER TAXES (RESEARCH CODE VARIABLE 153) AGAINST SELECTED GROUP VARIABLES

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
73	Research and Development Harnessing Experiences (5)	Kiefer T 4.2519	0.0344
88	Outlay Trends for Product Promotion (4)	Kruskal-Wallis H 10.4853	0.0149
90	Effect of Industrial Advertising on Manufacturer Selection (3)	Kruskal-Wallis H 10.4179	0.0055
124	Type of Fixed Capital Employed (3)	Kruskal-Wallis H 9.7431	0.0077

Research Code Variable Number
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18[illegible]
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TABLE 8-19

SPEARMAN RANK CORRELATION TESTS OF TIMING OF PROFIT CYCLE (RESEARCH CODE VARIABLE 9) AGAINST SELECTED VARIABLES

Research Code Variable Number	Variable	Rank Correlation	Significance (one-tail)
2	Accounting Rate of Return	0.7028	< 0.0001
5	Rate of Growth of Net Sales	0.0197	0.4612
6	Rate of Growth of Net Profits	0.2456	0.1353
7	Rate of Growth of Net Losses	-0.3162	0.3419
8	Timing of Sales Cycle	0.4465	0.0098
10	Payback Period	-0.7019	< 0.0001
11	Equivalent Rate of Return	0.7344	< 0.0001
12	Profitability Ratio	0.7238	< 0.0001
13	Return on Investment	0.6623	0.0001
19	Cost of Capital	-0.3109	0.0572
20	Market Share Statistics	0.1674	0.2020
21	Aggregate Research & Development Expenditures	-0.1267	0.2644
118	Mean Cumulative Investment Requirements	0.3241	0.0495
126	Extent of Plant Capacity Utilization	-0.3791	0.0256
147	Annualized Discounted Present Value Sum	0.5730	0.0009
149	Performance Index	0.7128	< 0.0001
152	Annualized Net Sales	0.5383	0.0019
153	Annualized Net Profits (Losses) After Taxes	0.7356	< 0.0001
154	Critical Turning Point for Present Value Calculations	-0.7034	< 0.0001

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4. Growth Characteristics

Just over three-fourths of all the products reviewed had median net sales growths greater than that of the national economy. And the same number of products exceeded the average annual growth rates of the chemical and allied products industry as well, one of the fastest growing sectors in the economy. Dynamic development in new products, then, offers the firms that can react sensibly to changes in demand and supply the rewards of new business.

TABLE 8-20

MEDIAN GROWTH RATE OF NET SALES

Class Interval	Frequency	Percentage
Between -53.6% and 15.1%	9	33.33
Between 15.1% and 24.8%	9	33.33
Between 24.8% and 56.4%	9	33.33
	27	100.0
Median	19.1	
Mean	17.4	
Standard Deviation	21.2	

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TABLE 8-21

MEDIAN GROWTH RATE OF NET PROFITS

Class Interval	Frequency[1]	Percentage
Between -100.0% and -1.0%	7	31.80
Between -1.0% and 31.8%	8	36.40
Between 31.8% and 56.7%	7	31.80
	22	100.0
Median	14.6	
Mean	9.5	
Standard Deviation	35.5	

[1]An indefinable situation existed between profit and loss data in one product history such that no meaningful disclosure of its growth rate was possible.

TABLE 8-22

MEDIAN GROWTH RATE OF NET LOSSES[1]

Number	Frequency[2]	Percentage
22.0	1	25.00
-11.1	1	25.00
-41.7	1	25.00
-76.3	1	25.00
	4	100.0
Median	-26.4	
Mean	-27.0	
Standard Deviation	42.0	

[1]Negative rates of growth of losses should be interpreted as reductions in loss positions through time.

[2]An indefinable situation existed between profit and loss data in one product history such that no meaningful disclosure of its growth rate was possible.

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Few of the rank correlation tests of growth characteristics against those variables examined which were continuously scored revealed statistically significant results. Table 8-23 lists the variables involved and their test outcomes. A rank correlation value of 0.6217 between sales growth and profit growth strongly suggests that they are interrelated. As market development of a new chemical product resulted in above average revenue gains, opportunities for notable profit expansions became enhanced.

New chemical products with fairly specific applications had no better performance records on either attained sales or profit levels. But the rate of profit growth did relate (see Table 8-24). A concerted effort at product promotion in specific application areas can be more efficient than shotgun selling. The critical issue is identifying and communicating with the key buying influences of large consuming firms. Since many industrial sectors are concentrated regionally, the location of manufacturing facilities in close proximity to user locations can realize important distribution cost savings.

Rapid sales growth stimulated increased research and development work in related areas which was partially defensive in character. For once a position of marked penetration appeared in any product area, the firm was willing to support additional research in related areas in order to maintain this position, exploiting as well new discoveries that would add greater depth to its product line.

Marketing-based product programs tended to have higher profit growths on the average, as referenced in Table 8-24. The absorbed costs of typical marketing- and research-oriented products differed little; investment patterns were also invariant. Once the need for a product had been clarified, the rate of product acceptance—after specifications had been met—was easily judged. Often company officials could tailor production facilities to certain minimum usage levels for greater operating efficiencies, at least during the earlier stages of the product life cycle. Other factors influencing the growth of profits included trade relations and the levels of product loyalty. Each variable will be discussed separately under its respective listing.

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Research Code Variable Number
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TABLE 8-23

SPEARMAN RANK CORRELATION TESTS OF GROWTH CHARACTERISTICS AGAINST SELECTED VARIABLES

Research Code Variable Number	Variable	Rank Correlation (Significance: one-tail) Rates of Growth Code Variables 5 Sales	6 Profits	7 Losses
2	Accounting Rate of Return	-0.0189 (0.4627)	0.1779 (0.2142)	-0.2000 (0.4000)
5	Rate of Growth of Net Sales	XXXX	0.6217 (0.0010)	0.6000 (0.2000)
6	Rate of Growth of Net Profits	0.6217 (0.0010)	XXXX	1.0000 (<.0001)
7	Rate of Growth of Net Losses	0.6000 (0.2000)	1.0000 (<.0001)	XXXX
8	Timing of Sales Cycle	0.1297 (0.2596)	-0.1393 (0.2683)	0.1054 (0.4473)
9	Timing of Profit Cycle	0.0197 (0.4612)	0.2456 (0.1353)	-0.3162 (0.3419)
10	Payback Period	0.2271 (0.1273)	0.0006 (0.4990)	1.0000 (<.0001)
11	Equivalent Rate of Return	-0.0263 (0.4483)	0.1846 (0.2054)	-0.8000 (0.1000)
12	Profitability Ratio	0.0324 (0.4364)	0.2626 (0.1189)	-1.0000 (<.0001)
13	Return on Investment	0.0263 (0.4483)	0.1824 (0.2083)	-0.2000 (0.4000)
19	Cost of Capital	-0.0061 (0.4879)	-0.0959 (0.3356)	-0.4000 (0.3000)
20	Market Share Statistics	0.0016 (0.4969)	0.2140 (0.1694)	-0.3162 (0.3419)
21	Aggregate Research & Development Expenditures	-0.0113 (0.4777)	-0.2194 (0.1633)	-0.2000 (0.4000)
118	Mean Cumulative Investment Requirements	0.0140 (0.4723)	-0.1903 (0.1982)	-0.4000 (0.3000)

(Continued)

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Research Code Variable Number
126
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154

TABLE 8-23

SPEARMAN RANK CORRELATION TESTS OF GROWTH CHARACTERISTICS AGAINST SELECTED VARIABLES

(Continued)

Research Code Variable Number	Variable	Rank Correlation (Significance: one-tail) Rates of Growth Code Variables 5 Sales	6 Profits	7 Losses
126	Extent of Plant Capacity Utilization	-0.0031 (0.4939)	-0.1615 (0.2364)	-0.2108 (0.3946)
147	Annualized Discounted Present Value Sum	0.0757 (0.3537)	0.2253 (0.1567)	0.2000 (0.4000)
149	Performance Index	0.0293 (0.4423)	0.3032 (0.0851)	-1.0000 (<.0001)
152	Annualized Net Sales	-0.0165 (0.4675)	-0.1993 (0.1869)	-0.8000 (0.1000)
153	Annualized Net Profits (Losses) After Taxes	-0.0446 (0.4127)	-0.0570 (0.4005)	0.2000 (0.4000)
154	Critical Turning Point for Present Value Calculations	-0.1444 (0.2362)	-0.2614 (0.1200)	-0.0000 (0.5000)

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Research Code Variable Number
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TABLE 8-24

NONPARAMETRIC STATISTICAL TESTS OF GROWTH CHARACTERISTICS AGAINST SELECTED GROUP VARIABLES

Research Code Variable Number	Variable (Number of k-Classes)	Rates of Growth Code Variables 5 Sales	6 Profits	7 Losses
	Test Statistic: Kruskal-Wallis H (Significance)			
51	Strategy Concerning Research and Development in Related Areas (2)	4.5039 (0.0338)	2.4920 (0.1144)	1.8000 (0.5000)
	Test Statistic: Bhapkar V (Significance)			
32	Specificity of Use (2)	1.5432 (0.2141)	4.6545 (0.0310)	0.7500 (0.3865)
104	Trade Relations (4)	0.7458 (0.8624)	11.1708 (0.0108)	3.7500 (0.1534)
107	Level of Product Loyalty (3)	1.7000 (0.4274)	8.2921 (0.0158)	3.7500 (0.1534)
111	Product Concept Acceptance (2)	0.0098 (0.9213)	3.0727 (0.0796)	0.7500 (0.3865)
123	Basing of Research and Development Program (2)	0.2924 (0.5887)	6.5682 (0.0104)	0.7500 (0.3865)

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5. Liquidity

The payback period is one financial statistic finding widespread use among product evaluators within the chemical industry. They have found that an analysis of projects using their calculated payback periods a worthwhile supplement to other evaluation approaches.

TABLE 8-25

PAYBACK PERIOD

Class Interval	Frequency	Percentage
Between 3.1 years and 7.5 years	8	33.33
Between 7.5 years and 11.7 years	8	33.33
Between 11.7 years and 35.9 years	8	33.33
	24	100.0
Median	8.9 years	
Mean	11.6 years	
Standard Deviation	8.2 years	

The rank correlation coefficient between the present value sum and the payback period, a negative 0.7295, possibly sheds light on the popularity of the payback period, a simple concept to compute and understand. The highest payback period still contributing to earnings growth on a net basis (i.e., having a positive present value sum) was 13.5 years. On the other hand, some products with payback periods as low as 7.1 years made no net contributions to corporate earnings. This evaluative technique has its limitations, moreover, in both the ranking process and selection of cut-off rates. If only those products with payback periods of less than 8.8 years were chosen for commercialization, eight out of eleven products would have been economically profitable ventures with positive net discounted cash flows, evidence of the necessity to continually refine financial analysis when evaluating a new product proposal.

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A higher correlation existed between the equivalent rate of return and the payback period, both measures of return on investment (see Table 8-26). The payback period formula relates investment to nondiscounted operating cash flows, while the equivalent rate of return directly expresses the return of discounted net cash flows on discounted investments. Generally, any proposal having a positive calculated equivalent rate of return once all appropriate risks have been evaluated will make an earnings contribution and the same is true with the present value sum. The selection of priorities based on the rankings of equivalent rates of return may not necessarily make the greatest contribution to net wealth, although it will insure the highest relative profit attainment in terms of asset utilization.

Products having strong product loyalty tended to have shorter payback periods as documented in Table 8-27, this factor being thought to vary with the price of the product, the prices of substitutes, product performance, service support, and the reputation of the manufacturer. Any manufacturer would have a clear competitive advantage if all these factors were combined to meet user approval in the most satisfying manner.

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TABLE 8-26

SPEARMAN RANK CORRELATION TESTS OF PAYBACK PERIOD (RESEARCH CODE VARIABLE 10) AGAINST SELECTED VARIABLE MEASUREMENTS

Research Code Variable Number	Variable	Rank Correlation	Significance (one-tail)
2	Accounting Rate of Return	-0.9408	<0.0001
5	Rate of Growth of Net Sales	0.2271	0.1273
6	Rate of Growth of Net Profits	0.0006	0.4990
7	Rate of Growth of Net Losses	1.0000	<0.0001
8	Timing of Sales Cycle	0.0906	0.3266
9	Timing of Profit Cycle	-0.7019	<0.0001
11	Equivalent Rate of Return	-0.9249	<0.0001
12	Profitability Ratio	-0.8919	<0.0001
13	Return on Investment	-0.8968	<0.0001
19	Cost of Capital	0.4364	0.0114
20	Market Share Statistics	-0.1400	0.2431
21	Aggregate Research & Development Expenditures	0.1369	0.2480
118	Mean Cumulative Investment Requirements	-0.0726	0.3594
126	Extent of Plant Capacity Utilization	0.3314	0.0456
147	Annualized Discounted Present Value Sum	-0.7295	<0.0001
149	Performance Index	-0.8901	<0.0001
152	Annualized Net Sales	-0.3309	0.0459
153	Annualized Net Profits (Losses) After Taxes	-0.6740	0.0001
154	Critical Turning Point for Present Value Calculations	0.7584	<0.0001

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Research Code Variable Number
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TABLE 8-27

NONPARAMETRIC STATISTICAL TESTS OF PAYBACK PERIOD (RESEARCH CODE VARIABLE 10) AGAINST SELECTED GROUP VARIABLES

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
21	Aggregate Research and Development Expenditures (5)	Kruskal-Wallis H 9.8386	0.0432
107	Level of Product Loyalty (3)	Bhapkar V 8.4376	0.0147

6. Return Structure

The next three tables document product experiences on return measures for the new industrial chemicals under study.

TABLE 8-28

ACCOUNTING RATE OF RETURN

Class Interval	Frequency	Percentage
Between -49.9% and 5.1%	9	33.33
Between 5.1% and 11.9%	9	33.33
Between 11.9% and 62.5%	9	33.33
	27	100.0
Median	7.5%	
Mean	9.4%	
Standard Deviation	22.6%	

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TABLE 8-29

EQUIVALENT RATE OF RETURN

Class Interval	Frequency	Percentage
Between -228.2% and -30.7%	9	33.33
Between -30.7% and 35.8%	9	33.33
Between 35.8% and 373.0%	9	33.33
	27	100.0
Median	-9.5%	
Mean	8.3%	
Standard Deviation	125.5%	

TABLE 8-30

MEDIAN RETURN ON INVESTMENT

Class Interval	Frequency	Percentage
Between -25.6% and 2.5%	9	33.33
Between 2.5% and 9.4%	9	33.33
Between 9.4% and 41.6%	9	33.33
	27	100.0
Median	5.0%	
Mean	7.1%	
Standard Deviation	14.2%	

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The distinctively different financial concepts measuring return achieved quite similar rankings of the products (see Table 8-31). The accounting rate of return more closely paralleled the return on investment calculation, having a rank correlation coefficient equaling .9799. Both techniques equalize returns for all time periods, giving the same weight to each period included in the analysis. But the selection of cut-off points continues to plague decision makers. One product having an accounting rate of return value of 6.60% actually made a contribution to net wealth, while another having an 11.94% return had a present value sum of $-932,828—a sizable loss in that product situation. Such inconsistency makes it difficult to get the true picture.

Since the ranking positions for equivalent rate of return calculations closely resembled those of the conventional return techniques, it would be informative and useful to use this formula for setting cut-off points and selection standards. All positive values will add to earnings growth, and as long as investment capabilities are limited, this approach will insure most efficient asset utilization. But it will not necessarily insure optimal financial efficiency in the aggregate sense. Product selection would be more profitable were the products ranked on the basis of annualized discounted present values because then overall maximum wealth would be more likely achieved.

Capacity utilization, market penetration, barriers to entry and the degree of influence that industrial advertising exerts on manufacturer selection all tended to relate to return performance records (see Table 8-32). Each variable will be discussed separately under its respective listing.

Research Code Variable Number
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[illegible]

TABLE 8-31

SPEARMAN RANK CORRELATION TESTS OF INVESTMENT RETURN MEASURES AGAINST SELECTED VARIABLES

Research Code Variable Number	Variable	Rank Correlation (Significance: one-tail) 2 Accounting Rate of Return	11 Equivalent Rate of Return	13 Return on Investment
2	Accounting Rate of Return	XXXX	0.9487 (<.0001)	0.9799 (<.0001)
5	Rate of Growth of Net Sales	-0.0189 (0.4627)	-0.0263 (0.4483)	0.0263 (0.4483)
6	Rate of Growth of Net Profits	0.1779 (0.2142)	0.1846 (0.2054)	0.1824 (0.2083)
7	Rate of Growth of Net Losses	-0.2000 (0.4000)	-0.8000 (0.1000)	-0.2000 (0.4000)
8	Timing of Sales Cycle	-0.0394 (0.4226)	-0.0465 (0.4088)	-0.0149 (0.4706)
9	Timing of Profit Cycle	0.7028 (<.0001)	0.7344 (<.0001)	0.6623 (0.0001)
10	Payback Period	-0.9408 (<.0001)	-0.9249 (<.0001)	-0.8968 (<.0001)
11	Equivalent Rate of Return	0.9487 (<.0001)	XXXX	0.9426 (<.0001)
12	Profitability Ratio	0.9408 (<.0001)	0.9921 (<.0001)	0.9512 (<.0001)
13	Return on Investment	0.9799 (<.0001)	0.9426 (<.0001)	XXXX
19	Cost of Capital	-0.3715 (0.0282)	-0.5041 (0.0037)	-0.3152 (0.0547)
20	Market Share Statistics	0.0650 (0.3736)	0.1574 (0.2165)	0.0694 (0.3655)
21	Aggregate Research and Development Expenditures	-0.1805 (0.1838)	-0.2814 (0.0776)	-0.2248 (0.1298)
118	Mean Cumulative Investment Requirements	-0.0171 (0.4663)	-0.0598 (0.3834)	-0.0611 (0.3811)
126	Extent of Plant Capacity Utilization	-0.2294 (0.1248)	-0.3572 (0.0337)	-0.1716 (0.1960)

(Continued)

Research Code Variable Number
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152
153
154

TABLE 8-31

SPEARMAN RANK CORRELATION TESTS OF INVESTMENT RETURN MEASURES AGAINST SELECTED VARIABLES

(Continued)

Research Code Variable Number	Variable	Rank Correlation (Significance: one-tail) 2 Accounting Rate of Return	11 Equivalent Rate of Return	13 Return on Investment
147	Annualized Discounted Present Value Sum	0.7698 (<.0001)	0.8504 (<.0001)	0.7582 (<.0001)
149	Performance Index	0.9444 (<.0001)	0.9872 (<.0001)	0.9505 (<.0001)
152	Annualized Net Sales	0.2753 (0.0823)	0.2149 (0.1409)	0.2485 (0.1057)
153	Annualized Net Profits (Losses) After Taxes	0.6435 (0.0001)	0.6026 (0.0004)	0.6062 (0.0004)
154	Critical Turning Point for Present Value Calculations	-0.8246 (<.0001)	-0.8625 (<.0001)	-0.8206 (<.0001)

Research Code Variable Number
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78
90

TABLE 8-32

NONPARAMETRIC STATISTICAL TESTS OF INVESTMENT RETURN MEASURES AGAINST SELECTED GROUP VARIABLES

Research Code Variable Number	Variable (Number of k-Classes)	Code Variables 2 Accounting Rate of Return	11 Equivalent Rate of Return	13 Return on Investment
	Test Statistic: Kruskal-Wallis H (Significance)			
20	Market Share Statistics (3)	5.0060 (0.0818)	5.2321 (0.0731)	6.2535 (0.0439)
126	Extent of Plant Capacity Utilization (5)	9.6931 (0.0459)	13.3095 (0.0099)	9.2884 (0.0543)
	Test Statistic: Bhapkar V (Significance)			
78	Duplication Difficulties by Competitors (5)	16.6667 (0.0022)	13.6852 (0.0084)	16.6667 (0.0022)
90	Effect of Industrial Advertising on Manufacturer Selection (3)	4.8430 (0.0888)	7.8688 (0.0196)	3.6877 (0.1582)

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7. Present Value Structure

Had one elected to use the annualized present value sum as a yardstick for measuring success, and limited the decision to actual results recorded for the first ten years of product histories, the successful new industrial chemical products would have numbered just under 41% of the total.[1] This figure contradicts completely the subjective ratings made by industrial respondents evaluating product performances: in all but four product situations, they considered the product involvement to be successful. We can only doubt they would have registered such fulsome praise had a more systematized, comprehensive approach to product evaluation been available at the time these judgments were made, unless factors other than economic were involved.

TABLE 8-33

DISCOUNTED PRESENT VALUE SUM[1]

Class Interval	Frequency	Percentage
Between \$-5,293,157 and \$-200,145	9	33.33
Between \$-200,145 and \$43,988	9	33.33
Between \$43,988 and \$5,886,044	9	33.33
	27	100.0
Median	\$ 13,771.0	
Mean	\$ 20,491.6	
Standard Deviation	\$1,748,466.2	

[1]Defined as the aggregate sum of net present values for all time periods in the analysis; provisions for the release of working capital and nondepreciated fixed assets at the end of the last period in the analysis have been incorporated in the calculations.

[1]Any positive present value sum figure at the end of the analysis would be viewed as successful; all nondepreciated fixed assets as well as working capital at the end of the last year in each product analysis were credited to the cash flow stream assuming full salvage capability.

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TABLE 8-34

ANNUALIZED DISCOUNTED PRESENT VALUE SUM[1]

Class Interval	Frequency	Percentage
Between $-529,315.7 and $-25,018.1	9	33.33
Between $-25,018.1 and $6,284.0	9	33.33
Between $6,284.0 and $735,755.5	9	33.33
	27	100.0
Median	$ -1,602.9	
Mean	$ 8,679.8	
Standard Deviation	$206,991.6	

[1]Found by dividing the number of time periods covered in the analysis into the aggregate present value sum.

TABLE 8-35

CRITICAL TURNING POINT FOR PRESENT VALUE CALCULATION[1]

Class Interval	Frequency[2]	Percentage
Between 2.2 years and 9.4 years	8	33.33
Between 9.4 years and 16.2 years	8	33.33
Between 16.2 years and 24.5 years	8	33.33
	24	100.0
Median	11.6 years	
Mean	12.4 years	
Standard Deviation	6.0 years	

[1]The critical turning point is that time measured in years that it takes for the present value sum to turn from a negative to a positive value, i.e., $\frac{d(PV\ sum)}{d(t)}$ changes from a negative to a positive sign.

[2]Three observations were not included in this listing because these products were withdrawn before their present value sum figures changed signs.

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In examining discounting techniques through a number of simulation runs, incidentally, it emerged that any cost of capital figure selected within a reasonable range of several percentage points generated approximately identical success rates, i.e., the cost of capital selected would not have altered go/no-go decisions based on discounted cash flow techniques and contemporary experience.

In testing the normality of the critical turning point sampling distribution, the calculated values on the Kolmogorov-Smirnov D statistic of .07 and .09 strongly suggested that the distribution was not skewed in either direction. According to the evidence collected, the critical turning point for new industrial chemical products was normally distributed over an estimated mean of 12.4 years with a standard deviation of 6.0 years.

Ignoring other financial formulas which measure discounted cash flows, measures of return showed a relatively high association with present value sum calculations. We might still improve the screening process significantly by using selected discounting techniques if we aim at an optimization of asset usage in terms of a time sequence. But we should remember, nevertheless, that the return on investment and equivalent rate of return measures produced similar rankings with a rank correlation coefficient of .9426 (see Tables 8-31 and 8-36). So it is easy to understand why the return on investment measure has such popularity among analysts. Any average return on investment calculation does not in itself tell the decision maker whether a proposal is acceptable from an investment standpoint. The evaluator's preconceived notion of a tolerable cut-off level—which may be related to the financial expectations of the investing public or not—usually assumes high enough levels to protect against dilution, unless of course the projections of net cash flows turn out to be quite overstated. The real problem faces industry today, of setting cut-off rates too high in relation to existing costs of capital, and thus rejecting many profitable new product ventures having acceptable risk levels. This may result in a

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stymied growth pattern for the firm and a cyclical performance pattern for its capital stock. Rank correlations between cost of capital and present value sum figures tended to support these observations (see Table 8-36).

A number of correlates of performance emerged from the routine statistical procedures: promotional outlay trends, plant utilization rates, and product loyalty experiences, among others. Nonparametric test results of present value structures against selected group variables are presented in Table 8-37.

No evidence supported the hypothesis that market share statistics directly influence present value sum data; the level of market penetration did not apparently affect cash flow patterns in any decisive way. In other words, it was possible to develop profitable marketing opportunities in the chemical field regardless of the expected market participation level of the firm.

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Research Code Variable Number
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TABLE 8-36

SPEARMAN RANK CORRELATION TESTS OF PRESENT VALUE STRUCTURE AGAINST SELECTED VARIABLES

Research Code Variable Number	Variable	Rank Correlation (Significance: one-tail) 1 Discounted Present Value Sum	147 Annualized Discounted Present Value Sum	154 Critical Turning Point for Present Value Calculations
1	Discounted Present Value Sum	XXXX	0.9908 (<.0001)	-0.7361 (<.0001)
2	Accounting Rate of Return	0.7619 (<.0001)	0.7698 (<.0001)	-0.8246 (<.0001)
5	Rate of Growth of Net Sales	0.0397 (0.4221)	0.0757 (0.3537)	-0.1444 (0.2362)
6	Rate of Growth of Net Profits	0.1971 (0.1897)	0.2253 (0.1567)	-0.2614 (0.1200)
7	Rate of Growth of Net Losses	0.4000 (0.3000)	0.2000 (0.4000)	-0.0000 (0.5000)
8	Timing of Sales Cycle	-0.1036 (0.3035)	-0.0475 (0.4071)	-0.0673 (0.3693)
9	Timing of Profit Cycle	0.5377 (0.0019)	0.5730 (0.0009)	-0.7034 (<.0001)
10	Payback Period	-0.7265 (<.0001)	-0.7295 (<.0001)	0.7584 (<.0001)
11	Equivalent Rate of Return	0.8394 (<.0001)	0.8504 (<.0001)	-0.8625 (<.0001)
12	Profitability Ratio	0.8309 (<.0001)	0.8431 (<.0001)	-0.8698 (<.0001)
13	Return on Investment	0.7485 (<.0001)	0.7582 (<.0001)	-0.8206 (<.0001)
19	Cost of Capital	-0.6992 (<.0001)	-0.6744 (0.0001)	0.4411 (0.0106)
20	Market Share Statistics	0.1353 (0.2505)	0.1104 (0.2917)	-0.1966 (0.1628)

(Continued)

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Research Code Variable Number
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149
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TABLE 8-36

SPEARMAN RANK CORRELATION TESTS OF PRESENT VALUE STRUCTURE AGAINST SELECTED VARIABLES

(Continued)

Research Code Variable Number	Variable	Rank Correlation (Significance: one-tail) 1 Discounted Present Value Sum	147 Annualized Discounted Present Value Sum	154 Critical Turning Point for Present Value Calculations
21	Aggregate Research & Development Expenditures	-0.3409 (0.0409)	-0.3699 (0.0288)	0.2799 (0.0787)
118	Mean Cumulative Investment Requirements	-0.1563 (0.2181)	-0.1404 (0.2424)	-0.0727 (0.3594)
126	Extent of Plant Capacity Utilization	-0.4014 (0.0190)	-0.3818 (0.0247)	0.1664 (0.2035)
147	Annualized Discounted Present Value Sum	0.9908 (<.0001)	XXXX	-0.7675 (<.0001)
149	Performance Index	0.8278 (<.0001)	0.8400 (<.0001)	-0.8771 (<.0001)
152	Annualized Net Sales	0.0830 (0.3403)	0.1032 (0.3043)	-0.3050 (0.0609)
153	Annualized Net Profits (Losses) After Taxes	0.4780 (0.0058)	0.4921 (0.0046)	-0.6085 (0.0004)
154	Critical Turning Point for Present Value Calculations	-0.7361 (<.0001)	-0.7675 (<.0001)	XXXX

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TABLE 8-37

NONPARAMETRIC STATISTICAL TESTS OF PRESENT VALUE STRUCTURE AGAINST SELECTED GROUP VARIABLES

Research Code Variable Number	Variable (Number of k-Classes)	1 Discounted Present Value Sum	147 Annualized Discounted Present Value Sum	154 Critical Turning Point for Present Value Calculations
	Test Statistic: Kruskal-Wallis H (Significance)			
88	Outlay Trends for Product Promotion (4)	15.2993 (0.0016)	14.5469 (0.0023)	9.7115 (0.0212)
107	Level of Product Loyalty (3)	6.7094 (0.0349)	7.2729 (0.0263)	11.3898 (0.0034)
	Test Statistic: Bhapkar V (Significance)			
126	Extent of Plant Capacity Utilization (5)	10.4261 (0.0338)	9.2837 (0.0544)	17.5961 (0.0015)

8. <u>Relative Contribution to Wealth</u>

Two performance measures, the profitability ratio and equivalent rate of return, were nearly interchangeable in practice in the rankings they produced. They recognize the time value of money, and both relate cash flows to investment levels. The experiences of the new industrial chemical products studied on an index measuring relative contribution to wealth are presented in Table 8-38.

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TABLE 8-38

PROFITABILITY RATIO[1]

Class Interval	Frequency	Percentage
Between -2.5256 and -0.1404	9	33.33
Between -0.1404 and 0.5428	9	33.33
Between 0.5428 and 5.6130	9	33.33
	27	100.0
Median	0.1133	
Mean	0.3503	
Standard Deviation	1.6618	

[1]An algebraic definition is given in Chapter III.

Like other discounted financial concepts, the profitability ratio generally showed dissimilar variations with sales outcome, growth, payback period, investment requirements and market share data as revealed in Table 8-39. For example, products with higher sales revenues showed no better relative earnings on the average than other products. But the relative contributions to wealth did relate in some statistical fashion to plant utilization rates, promotional outlay trends, dependency on field representation, level of product loyalty, extent of backward integration, marketing costs, product duplication difficulties, and the impact of industrial advertising on source selection (see Table 8-40). A more detailed analysis of these relationships and others is presented in the next section.

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TABLE 8-39

SPEARMAN RANK CORRELATION TESTS OF RELATIVE CONTRIBUTION TO WEALTH AGAINST SELECTED VARIABLES

Research Code Variable Number	Variable	Rank Correlation (Significance: one-tail) 12 Profitability Ratio
2	Accounting Rate of Return	0.9408 (<.0001)
5	Rate of Growth of Net Sales	0.0324 (0.4364)
6	Rate of Growth of Net Profits	0.2626 (0.1189)
7	Rate of Growth of Net Losses	-1.0000 (<.0001)
8	Timing of Sales Cycle	-0.0400 (0.4214)
9	Timing of Profit Cycle	0.7238 (<.0001)
10	Payback Period	-0.8919 (<.0001)
11	Equivalent Rate of Return	0.9921 (<.0001)
13	Return on Investment	0.9512 (<.0001)
19	Cost of Capital	-0.4695 (0.0067)
20	Market Share Statistics	0.1506 (0.2267)
21	Aggregate Research and Development Expenditures	-0.2988 (0.0650)
118	Mean Cumulative Investment Requirements	-0.0763 (0.3526)
126	Extent of Plant Capacity Utilization	-0.3146 (0.0550)
147	Annualized Discounted Present Value Sum	0.8431 (<.0001)

TABLE 8-39

SPEARMAN RANK CORRELATION TESTS OF RELATIVE CONTRIBUTION TO WEALTH AGAINST SELECTED VARIABLES

(Continued)

Research Code Variable Number	Variable	Rank Correlation (Significance: one-tail) 12 Profitability Ratio
149	Performance Index	0.9969 (<.0001)
152	Annualized Net Sales	0.2070 (0.1502)
153	Annualized Net Profits (Losses) After Taxes	0.5800 (0.0008)
154	Critical Turning Point for Present Value Calculations	-0.8698 (<.0001)

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TABLE 8-40

NONPARAMETRIC STATISTICAL TESTS OF RELATIVE CONTRIBUTION TO WEALTH AGAINST SELECTED GROUP VARIABLES

Research Code Variable Number	Variable (Number of k-Classes)	12 Profitability Ratio
	Test Statistic: Kruskal-Wallis H (Significance)	
88	Outlay Trends for Product Promotion (4)	8.3888 (0.0386)
89	Dependence on Contacts By Company Representatives (3)	6.6696 (0.0356)
107	Level of Product Loyalty (3)	7.2068 (0.0272)
126	Extent of Plant Capacity Utilization (5)	12.4173 (0.0145)
	Test Statistic: Bhapkar V (Significance)	
23	Relative Marketing Costs (4)	8.4689 (0.0373)
78	Duplication Difficulties by Competitors (5)	11.6296 (0.0203)
90	Effect of Industrial Advertising on Manufacturer Selection (3)	7.7958 (0.0203)
109	Degree of Backward Integration (2)	4.1728 (0.0411)

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An Analysis of Possible Determinants of Product Performance

We have thus far been able to empirically examine a number of measures of product performance for representative new industrial chemical products. And, of course, product management has the option to base its own specific objectives in new product behavior upon established corporate policies through regularly delegated responsibilities. Nevertheless, any firm can strengthen its future decision making process by developing a rigorous analytical approach to new product evaluation. A thorough understanding of performance standards and how they are established should help us relate actual performance with our preconceived notions of how products behave.

This section examines minutely such possible determinants of product performance as market structure, buyer behavior, product characteristics and related intrafirm experiences, testing each hypothesized relationship statistically, thus rendering the number of possible determinants of product behavior more manageable so that models can be built around those relationships verified in the tests. For brevity, however, we shall give the evidence here only for those relationships which statistical tests found were significant as a general rule.

Specific test statistics and their significance levels are cited in tabular form immediately following the discussion of findings for each variable covered. Complete documentation of the mean ranks for the groups tested which tend to support the conclusions drawn in any discussion is referenced in the appendix.

1. Mark

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1. Market Structure

A. Competitive Situation

(1) Direct Competitive Situation

The average number of significant direct competitors was:

	Number of Responses	Group	Percentage
None	10	1	37.04
One	3	2	11.11
Two	3	3	11.11
Three	5	4	18.52
Four or more	6	5	22.22
	27		100.0

Median	2.0000
Mean	2.2593
Standard Deviation	2.6398

(NOTE: The median number of competing firms offering the identical product (both in form and composition) of all years for any product selected.)

As data on competition were factored into product behavior, it became difficult to generalize with any validity about performance under actual operating conditions. Predictably, demand levels differed significantly among the groups of direct competitors, those products having either fewer or more competitors than average attaining higher sales. Given sufficient market potential, the presence of four or more competitors still permitted sizable revenues, even though market penetrations for this group were typically quite low (less than 25%). In fact this group outperformed all others, including those products holding monopolistic positions.

Curiously enough, no measures of profitability or return differed significantly among the groupings by number of direct competitors, that is, nothing i

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nothing indicated that market dominance assured superior profitability over the long run, despite theories to that effect. Naturally, certain pricing and expense patterns differed with the type of market structure the organization was facing; and it was these intrafirm responses to specific marketing opportunities which essentially determined final sales.

TABLE 8-41

NONPARAMETRIC STATISTICAL TESTS OF DIRECT COMPETITIVE SITUATION (RESEARCH CODE VARIABLE 27) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
8	Timing of Sales Cycle (5)	Kruskal-Wallis H 5.5101	0.2388
152	Annualized Net Sales (5)	Kruskal-Wallis H 10.3619	0.0348

(2) Indirect Competitive Situation

The average number of significant indirect competitors was:

	Number of Responses	Group	Percentage
None	17	1	62.96
One or more	10	2	37.04
	27		100.0
Median	0.0000		
Mean	1.2222		
Standard Deviation	1.9823		

(NOTE: The median number of competing firms offering substitute products in the same application areas of all years for any product selected, even though their form and/or composition differed from the product under study.)

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Products experiencing indirect competition, apparently a healthy phenomenon in typical industrial chemical marketing situations, generated higher annualized net profits on the average, with product recognition and exposure particularly influencing product acceptance by users.

TABLE 8-42

NONPARAMETRIC STATISTICAL TESTS OF INDIRECT COMPETITIVE SITUATION (RESEARCH CODE VARIABLE 28) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
9	Timing of Profit Cycle (2)	Kruskal-Wallis H 4.7715	0.0289
153	Annualized Net Profits (Losses) After Taxes (2)	Bhapkar V 3.9765	0.0461

B. Degree of Patent Protection

(1) Process Patent Experiences

In terms of protecting the products from external competition, the process patents had a:

	Number of Responses	Group	Percentage
Strong beneficial effect	1	1	3.70
Moderate beneficial effect	2	1	7.41
Slight beneficial effect	4	1	14.82
Indifferent or so-so	5	1	18.52
Slight to strong detrimental or limiting effect	0	1	0.00
No process patent	15	2	55.56
	27		100.0

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We should note from the first that no statistical evidence supported the notion that patent protection is a desirable instrument at the firm level. Although individual respondents assessed the experiences of process patent protection quite differently, all concluded that this form of protection had neither detrimental nor limiting effects on product behavior. But, though the evidence was not conclusive, it appeared that patent protection may have in fact limited performance. While no statistical relationship between patent protection and the sales structure could be asserted, still profits seemed generally to be limited for products protected by patents, though this may have been the result of an overemphasis being placed on the establishment of costly patent protection where limited returns existed.

TABLE 8-43

NONPARAMETRIC STATISTICAL TESTS OF PROCESS PATENT PROTECTION (RESEARCH CODE VARIABLE 24) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
6	Rate of Growth of Net Profits (2)	Kruskal-Wallis H 2.2575	0.1330
9	Timing of Profit Cycle (2)	Kruskal-Wallis H 2.4719	0.1159
11	Equivalent Rate of Return (2)	Bhapkar V 3.2000	0.0736
12	Profitability Ratio (2)	Bhapkar V 2.8543	0.0911
13	Return on Investment (2)	Kruskal-Wallis H 2.5929	0.1073
147	Annualized Discounted Present Value Sum (2)	Kruskal-Wallis H 1.8667	0.1719
152	Annualized Net Sales (2)	Kruskal-Wallis H 1.8667	0.1719

(2) Product and Use Patent Experiences

In terms of protecting the products from external competition, the product patent rights had a:

	Number of Responses	Percentage
Strong beneficial effect	1	3.70
No product patent	26	96.30
	27	100.0

In terms of protecting the products from external competition, the use patents had a:

	Number of Responses	Percentage
Strong beneficial effect	0	0.00
Moderate beneficial effect	1	3.70
Slight beneficial effect	0	0.00
Indifferent or so-so	1	3.70
Slight to strong detrimental or limiting effect	0	0.00
No use patent	25	92.60
	27	100.0

So few products possessed either product or use patents as to preclude any effective statistical analysis.

C. Demand Trends in Derived Demand Situations

If the new products were intermediates, the demands for other products upon which the derived demand situations existed had:

	Number of Responses	Group	Percentage
Strongly increased, i.e., annual growth rates exceeding 10%	7	1	36.84
Moderately increased, i.e., annual growth rates between 3% and 10%	8	2	42.11
Slightly increased, i.e., annual growth rates of 3% or less	4	3	21.05
	19		100.0

(NOTE: The median response of all recorded years for any product selected.)

The performance of chemical intermediates correlated strongly with trends in derived demand; that is, whenever the demands for finished goods were increasing at above average rates, products consumed as factors passed more rapidly through the marketing channels, experiencing higher annualized sales and profits. When product movements could be anticipated and production capabilities provided on demand, greater sales revenues were achieved. Fixed costs allocated over a larger number of units allowed for higher margins and net profitabilities when matched against authorized investment levels. More favorable cash flows from improved sales structures characterized those products experiencing moderate to strong increases in demand levels for the relevant derived demand situations, a dramatic support of how critical timing is in investment decision making.

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TABLE 8-44

NONPARAMETRIC STATISTICAL TESTS OF DEMAND TRENDS IN DERIVED DEMAND SITUATIONS (RESEARCH CODE VARIABLE 99) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
147	Annualized Discounted Present Value Sum (4)	Bhapkar V 9.7254	0.0211
152	Annualized Net Sales (4)	Kruskal-Wallis H 7.9326	0.0474
153	Annualized Net Profits (Losses) After Taxes (4)	Kruskal-Wallis H 9.2246	0.0265

D. Duplication Difficulties by Competitors

The degree of difficulty for competitors to duplicate the important characteristics of the new products when evaluated over the dimensions of existing patent rights and technological obstacles was:

	Number of Responses	Group	Percentage
Extremely difficult	2	1	7.41
Moderately difficult	7	2	25.93
Slightly difficult to slightly easy	6	3	22.22
Moderately easy	7	4	25.93
Very easy	5	5	18.52
	27		100.0

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The difficulty of duplicating new industrial chemical products where competitors might have had opportunities to market similar products—apparently a long-range phenomenon—primarily affected profit residuals. Legal and technological barriers to market entry of course correlated with the absence of market competition. The typical length and timing of sales and profit cycles differed little among the five classed groups, but aggregate sales and profit figures and return measures varied significantly. Straightforward development programs, generally those directed toward larger revenue-producing markets, generated greater annual profit contributions on the average than those new product programs that required more challenging and imaginative development support. Competitive pressures accounted for the poor return of products having few duplication difficulties, while heavy expenses and limited demand curtailed the average return of products extremely difficult to duplicate. Those products in the middle groups achieved better than average returns simply because the decision variables were in better balance.

TABLE 8-45

NONPARAMETRIC STATISTICAL TESTS OF DUPLICATION DIFFICULTIES BY COMPETITORS (RESEARCH CODE VARIABLE 78) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
9	Timing of Profit Cycle (5)	Kruskal-Wallis H 6.3160	0.1768
10	Payback Period (5)	Kruskal-Wallis H 7.9129	0.0948
11	Equivalent Rate of Return (5)	Bhapkar V 13.6852	0.0084
12	Profitability Ratio (5)	Bhapkar V 11.6296	0.0203
13	Return on Investment (5)	Bhapkar V 16.6667	0.0022
152	Annualized Net Sales (5)	Kruskal-Wallis H 9.7723	0.0444
153	Annualized Net Profits (Losses) After Taxes (5)	Bhapkar V 16.6667	0.0022

E. Industrial Plant Capacity Experiences

In regard to overall industry and its plant facilities to supply these products, there was on the average:

	Number of Responses	Group	Percentage
Marked overcapacity, i.e., greater than 20% idle capacity present	5	1	18.52
Moderate overcapacity, i.e., between 5% and 20% idle capacity present	11	1	40.74
Slight overcapacity, i.e., less than 5% idle capacity present, or some undercapacity present	11	2	40.74
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

No apparent relationship with the exception of the timing of the profit cycle was isolated between industry-wide production capacity and product performance at the firm level, the more critical issue being the distribution of plant utilization among competing firms. Relatively longer profit cycles encouraged industry-wide plant expansions with the expectation of tapping future profit opportunities.

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TABLE 8-46

NONPARAMETRIC STATISTICAL TESTS OF INDUSTRIAL PLANT CAPACITY EXPERIENCES (RESEARCH CODE VARIABLE 65) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
2	Accounting Rate of Return (2)	Kruskal-Wallis H 2.4935	0.1143
9	Timing of Profit Cycle (2)	Bhapkar V 9.2579	0.0023
10	Payback Period (2)	Kruskal-Wallis H 3.3336	0.0679
11	Equivalent Rate of Return (2)	Kruskal-Wallis H 2.0479	0.1524
149	Performance Index (2)	Kruskal-Wallis H 1.6461	0.1995
154	Critical Turning Point for Present Value Calculations (2)	Kruskal-Wallis H 1.7105	0.1909

F. Import Patterns

The approximate percentages of imports to domestic sales for the new products were:

	Number of Responses	Group	Percentage
Eleven percent or more	2	1	7.41
Less than eleven percent	6	2	22.22
No importing occurred	19	3	70.37
Unknown	0		XXXX
Not applicable	0		XXXX
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

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Although imported chemical products made a few marked penetrations, the new chemical industrial products studied here experienced little domestic competition from these trade flows; the levels of industrial chemical performance were unrelated to the percentages of total imports. The entire trade posture of the chemical industry, however, will likely change under the influence of such liberalized international trade agreements as the so-called "Kennedy Round." Current controversy over the ramifications of such agreements for the industry require close attention to developments in the near future. Whenever imported products are expected to affect sales, the estimated degree of this influence should be incorporated in the new product evaluation process.

TABLE 8-47

NONPARAMETRIC STATISTICAL TESTS OF IMPORT PATTERNS (RESEARCH CODE VARIABLE 115) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (3)	Kruskal-Wallis H 2.0802	0.3534
10	Payback Period (3)	Kruskal-Wallis H 1.3606	0.5065

G. Market Share Statistics

The attained market share levels were:

	Number of Responses	Group	Percentage
Less than 20.0%	6	1	22.22
Between 20.0% and 39.9%	4	2	14.81
Between 40.0% and 59.9%	3	3	11.11
Between 60.0% and 99.9%	5	4	18.52
100%	9	5	33.33
	27		100.0
Median	70.00		
Mean	58.33		
Standard Deviation	38.33		

(NOTE: The median market penetration as a percentage of realized sales to the relevant existing market valuation of all recorded years for any product selected.)

A few irregular and complex patterns appeared between performance and market share figures though statistical tests were inconclusive. Industrial chemical products without a dominant market position apparently experienced fewer minimum profit years in the marketplace; on the other hand, interestingly enough, products having roughly vertical monopolies showed fewer minimum profit years than those with dominant but oligopolistic positions. The decision maker generally planned incremental expansions in plant capacity more cautiously whenever he faced an oligopolistic market, for fear of triggering complementary expansions from competitive firms and the consequent industry-wide overcapacity and depression in the average price of the product. Conversely, the decision maker in a monopolistic situation inclined toward authorizing more than adequate capacity. Only 56% of these products enjoying monopolies were buffered against competition through patent protection so the market dominance of the others could only be explained through the ignorance or disinterest of potential competitors.

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Return on investment also varied with the degree of market control, those firms having either little (less than 40% market share) or complete market control showing less impressive returns than oligopolies did. But even though oligopolistic market situations took longer to develop profits before net cash flows turned toward positive values, they turned in larger annualized net sales.

TABLE 8-48

NONPARAMETRIC STATISTICAL TESTS OF MARKET SHARE STATISTICS (RESEARCH CODE VARIABLE 20) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
9	Timing of Profit Cycle (5)	Kruskal-Wallis H 8.3101	0.0809
10	Payback Period (5)	Kruskal-Wallis H 6.2994	0.1779
11	Equivalent Rate of Return (5)	Bhapkar V 8.6189	0.0714
12	Profitability Ratio (5)	Bhapkar V 9.0528	0.0598
13	Return on Investment[1] (5)	Kruskal-Wallis H 8.7531	0.0676
152	Annualized Net Sales (5)	Kruskal-Wallis H 8.7192	0.0685
153	Annualized Net Profits (Losses) After Taxes (5)	Kruskal-Wallis H 8.7459	0.0678
154	Critical Turning Point for Present Value Calculations (5)	Kruskal-Wallis H 9.3987	0.0519

[1]The test statistic Kruskal-Wallis H was significant at 0.0439 when the data were aggregated into three classes.

H. Market Trends

The trends in the specific markets for the new products were:

	Number of Responses	Group	Percentage
Strongly increasing, i.e., annual growth rates exceeding 10%	7	1	25.93
Moderately increasing, i.e., annual growth rates exceeding 3% but not greater than 10%	14	2	51.85
Slightly increasing, i.e., annual growth rates of 3% or less, or decreasing	6	3	22.22
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

The performance of new industrial chemical products was proven to correlate with general market trends. As overall market development accelerated at an annual growth rate of above 3%, absolute levels of sales revenues also grew, in direct relation to the growth rates in specific markets. On the other hand, the growth characteristics of new products remained unrelated, displaying an apparent erratic sales pattern over time. The critical issue was investment timing. Those product managers who maintained the capacities for producing and marketing a product as demands developed got the orders, though most often, however, they over-estimated needed capacities from time to time in the life of the product, causing variations in profitability.

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TABLE 8-49

NONPARAMETRIC STATISTICAL TESTS OF MARKET TRENDS (RESEARCH CODE VARIABLE 95) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
8	Timing of Sales Cycle (3)	Kruskal-Wallis H 3.4722	0.1762
152	Annualized Net Sales (3)	Kruskal-Wallis H 6.5911	0.0370
153	Annualized Net Profits (Losses) After Taxes (3)	Kruskal-Wallis H 3.5072	0.1732

I. Minimum Corporate Asset Size of Competitors Required to Compete Effectively

The apparent corporate asset size that competed effectively in the production and marketing of these products was:

	Number of Responses	Group	Percentage
Minimum of $10 million or less	6	1	30.00
Minimum between $10 million and $40 million	3	2	15.00
Only major firms, i.e., those in the top 500 industrial firm class	11	3	55.00
Not applicable	7		XXXX
	27		100.0

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Some relationships appeared between performance and the asset structure required to compete effectively, though not always what one would expect. With products having heavy demands for entry—those introduced by firms among the top 500 industrial manufacturing firms—the discounted present value tended to be significantly lower than with products where demands were in the other product situations. Markets were more competitive where companies altered pricing strategies frequently and accepted lower returns for market participation.

TABLE 8-50

NONPARAMETRIC STATISTICAL TESTS OF MINIMUM CORPORATE ASSET SIZE OF COMPETITORS REQUIRED TO COMPETE EFFECTIVELY (RESEARCH CODE VARIABLE 94) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
10	Payback Period (3)	Bhapkar V 5.5429	0.0626
13	Return on Investment (3)	Bhapkar V 3.9256	0.1405
147	Annualized Discounted Present Value Sum (3)	Kruskal-Wallis H 6.5532	0.0378
153	Annualized Net Profits (Losses) After Taxes (3)	Kruskal-Wallis H 3.2273	0.1992
154	Critical Turning Point for Present Value Calculations (3)	Bhapkar V 5.5429	0.0626

J. Profile of Consuming Industries

(1) Number of Major Consuming Industries

The number of major consuming industries was:

	Number of Responses	Group	Percentage
None	2	1	7.41
One	23	2	85.19
Two or more	2	3	7.41
	27		100.0
Median	1.0000		
Mean	1.0370		
Standard Deviation	0.5175		

(NOTE: The median response of all recorded years for any product selected.)

Since most new industrial chemical products under study supplied just one major consuming industry, the disaggregation of data precluded valid statistical analysis.

TABLE 8-51

NONPARAMETRIC STATISTICAL TESTS OF NUMBER OF MAJOR CONSUMING INDUSTRIES (RESEARCH CODE VARIABLE 30) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
147	Annualized Discounted Present Value Sum (3)	Kruskal-Wallis H 4.4300	0.1092
152	Annualized Net Sales (3)	Bhapkar V 4.3863	0.1116

(2) Number of Minor Consuming Industries

The number of minor consuming industries was:	Number of Responses	Group	Percentage
None	10	1	37.04
One to two	10	2	37.04
Three or more	7	3	25.92
	27		100.0
Median	2.0000		
Mean	2.2593		
Standard Deviation	2.8092		

(NOTE: The median response of all recorded years for any product selected.)

The impact of minor consuming industries on overall product performance, fortuitous almost by definition, showed no statistical relationships of any significance across the dimensions examined.

TABLE 8-52

NONPARAMETRIC STATISTICAL TESTS OF NUMBER OF MINOR CONSUMING INDUSTRIES (RESEARCH CODE VARIABLE 31) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
9	Timing of Profit Cycle (3)	Bhapkar V 1.8650	0.3936
11	Equivalent Rate of Return (3)	Bhapkar V 1.3768	0.5024
152	Annualized Net Sales (3)	Kruskal-Wallis H 1.0426	0.5937

K. Supply Characteristics

In regard to raw materials used in the manufacture of the new products, there was on the average:

	Number of Responses	Percentage
Heavy shortage with difficult access to existing supplies	0	0.0
Moderate shortage with difficult access to existing supplies	0	0.0
Moderate shortage with moderate difficulty in getting access to existing supplies	0	0.0
Moderate shortage with slight difficulty in getting access to existing supplies	0	0.0
Slight shortage with moderate difficulty in getting access to existing supplies	0	0.0
Slight shortage with slight difficulty in getting access to existing supplies	0	0.0
No shortage or access difficulties	27	100.0
Unknown	0	XXXX
Not applicable	0	XXXX
	27	100.0

(NOTE: The median response of all recorded years for any product selected.)

Since new industrial chemical products rarely suffered raw material shortages, no significant relationships were found, though any acceptance of proposed capital expenditures remained contingent on adequate raw material supplies in the future.

2. Buyer Behavior

A. Annual Purchasing Patterns by Buyers

The number of purchases on the average made by industrial buyers each year was:

	Number of Responses	Group	Percentage
One to three	2	1	7.69
Four to six	10	2	38.46
Seven to eight	3	3	11.54
Nine to twelve	5	4	19.23
Over twelve	6	5	23.08
Unknown	1		XXXX
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

No relationship between purchasing patterns and performance appeared significant at the cut-off level established, but the small sample size and the closeness of many statistical tests warrant some discussion of the possibly relevant relationships. Both infrequent and extra-frequent purchasers (under four or over twelve annual purchases) tended to demand larger volumes of product. Yet these actions placed such erratic strains on the new product planning process that products having these purchasing patterns tended to show lower discounted present value sum and equivalent rate or return results.

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TABLE 8-53

NONPARAMETRIC STATISTICAL TESTS OF NUMBER OF ANNUAL PURCHASES BY BUYERS (RESEARCH CODE VARIABLE 82) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (5)	Bhapkar V 8.0625	0.0893
3	Aggregate Net Sales (5)	Bhapkar V 8.3148	0.0807
6	Rate of Growth of Net Profits (5)	Kruskal-Wallis H 8.8377	0.0653
11	Equivalent Rate of Return (5)	Bhapkar V 8.4860	0.0753
12	Profitability Ratio (5)	Bhapkar V 8.5253	0.0741

B. Degree of Backward Integration

To what extent did customers integrate backward?

	Number of Responses	Group	Percentage
Very slight move, i.e., less than 5% of customers	24	1	88.89
Slight move, i.e., between 5% and 10% of customers	3	2	11.11
Moderate to marked move, i.e., greater than 10% of customers	0		0.00
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

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Backward integration of existing and potential customers, apparently a rare occurrence, occasionally becomes a problem to chemical marketers. The median response of all recorded years which was taken to be most representative, pinpointing those products with long histories of integration movements, included approximately 11% of the products studied; nevertheless, just six of the twenty-seven products experienced any backward consumer integration moves whatsoever during any one year of their life cycles.

Effective protection from patent rights quite naturally thwarted backward integration moves on the part of customers. And pricing policies too acted as a deterrent. Whenever pricing policies allowed for above average returns, the profitability of such business would stimulate backward integration movements. Then too, the ability to supply a product selectively when demand was expanding rapidly boosted profit performance. So adequate patent protection, sensitive pricing policies and sufficient supply capabilities together explained how backward integration moves could be prevented in typical marketing situations. Clearly most large buyers of industrial chemical products maintained constant surveillance over the economic, legal and marketing conditions involved in purchasing decisions. Any make or buy decision was based on critical quantitative analyses of the alternatives available to the firm in the allocation of resources, especially as many firms could simulate the effects of various courses of action on their earnings streams over suitable time horizons.

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TABLE 8-54

NONPARAMETRIC STATISTICAL TESTS OF DEGREE OF BACKWARD INTEGRATION (RESEARCH CODE VARIABLE 109) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
10	Payback Period (2)	Kruskal-Wallis H 2.3810	0.1228
11	Equivalent Rate of Return (2)	Bhapkar V 3.2654	0.0708
12	Profitability Ratio (2)	Bhapkar V 4.1728	0.0411
13	Return on Investment (2)	Kruskal-Wallis H 4.3393	0.0372
147	Annualized Discounted Present Value Sum (2)	Bhapkar V 3.5556	0.0593
154	Critical Turning Point for Present Value Calculations (2)	Bhapkar V 4.1728	0.0411

C. Degree of Required Deliberation

Initial purchases of the new products required:

	Number of Responses	Group	Percentage
Detailed deliberation	10	1	38.46
Moderate deliberation	9	2	34.61
Slight to very slight deliberation	7	3	26.93
No deliberation	0		0.00
Unknown	1		XXXX
	27		100.0

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Performance showed no distinguishable relation to the degree of deliberation required before the initial purchase decision was concluded, not in demand, profitability, nor discounted cash flows.

TABLE 8-55

NONPARAMETRIC STATISTICAL TESTS OF DEGREE OF REQUIRED DELIBERATION (RESEARCH CODE VARIABLE 108) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
3	Aggregate Net Sales (3)	Kruskal-Wallis H 1.6320	0.4422
5	Rate of Growth of Net Sales (3)	Kruskal-Wallis H 3.1308	0.2090

D. Dependence on Contacts by Company Representatives

The general dependency of the final sale on personal contacts by company representatives was:

	Number of Responses	Group	Percentage
Strongly dependent	12	1	44.44
Moderately dependent	10	2	37.04
Slightly dependent, indifferent or not dependent	5	3	18.51
	27		100.0

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Dependence on company representative contacts related to performance along many dimensions, though aggregate net sales did not vary statistically with varying levels of acknowledged dependencies. One seeks in isolating the causes of the buying decision to measure all influences. Whether by direct confrontation with field personnel or indirectly through selected communication media, degree of total exposure is one significant dimension, and the sales of the new industrial chemical products under study were always partly a direct result of selective exposure. Greater promotional expenditures were generally allowed where contact dependencies were either very strong or slight, to reinforce or even supplant field work. Even though both these strategies contributed to any realized sales potential, profitability (particularly discounted cash flows and investment returns) varied decisively with the degree of contact dependency. Products thought to depend heavily on personal contact to conclude the final sale demonstrated superior annualized net profit results. Sales organizations which established priorities, giving preference to those larger volume accounts in which the contact requirements were stronger, appeared to optimize their sales efforts more effectively.

TABLE 8-56

NONPARAMETRIC STATISTICAL TESTS OF DEPENDENCE ON CONTACTS BY COMPANY REPRESENTATIVES (RESEARCH CODE VARIABLE 89) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (3)	Kruskal-Wallis H 6.5751	0.0373
10	Payback Period (3)	Kruskal-Wallis H 4.9976	0.0822
11	Equivalent Rate of Return (3)	Bhapkar V 8.4008	0.0150
12	Profitability Ratio (3)	Kruskal-Wallis H 6.6696	0.0356
13	Return on Investment (3)	Kruskal-Wallis H 7.0823	0.0290
153	Annualized Net Profits (Losses) After Taxes (3)	Kruskal-Wallis H 7.8140	0.0201
154	Critical Turning Point for Present Value Calculations (3)	Kruskal-Wallis H 4.9243	0.0853

E. Educational Requirements of Users

The time it generally took to educate the user in product characteristics, advantages and uses was:

	Number of Responses	Group	Percentage
Two or more years	8	1	34.78
Six months but less than two years	10	2	43.48
Less than six months	5	3	21.74
Not applicable if no education required	3	4	XXXX
Unknown	1		XXXX
	27		100.0

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The complexity of the evaluation process appeared unrelated to performance.

TABLE 8-57

NONPARAMETRIC STATISTICAL TESTS OF TIME TO EDUCATE THE USER (RESEARCH CODE VARIABLE 112) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
10	Payback Period (4)	Bhapkar V 4.5329	0.2094
147	Annualized Discounted Present Value Sum (4)	Bhapkar V 4.2490	0.2358

F. Effect of Industrial Advertising on Manufacturer Selection

The general effect of industrial advertising in selecting a manufacturer for the new products was:

	Number of Responses	Group	Percentage
Moderate to strong positive effect	5	1	18.52
Slight positive effect	8	2	29.63
Indifferent to strong negative effect	14	3	51.84
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

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Considerable evidence challenges the common assumption of industrialists that industrial advertising has little specific influence on product performance. Respondents asked to evaluate the general effects of industrial advertising believed, in five of the twenty-seven cases examined, that industrial advertising had a moderate to strong positive effect on manufacturer selection; these same five products had statistically superior annualized revenues and profits, timings of the profit cycle, equivalent rates of return, profitability ratios and annualized discounted present value sum calculations, although such conclusions incorporate uncontrolled error. Similar relationships emerged with the remaining two groups, the products enjoying a slight positive advantage from advertising outdistancing the group with indifferent to strongly negative effects. It seems likely that, as competition for select markets becomes more intense, product management will turn with greater frequency to advertising programs designed to generate future business; historical evidence suggests that programs which have affected source selection also influenced product performance.

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TABLE 8-58

NONPARAMETRIC STATISTICAL TESTS OF EFFECT OF INDUSTRIAL ADVERTISING ON MANUFACTURER SELECTION (RESEARCH CODE VARIABLE 90) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
9	Timing of Profit Cycle (3)	Bhapkar V 7.5905	0.0225
10	Payback Period (3)	Kruskal-Wallis H 4.0261	0.1336
11	Equivalent Rate of Return (3)	Bhapkar V 7.8688	0.0196
12	Profitability Ratio (3)	Bhapkar V 7.7958	0.0203
147	Annualized Discounted Present Value Sum (3)	Kruskal-Wallis H 7.9623	0.0187
152	Annualized Net Sales (3)	Kruskal-Wallis H 7.8980	0.0193
153	Annualized Net Profits (Losses) After Taxes (3)	Kruskal-Wallis H 10.4179	0.0055
154	Critical Turning Point for Present Value Calculations (3)	Kruskal-Wallis H 5.2794	0.0714

G. Effect of Product Quality on Source Selection

From an industrial user viewpoint, to what extent was the quality of the new products an important consideration?

	Number of Responses	Group	Percentage
Highly important	16	1	59.26
Moderately important	6	2	22.22
Slightly important	5	3	18.52
	27		100.0

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Product quality, always a buying consideration, influenced the industrial user differently, depending upon the product in question and the intended application. Many industrial commodities were offered in different formulations and grades of purity to meet specific needs. Demand levels varied with quality standards: higher sales levels were attained with products sold more on the basis of desired standards. In other words, as products attracted larger sales commitments, industrial users attached more significance to quality assurances. This conclusion remains purely a matter of judgment, however, since (with the exception of the timing of the sales cycle) no other statistical relationship between performance and the effect of quality on source selection was isolated in the screening process.

TABLE 8-59

NONPARAMETRIC STATISTICAL TESTS OF EFFECT OF PRODUCT QUALITY ON SOURCE SELECTION (RESEARCH CODE VARIABLE 86) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
3	Aggregate Net Sales (3)	Bhapkar V 7.4953	0.0236
4	Aggregate Net Profits (Losses) After Taxes (3)	Kruskal-Wallis H 4.3084	0.1160
8	Timing of Sales Cycle (3)	Kruskal-Wallis H 6.4564	0.0396

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H. Effect of Reputation and Image of Manufacturer

From the viewpoint of industrial users, of what importance did the reputation and image of the manufacturer and its established rapport in cooperative development programs to meet specific user requirements have on the selection of the manufacturer for supply of these products as well as others?

	Number of Responses	Group	Percentage
Highly important	6	1	22.22
Moderately important	11	2	40.74
Slightly important	4	3	14.81
Indifferent or so-so	6	4	22.22
	27		100.0

Many corporate communication programs have been initiated under the assumption that the reputation and image of a manufacturer critically influenced source selection; but this study observed no particular relationship between image and performance. The extent to which cooperative development programs actually promote mutually profitable objectives remains open to extended research which could well shed light on these interactions.

TABLE 8-60

NONPARAMETRIC STATISTICAL TESTS OF EFFECT OF REPUTATION AND IMAGE OF MANUFACTURER (RESEARCH CODE VARIABLE 77) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
5	Rate of Growth of Net Sales (4)	Kruskal-Wallis H 4.4503	0.2168
149	Performance Index (4)	Bhapkar V 5.6365	0.1307

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I. Effect on Sales of Related Products

The effect of the new products on the sales of related products in the product line was:

	Number of Responses	Group	Percentage
No effect to detrimental effect	14	1	51.85
Slight beneficial effect, since slight increases in sales of related products were experienced	9	2	33.33
Moderate to strong beneficial effect, since moderate to large increases in sales of related products were experienced	4	3	14.81
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

The effect of a new product on the sales of related products showed no relation to performance, a predictable finding since no attempt was made to examine the historical records of product families.

TABLE 8-61

NONPARAMETRIC STATISTICAL TESTS OF EFFECT ON SALES OF RELATED PRODUCTS (RESEARCH CODE VARIABLE 87) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
10	Payback Period (3)	Bhapkar V 4.7318	0.0939
147	Annualized Discounted Present Value Sum (3)	Kruskal-Wallis H 3.9563	0.1383
154	Critical Turning Point for Present Value Calculations (3)	Bhapkar V 5.5744	0.0616

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J. Extent of User Laboratory Evaluation

The percentage of potential users that evaluated the new products in their own laboratories on an experimental quantity basis once approached by the producing firms was:

	Number of Responses	Group	Percentage
100%	4	1	14.82
Between 80% and 99%	7	1	25.93
Between 60% and 79%	5	2	18.52
Between 40% and 59%	6	2	22.22
Between 20% and 39%	2	3	7.40
Between 1% and 19%	3	3	11.11
None	0		0.00
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

In examining the relationship between the extent of user laboratory evaluation and performance, no clear-cut pattern emerged except in annualized net sales data. The lower the penetration rates achieved in specific evaluation programs, the larger on the average were the eventual revenues for a new industrial chemical product, a surprising but plausible finding. Apparently penetration rates drop when competition for cooperative evaluation programs among similar products is intense. In such a case, usage of any given product could be high, supporting larger unit annual consumption rates, a significant factor in those product structures studied.

Companies need not be discouraged when relatively little interest is expressed in proposed evaluation programs; lower turnabout rates in recovering investments were attained with low penetration rates in comparison with "in-house" evaluation programs, although statistical tests were inconclusive.

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TABLE 8-62

NONPARAMETRIC STATISTICAL TESTS OF PERCENTAGE OF USER LABORATORY EVALUATION (RESEARCH CODE VARIABLE 76) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
6	Rate of Growth of Net Profits (3)	Kruskal-Wallis H 3.5238	0.1717
10	Payback Period (3)	Kruskal-Wallis H 3.6260	0.1632
13	Return on Investment (3)	Kruskal-Wallis H 3.3362	0.1886
152	Annualized Net Sales (3)	Kruskal-Wallis H 6.8098	0.0332

K. Field Contact Requirements

The number of contacts on the average required by marketing and technical development people before the initial sale was concluded was:

	Number of Responses	Group	Percentage
Three or less	8	1	29.63
Four to five	7	2	25.93
Six or more	12	3	44.44
	27		100.0

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Since products grouped by their respective contact requirements for field representation showed no differences in performance, knowledge of expected contact requirements seems an unlikely clue to product behavior, though product management should project these requirements before adequate marketing strategies can be planned.

TABLE 8-63

NONPARAMETRIC STATISTICAL TESTS OF NUMBER OF CONTACTS REQUIRED BY MARKETING AND TECHNICAL PERSONNEL (RESEARCH CODE VARIABLE 113) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
2	Accounting Rate of Return (3)	Kruskal-Wallis H 3.3716	0.1853
10	Payback Period (3)	Kruskal-Wallis H 3.6533	0.1610

L. Level of Product Loyalty

Product loyalty on the average was:

	Number of Responses	Group	Percentage
Strong to very strong	12	1	44.44
Moderately strong	9	2	33.33
Moderately weak to none	6	3	22.22
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

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Those new industrial chemical products having strong responses in product loyalty had significantly higher aggregate discounted present value sums, higher accounting rates of return, longer profit cycles, shorter payback periods, higher equivalent rates of return and returns on investment, more impressive performance index records, and shorter critical turning points for cash flows. In short, performance is likely quite sensitive to changes in product loyalty through time.

TABLE 8-64

NONPARAMETRIC STATISTICAL TESTS OF LEVEL OF PRODUCT LOYALTY (RESEARCH CODE VARIABLE 107) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (3)	Kruskal-Wallis H 6.7094	0.0349
2	Accounting Rate of Return (3)	Kruskal-Wallis H 7.4965	0.0236
6	Rate of Growth of Net Profits (3)	Bhapkar V 8.2921	0.0158
9	Timing of Profit Cycle (3)	Kruskal-Wallis H 8.8337	0.0121
10	Payback Period (3)	Bhapkar V 8.4376	0.0147
11	Equivalent Rate of Return (3)	Kruskal-Wallis H 6.4383	0.0400
13	Return on Investment (3)	Kruskal-Wallis H 7.0282	0.0298
149	Performance Index (3)	Kruskal-Wallis H 8.0238	0.0181
153	Annualized Net Profits (Losses) After Taxes (3)	Kruskal-Wallis H 3.3404	0.1882
154	Critical Turning Point for Present Value Calculations (3)	Kruskal-Wallis H 11.3898	0.0034

M. Number of Purchasers

The number of customers for the new products was:

	Number of Responses	Group	Percentage
Five or less	5	1	18.52
Six to ten	5	2	18.52
Eleven to twenty	8	3	29.63
Twenty-one to forty	3	4	11.11
Forty-one or more	6	5	22.22
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

One straightforward product characteristic, the number of purchasers, should be a useful determinant of sales behavior, as indeed the evidence indicates. In general, the more purchasing accounts a product had, the longer was its sales cycle and the larger its annualized net sales through time (true even in industrial markets displaying product sales concentrations). Widespread demand, as reflected in the number of purchasers, tended to sustain sales over a longer time period, although this fact says nothing of the profitability of continued market participation.

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TABLE 8-65

NONPARAMETRIC STATISTICAL TESTS OF NUMBER OF PURCHASERS (RESEARCH CODE VARIABLE 101) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
5	Rate of Growth of Net Sales (5)	Bhapkar V 12.5826	0.0135
8	Timing of Sales Cycle (5)	Kruskal-Wallis H 12.6918	0.0129
9	Timing of Profit Cycle (5)	Kruskal-Wallis H 6.3410	0.1751
152	Annualized Net Sales (5)	Bhapkar V 11.3047	0.0233
153	Annualized Net Profits (Losses) After Taxes (5)	Kruskal-Wallis H 9.7540	0.0448
154	Critical Turning Point for Present Value Calculations (5)	Kruskal-Wallis H 7.0117	0.1353

N. Product Source Intelligence

The average industrial buyer purchased the new products from:

	Number of Responses	Group	Percentage
One producer	14	1	51.85
Two or more producers	13	2	48.15
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

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The selection patterns of industrial buyers varied: just over half of the products included in the study characteristically had one producer associated with the buying practices of typical industrial buyers. But tested against numerous performance criteria, no noticeable differences existed among the different supplying preferences of buyers.

TABLE 8-66

NONPARAMETRIC STATISTICAL TESTS OF NUMBER OF PRODUCT SOURCES BY BUYERS (RESEARCH CODE VARIABLE 100) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
3	Aggregate Net Sales (2)	Kruskal-Wallis H 0.6805	0.4094
10	Payback Period (2)	Kruskal-Wallis H 0.7630	0.3824

O. Recognition Experiences of Product Advantages by Users

The new products may have had advantages that were recognizable by industrial users, i.e., those responsible for the buying decision, at varying degrees. The following response pattern was indicated as typical for the new products under study:

	Number of Responses	Group	Percentage
Moderately to extremely difficult to recognize	5	1	18.52
Slightly difficult to recognize	3	1	11.11
Indifferent or so-so	5	2	18.52
Slightly easy to recognize	6	2	22.22
Moderately to extremely easy to recognize	8	2	29.62
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

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The recognition by industrial users of product advantages had no discernible effect on product performance.

TABLE 8-67

NONPARAMETRIC STATISTICAL TESTS OF RECOGNITION EXPERIENCES OF PRODUCT ADVANTAGES BY USERS (RESEARCH CODE VARIABLE 81) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
8	Timing of Sales Cycle (2)	Kruskal-Wallis H 2.9828	0.0842
9	Timing of Profit Cycle (2)	Kruskal-Wallis H 0.7600	0.3833
154	Critical Turning Point for Present Value Calculations (2)	Kruskal-Wallis H 0.7220	0.3955

P. Trade Relations

Trade relations with users were best described as:

	Number of Responses	Group	Percentage
Moderately to extremely good	13	1	48.15
Slightly good	4	2	14.81
Indifferent or so-so	7	3	25.93
Slightly to extremely weak	3	4	11.11
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

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As performance was evaluated against the types of trade relationships among users, the minimum product life cycle lengthened as described trade relations with users improved; at the same time, however, profits decreased. This research suggested no particular reason for the relationship.

TABLE 8-68

NONPARAMETRIC STATISTICAL TESTS OF TRADE RELATIONS (RESEARCH CODE VARIABLE 104) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
6	Rate of Growth of Net Profits (4)	Bhapkar V 11.1708	0.0108
8	Timing of Sales Cycle (4)	Kruskal-Wallis H 7.8070	0.0502

3. Product Characteristics

A. Cyclical Patterns

The cyclical patterns for the new products were:

	Number of Responses	Group	Percentage
Very slightly to highly cyclical	7	1	31.83
Noncyclical	15	2	68.18
Unknown	5		XXXX
Not applicable	0		XXXX
	27		100.0

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Since business expansions have predominated over contractions during the ten years covered by the study, we would expect products with noticeably cyclical patterns to outperform the others in sales; except for two periods of nine months each designated by the National Bureau of Economic Research as periods of recessionary behavior, lengthy periods of improved business conditions did strengthen products sensitive to macromarket developments. Yet profitability itself related in no detectable manner to cyclical behavior.

TABLE 8-69

NONPARAMETRIC STATISTICAL TESTS OF CYCLICAL PATTERNS (RESEARCH CODE VARIABLE 103) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
3	Aggregate Net Sales (2)	Bhapkar V 4.2195	0.0400
8	Timing of Sales Cycle (2)	Kruskal-Wallis H 1.8448	0.1744

B. End-Use Patterns

The major end-uses for the new chemical products were:

	Number of Responses	Group	Percentage
Monomeric material in polymer systems	8	1	27.59
Chemical additive in polymer systems	3	2	10.34
Chemical additive in rubber production	3	3	10.34
Chemical additive in gasoline production	2	4	6.90
Chemical additive in fiber production	2	5	6.90
Chemical additive in soap and detergent manufacturing	1	6	3.45
Process chemical in mining operations	2	7	6.90
Food preservative	1	8	3.45
Process chemical in water treatment	1	9	3.45
Industrial solvent	1		3.45
Chemical intermediate in fibers	2	10	6.90
Other chemical intermediates	3	11	10.34
	29		100.0

(NOTE: Since some chemical products had multiple end-uses, the number of responses exceeded the sample size.)

Because of marked variations in performance within any given end-use classification, no direct relationships between performance and end-uses could be isolated, not even when group variables were consolidated down to as few as four classes. Product behavior is apparently unique to the decisions made by product management in response to specific marketing opportunities.

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TABLE 8-70

NONPARAMETRIC STATISTICAL TESTS OF END-USE PATTERNS[1] (RESEARCH CODE VARIABLE 134) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
13	Return on Investment (11)	Bhapkar V 10.9500	0.3614
152	Annualized Net Sales (11)	Kruskal-Wallis H 15.7169	0.1080

[1] The dominant end-use classification for any product was used in this testing procedure.

C. <u>Innovation in Marketing</u>

From a marketing standpoint, the new products were:

	Number of Responses	Group	Percentage
Moderately to highly innovative	11	1	40.74
Slightly innovative to slightly duplicative	7	2	25.92
Moderately to highly duplicative	9	3	33.33
	27		100.0

Though it may well improve the firm's competitive position, marketing innovation often failed by itself to explain final performance rankings. In some cases firms had not exploited their unique marketing positions properly.

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TABLE 8-71

NONPARAMETRIC STATISTICAL TESTS OF DEGREE OF MARKETING INNOVATIVENESS (RESEARCH CODE VARIABLE 84) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (3)	Kruskal-Wallis H 2.7087	0.2581
2	Aggregate Net Sales (3)	Kruskal-Wallis H 2.7772	0.2494

D. Innovation in Technology

From a technological standpoint, the new products were:

	Number of Responses	Group	Percentage
Highly innovative	6	1	22.22
Moderately innovative	9	1	33.33
Slightly innovative to slightly duplicative	6	2	22.22
Moderately to highly duplicative	6	2	22.22
	27		100.0

Any progressive technology demands the capacity to innovate, both in the research laboratory and on the production line. And the chemical industry characteristically invests heavily in technological developments: the question is, to what extent has innovation produced economically rewarding new product development. There was no evidence in the collected data to support the notion that technological innovation was a correlate of performance. Many firms have failed to establish economic eminence on the basis of technological innovation alone. Disciplined business acumen, a

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acumen, applied effectively in any product situation, most probably will determine the eventual outcome regardless of the technological sophistication of the product.

TABLE 8-72

NONPARAMETRIC STATISTICAL TESTS OF DEGREE OF TECHNOLOGICAL INNOVATIVENESS (RESEARCH CODE VARIABLE 85) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (2)	Kruskal-Wallis H 2.0024	0.1571
11	Equivalent Rate of Return (2)	Kruskal-Wallis H 0.9524	0.3291

E. Matching of Technological Characteristics with Market Requirements

In regard to the matching of technological characteristics of the new products with the market requirements as perceived by industrial users, they were:

	Number of Responses	Group	Percentage
Extremely well matched	12	1	44.44
Moderately well matched	8	2	29.63
Slightly well matched	3	2	11.11
Indifferent or not well matched	4	2	14.82
	27		100.0

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One important measure of research and development effectiveness, the extent to which chemical product specifications met market requirements, significantly affected performance in just one particular way: those products extremely well matched to needs tended to have shorter profit cycles and this more than likely decreased the chance of adequate returns on invested resources. Even this result could be due to error from the peculiarities of sample inclusions.

TABLE 8-73

NONPARAMETRIC STATISTICAL TESTS OF MATCHING OF TECHNOLOGICAL CHARACTERISTICS WITH MARKET REQUIREMENTS (RESEARCH CODE VARIABLE 83) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
5	Rate of Growth of Net Sales (2)	Kruskal-Wallis H 1.7357	0.1877
9	Timing of Profit Cycle (2)	Kruskal-Wallis H 4.4044	0.0358
10	Payback Period (2)	Kruskal-Wallis H 2.5929	0.1073
11	Equivalent Rate of Return (2)	Kruskal-Wallis H 2.1429	0.1432

F. Price Movements

With enough accurate data on price-volume relationships and expected demand shifts through time, optimizing product profitability through pricing policies would be relatively easy. Unfortunately the typical pricing situation involves great uncertainty; current industrial practice has therefore evolved around evaluations of relative cost positions, predetermined returns on invested capital, and production capacities.

(1) Action Regarding Price Changes

The actions taken to change the average price offerings of the new products were:

	Number of Responses	Group	Percentage
Yes	9	1	33.33
No	18	2	66.67
	27		100.0

(NOTE: This is an analysis of an action taken in a given time period when compared with the previous year in the analysis; the median response of all recorded years for any product selected.)

The typical price movement patterns for the products were:

	Number of Responses	Percentage
Severe price increases, i.e., greater than 20%	0	0.00
Moderate price increases, i.e., between 10% and 20%	0	0.00
Relatively stable price increases, i.e., between 5% and 10%	0	0.00
Stable price movements, i.e., less than 5% change	21	77.78
Relatively stable price decreases, i.e., between 5% and 10%	4	14.81
Moderate price decreases, i.e., between 10% and 20%	1	3.70
Severe price decreases, i.e., greater than 20%	1	3.70
	27	100.0

(NOTE: The average price data as a percentage change over the previous year recorded, taking the median response of all recorded years for any product.)

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Aggregate economic data typically showed an overall attrition in the prices of new industrial chemical products. The price commonly declined early in the life cycles, a few decreases exceeding 10% annually. While high introductory prices gave the marketing organization greater flexibility, the same high prices could limit immediate market penetration. New products characterized by frequent price pressures tended to lower profit growth rates. The evidence contradicted a frequently expressed belief that price declines have had beneficial effects on the average by expanding consumption into newly developing markets. More importantly, these same products showed lower profitability.

TABLE 8-74

NONPARAMETRIC STATISTICAL TESTS OF ACTION REGARDING PRICE CHANGES (RESEARCH CODE VARIABLE 63) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (2)	Bhapkar V 3.1715	0.0749
6	Rate of Growth of Net Profits (2)	Kruskal-Wallis H 4.9304	0.0264
8	Timing of Sales Cycle (2)	Kruskal-Wallis H 3.5421	0.0598
9	Timing of Profit Cycle (2)	Kruskal-Wallis H 3.0537	0.0806
10	Payback Period (2)	Kruskal-Wallis H 3.0582	0.0803
11	Equivalent Rate of Return (2)	Kruskal-Wallis H 3.4286	0.0641
149	Performance Index (2)	Kruskal-Wallis H 4.0238	0.0449
154	Critical Turning Point for Present Value Calculations (2)	Bhapkar V 3.7558	0.0526

(2) Causes of Marked Price Declines

If the new products experienced marked price declines, the causes for such pressures were:

	Number of Responses	Group	Percentage
Severe competition, i.e., external attrition by competitors	11	1	84.62
Internal market strategy to improve market position, i.e., internal attrition	2	2	15.38
	13		100.0

(NOTE: The reason behind any moderate to severe price decrease listed, taking the median response of all recorded years for any product.)

Over 86% of all decisions to lower price were caused by environmental competitive pressures. But the end results were mixed. Sales cycles tended to be longer, extending product life; but profitability was curtailed since accrued efficiencies from technological improvements and higher capacity utilizations failed to offset lost revenues completely.

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TABLE 8-75

NONPARAMETRIC STATISTICAL TESTS OF CAUSES OF MARKED PRICE DECLINES (RESEARCH CODE VARIABLE 34) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)[1]	Test Statistic	Significance
1	Discounted Present Value Sum (2)	Kruskal-Wallis H 2.8846	0.0894
2	Accounting Rate of Return (2)	Kolmogorov-Smirnov D 0.4835	0.0855
6	Rate of Growth of Net Profits (2)	Kruskal-Wallis H 8.8043	0.0030
8	Timing of Sales Cycle (2)	Kruskal-Wallis H 3.9903	0.0458
10	Payback Period (2)	Kruskal-Wallis H 1.8462	0.1742
11	Equivalent Rate of Return (2)	Kruskal-Wallis H 2.1193	0.1455

[1]The statistical tests for this run were based on a two-class grouping: those products having marked price declines at least once in their histories were classed against those that did not have such recorded experiences.

G. Relative Technical Service Requirements

The service requirements of technical personnel essential to assure user satisfaction (measured as the number of man-hours of technical personnel required relative to the number of man-hours of marketing personnel) for the new products were:

	Number of Responses	Group	Percentage
Fractional values of less than 0.5	10	1	37.04
Fractional values between 0.5 and 1.5	8	2	29.63
Fractional values greater than 1.5	4	3	14.81
Not applicable if no technical service needed	1	4	3.70
Unknown	4		14.81
	27		100.0

Products requiring either below or above average technical servicing (i.e., less than 0.5 or greater than 1.5 man-hours of technical representation to man-hours of marketing coverage) outperformed others in terms of the equivalent rate of return and profitability ratio. The field investigation offered no particular explanation for this outcome, which may even represent some as yet unknown error.

Occasionally chemical manufacturers have had to implement disproportionately extensive technical service programs in order to accelerate market acceptance. Where they were required, such commitments were typically profitable.

TABLE 8-76

NONPARAMETRIC STATISTICAL TESTS OF RELATIVE TECHNICAL SERVICE REQUIREMENTS (RESEARCH CODE VARIABLE 114) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
10	Payback Period (4)	Kruskal-Wallis H 6.1137	0.1062
11	Equivalent Rate of Return (4)	Kruskal-Wallis H 7.8355	0.0495
12	Profitability Ratio (4)	Kruskal-Wallis H 8.4085	0.0383
13	Return on Investment (4)	Kruskal-Wallis H 6.8547	0.0767
147	Annualized Discounted Present Value Sum (4)	Kruskal-Wallis H 5.9184	0.1156
154	Critical Turning Point for Present Value Calculations (4)	Kruskal-Wallis H 7.6030	0.0550

H. <u>Research and Development Harnessing Experiences</u>

The degree of difficulty in harnessing the research and development programs in order to commercialize the new products was:

	Number of Responses	Group	Percentage
Moderately to highly difficult	15	1	55.55
Slightly difficult	4	2	14.81
Indifferent or so-so to slightly easy	2	3	7.41
Moderately easy	2	4	7.41
Very easy	4	5	14.81
	27		100.0

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The allocation of research and development funds appeared independent of the difficulty in harnessing research and development programs for product commercialization; that is, a difficult task facing the scientist was not necessarily the most expensive to the firm. Research and development requirements differed for each process with the availability of existing knowledge. More sophisticated resource management may help insure future payoffs in research and development work to chemical manufacturers. Products with elementary development programs generated better-than-average sales and profits, thus suggesting a strategy for the allocation of research and development work. So a careful evaluation of the market requirements and the technological and marketing capabilities of the firm to achieve acceptable performance results must clearly precede any decision to commit existing resources.

TABLE 8-77

NONPARAMETRIC STATISTICAL TESTS OF RESEARCH AND DEVELOPMENT HARNESSING EXPERIENCES (RESEARCH CODE VARIABLE 73) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
152	Annualized Net Sales (5)	Bhapkar V 14.3002	0.0064
153	Annualized Net Profits (Losses) After Taxes (5)	Kiefer T 4.2519	0.0344

I. Seasonal Patterns

The seasonal patterns for the new products were:

	Number of Responses	Group	Percentage
Very slightly to highly seasonal	10	1	38.46
Nonseasonal	16	2	61.54
Unknown	1		XXXX
	27		100.0

Time series decomposition runs generated information on the trends in seasonal patterns potentially quite useful in marketing planning. This study, however, revealed no significant relationship between seasonal patterns and overall performance, either because increases in field productivity were generally offset by operational inefficiencies or because product management was not exploiting the known patterns of seasonal product behavior.

TABLE 8-78

NONPARAMETRIC STATISTICAL TESTS OF SEASONAL PATTERNS (RESEARCH CODE VARIABLE 102) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
9	Timing of Profit Cycle (2)	Kruskal-Wallis H 1.7537	0.1854
154	Critical Turning Point for Present Value Calculations (2)	Kruskal-Wallis H 0.7114	0.3990

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J. Specificity of Use

In terms of usage, the new products were best described as:

	Number of Responses	Group	Percentage
Highly specific	12	1	44.44
Moderately specific to highly general	15	2	55.56
	27		100.0

Without treating for possible differences in respondent interpretations, data collected on the specificity of use suggested no particular relation to sales behavior. Significantly large revenue levels could be attained even when the new product was highly specific in use, as long as the product served a useful need on an economical basis and was backed by a timely, balanced marketing program; such a product, in fact, actually achieved a better-than-average median profit growth rate, but only because the product either had an initial history of loss position or started at a nominal profit level early in the profit cycle. Discounted cash flow results did seem to favor products that were more general in application, although no statistical support can be cited because of the small sample size.

TABLE 8-79

NONPARAMETRIC STATISTICAL TESTS OF SPECIFICITY OF USE (RESEARCH CODE VARIABLE 32) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
6	Rate of Growth of Net Profits (2)	Bhapkar V 4.6545	0.0310
147	Annualized Discounted Present Value Sum (2)	Bhapkar V 2.8543	0.0911

K. Standard Industrial Classification (SIC) Code

The appropriate classification for the new products under the SIC code system were:

		Number of Responses	Group	Percentage
28183	Synthetic Organic Chemicals NEC	6	1	22.22
28185	Ethyl Alcohol and Other Industrial Organic Chemicals NEC	1	2	3.70
28187	Miscellaneous Chemicals and Related Organic Chemicals NEC	1	3	3.70
28188	Miscellaneous Industrial Organic Chemicals NEC	3	4	11.11
28181	Miscellaneous Organic Cyclic Chemical Products	7	5	25.93
28182	Miscellaneous Organic Acyclic Chemicals and Chemical Products	5	6	18.52
281XX	Other 281 codes[1]	4		14.81
		27		100.0

(NOTE: The five digit reporting level for the product classification used.)

[1]Placed in this category to prevent disclosure of true identity.

This breakdown of the chemical products randomly selected for this study illustrates the widespread interest of commercial chemical marketers in a variety of chemical structures having unique end-use patterns. Performance records correlated with standardized chemical nomenclature only in the sense that certain categories of chemical products had wider market acceptances in specific end-use areas and tended to generate higher annualized sales records on the average and, more importantly, to yield higher annualized profits. But managerial actions on charting future business strategies varied extensively, obscuring any possible relationship between discounted cash flows and performance.

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TABLE 8-80

NONPARAMETRIC STATISTICAL TESTS OF STANDARD INDUSTRIAL CLASSIFICATION (SIC) CODE (RESEARCH CODE VARIABLE 133) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
152	Annualized Net Sales (6)	Bhapkar V 23.1325	0.0003
153	Annualized Net Profits (Losses) After Taxes (6)	Bhapkar V 12.0999	0.0334

L. Strategy on Product Differentiation

The number of product offerings for the same end-use was:

	Number of Responses	Group	Percentage
Increased	2	1	7.69
Not changed	24	2	92.31
Decreased	0		0.00
Unknown	1		XXXX
	27		100.0

(NOTE: These are changes in any given year over the last period in the analysis; the median response of all recorded years for any product selected.)

Product evaluators differed considerably over the possible effectiveness of various differentiation alternatives. Roughly one-sixth of the respondents considered that their established strategies provided beneficial outcomes, while the same percentage reported detrimental effects of some sort. One really should group the behavior of products into families having similar end-uses. Although this research design made no effort to investig

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investigate families of products, still product diversification was a demonstrably frequent maneuver in industrial chemical marketing because of the need to meet unique performance requirements. In fact, for nearly 50% of the products studied a similar product had been available for distribution during at least one year of the life cycle under study. At all events, the inadequate median response distribution on diversification strategies prevented any meaningful application of statistical tests.

TABLE 8-81

NONPARAMETRIC STATISTICAL TESTS OF STRATEGY CONCERNING NUMBER OF PRODUCT OFFERINGS FOR SAME END-USE (RESEARCH CODE VARIABLE 45) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (2)	Kruskal-Wallis H 2.3704	0.1237
9	Timing of Profit Cycle (2)	Kruskal-Wallis H 1.7755	0.1827

M. Trends in Gross Margins

Gross margins for the new products had:

	Number of Responses	Group	Percentage
Slightly to strongly increased	5	1	18.52
Not changed	15	2	55.56
Slightly to strongly decreased	7	3	25.92
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

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Chemical products with decreasing gross margins generally displayed superior sales and profit performances (reflected in their adjusted annualized figures). Higher volume products tended to be more susceptible to a cost-price squeeze; and greater absolute profits may still accompany declining margin figures since after all, we are dealing with dynamic, not static situations. This study had originally hypothesized that improved demand positions (i.e., actual shifts in demand) typically grew out of softening price structures, but the previous statistical tests on the pricing variable failed to support this general conclusion.

TABLE 8-82

NONPARAMETRIC STATISTICAL TESTS OF TRENDS IN GROSS MARGINS (RESEARCH CODE VARIABLE 120) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
9	Timing of Profit Cycle (3)	Bhapkar V 4.7548	0.0928
10	Payback Period (3)	Bhapkar V 5.1162	0.0775
13	Return on Investment (3)	Bhapkar V 4.7392	0.0935
152	Annualized Net Sales (3)	Kruskal-Wallis H 9.7058	0.0078
153	Annualized Net Profits (Losses) After Taxes (3)	Kruskal-Wallis H 11.2913	0.0035
154	Critical Turning Point for Present Value Calculations (3)	Kruskal-Wallis H 4.5946	0.1005

N. Type of Product

The new products were best described as:	Number of Responses	Group	Percentage
Chemical products unrelated by process to other products	19	1	70.37
Chemical products related by process to other products, i.e., coproducts or byproducts	8	2	29.63
	27		100.0

Since statistical measures of performance varied little among the types of chemical products marketed, either the product decisions for the related products in question had been considered as independent opportunities, or else equalizing financial criteria had been applied in the evaluation process. Normative decisions would, of course, have weighed the contributions of coproducts and byproducts, but such data were usually disaggregated for reporting purposes.

TABLE 8-83

NONPARAMETRIC STATISTICAL TESTS OF TYPE OF PRODUCT (RESEARCH CODE VARIABLE 130) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
6	Rate of Growth of Net Profits (2)	Kruskal-Wallis H 0.4484	0.5031
153	Annualized Net Profits (Losses) After Taxes (2)	Kruskal-Wallis H 0.2820	0.5954

O. Type of Product Demand

The demand for the new products rested on a:

	Number of Responses	Group	Percentage
Strong necessity	7	1	25.93
Moderate necessity	10	2	37.04
Slight necessity	5	3	18.52
Indifferent to very weak desire	5	4	18.52
	27		100.0

New chemical products considered somehow vital showed no higher consumption in general, because the growth situation which attracted all the major producers into the market generated industry-wide overcapacity, with subsequent losses in unit returns. Technological improvements in manufacturing processes, potentially a source of increased profitability, were often negated by compensatory price reductions designed to stimulate market expansions.

Product strategies formulated around products associated with a slight necessity type demand displayed both higher aggregate sales revenues and above average discounted present value sums as well; such business more often escaped those competitive pressures which depressed performance results at the firm level.

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TABLE 8-84

NONPARAMETRIC STATISTICAL TESTS OF TYPE OF PRODUCT DEMAND (RESEARCH CODE VARIABLE 97) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (4)	Bhapkar V 12.9374	0.0048
3	Aggregate Net Sales (4)	Bhapkar V 15.4085	0.0015
8	Timing of Sales Cycle (4)	Kruskal-Wallis H 9.5103	0.0232

P. Valuation of Byproducts

Annual byproduct valuations were classed as:

	Number of Responses	Group	Percentage
100% of sales or greater	0		0.00
Between 50% and 100% of sales	0		0.00
Between 25% and 50% of sales	0		0.00
Less than 25% of sales	1	1	3.70
Zero	26	2	96.30
	27		100.0

(NOTE: The median yearly byproduct sales as a percentage of gross sales of all recorded years for any product selected.)

The low incidence of attempted byproduct recovery was responsible for the inconclusive results on the statistical tests evaluated, though present concern over water and air pollution will undoubtedly increase future efforts to recover contaminants as byproducts in chemical process industries whenever feasible.

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TABLE 8-85

NONPARAMETRIC STATISTICAL TESTS OF VALUATION OF BYPRODUCTS (RESEARCH CODE VARIABLE 121) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (2)	Kruskal-Wallis H 2.7857	0.0951
3	Aggregate Net Sales (2)	Kruskal-Wallis H 2.3736	0.1234

4. Related Intrafirm Experiences

A. Action Concerning Product Improvements

Were actions taken to underwrite product improvement activities that were fruitful?

	Number of Responses	Group	Percentage
Yes	6	1	22.22
No	21	2	77.78
	27		100.0

(NOTE: This is an analysis of an action taken in a given time period when compared with the previous year in the analysis; the median response of all recorded years for any product selected.)

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Improvements to a product varied its market behavior only subtly: any variations in sales, profits and return patterns could have been explained by chance, though products frequently modified often turned in poorer annualized discounted present value sums, an important discriminant among the classed data. All products studied were grouped according to whether or not improvements were introduced each year on the average. Far too often a new product was introduced prematurely. And failure to meet user specifications meant that product formulations had to be altered for continued improvement in product acceptance. Over 70% of the products in the sample were modified at least once during the portions of their life cycles under study. Some 22% of the products plagued with specification pitfalls underwent numerous improvements and displayed inferior annualized discounted present sums; in fact, only one of these products actually ended with a positive present value figure over its product life span.

TABLE 8-86

NONPARAMETRIC STATISTICAL TESTS OF ACTION CONCERNING PRODUCT IMPROVEMENTS (RESEARCH CODE VARIABLE 55) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
11	Equivalent Rate of Return (2)	Kruskal-Wallis H 1.9592	0.1616
12	Profitability Ratio (2)	Kruskal-Wallis H 2.2993	0.1294
147	Annualized Discounted Present Value Sum (2)	Kruskal-Wallis H 4.9116	0.0267
152	Annualized Net Sales (2)	Kruskal-Wallis H 1.6463	0.1995

B. Basing of Research and Development Program

The research and development program for the new products under study can best be described as:

	Number of Responses	Group	Percentage
Research-based, i.e., products were developed as a result of pure scientific investigation	8	1	29.63
Marketing-based, i.e., products were developed through applied scientific investigation only after user requirements became known	19	2	70.37
	27		100.0

In evaluating the research and development effort, product management could possibly attain a more economical distribution of company resources from marketing-based product investigations. Some evidence suggested that profits related to the orientation of research and development programs, with profits growing significantly faster for products having marketing-based research and development programs. For once a prospective user need had been identified, product management could more efficiently coordinate the development, production and marketing efforts of the firm and meet user specifications, which is thought to have favored profitability. Without conclusive statistical support, then, marketing-based research and development programs tended to have longer profit cycles, higher profitability ratios and shorter critical turning points in present value flows.

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TABLE 8-87

NONPARAMETRIC STATISTICAL TESTS OF BASING OF RESEARCH AND DEVELOPMENT PROGRAM (RESEARCH CODE VARIABLE 123) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
6	Rate of Growth of Net Profits (2)	Bhapkar V 6.5682	0.0104
9	Timing of Profit Cycle (2)	Kruskal-Wallis H 3.5114	0.0610
11	Equivalent Rate of Return (2)	Bhapkar V 2.9942	0.0836
12	Profitability Ratio (2)	Bhapkar V 3.1842	0.0744
13	Return on Investment (2)	Kruskal-Wallis H 2.5376	0.1112
147	Annualized Discounted Present Value Sum (2)	Kruskal-Wallis H 2.2105	0.1371
154	Critical Turning Point for Present Value Calculations (2)	Bhapkar V 3.5819	0.0584

C. Clarity of Product Demand

The demand for the new products was:

	Number of Responses	Group	Percentage
Slightly to clearly understood	24	1	89.88
Indifferent or misunderstood	3	2	11.11
Unknown	0		XXXX
Not applicable	0		XXXX
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

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Performance related in no detectable manner to the general modus operandi of product management; whenever they misread market movements, the organization could alter its approach sufficiently to recover in the marketplace. So a clear understanding of product demand was seldom a determinant of eventual product behavior at the time the decision was made to enter a market. Indeed, after market introduction many modifications can provide more effective marketing coverage according to priorities of existing product opportunities and the relative capital committed prior to the review.

TABLE 8-88

NONPARAMETRIC STATISTICAL TESTS OF CLARITY OF PRODUCT DEMAND (RESEARCH CODE VARIABLE 98) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
5	Rate of Growth of Net Sales (2)	Kruskal-Wallis H 0.7202	0.3961
8	Timing of Sales Cycle (2)	Kruskal-Wallis H 1.8235	0.1769

D. Effectiveness of Channel for Product Flows

The effectiveness of the distribution channel in terms of product flows was rated as:

	Number of Responses	Group	Percentage
Highly effective	10	1	37.04
Moderately effective	9	2	33.33
Slightly effective to ineffective	8	3	29.63
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

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Chemical marketers have generally felt that effective penetration in key accounts in the product life cycle can only be attained if distribution is handled by the manufacturer. This study indeed suggested that products distributed at least partially through distributors tended to have less effective product movement through the channels of distribution. But on the other hand, the level of channel effectiveness did not materially affect the measures of sales, profits, or investment return.

TABLE 8-89

NONPARAMETRIC STATISTICAL TESTS OF EFFECTIVENESS OF CHANNEL FOR PRODUCT FLOWS (RESEARCH CODE VARIABLE 110) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
152	Annualized Net Sales (3)	Kruskal-Wallis H 1.3530	0.5084
153	Annualized Net Profits (Losses) After Taxes (3)	Kruskal-Wallis H 2.4464	0.2943
154	Critical Turning Point for Present Value Calculations (3)	Kruskal-Wallis H 1.9246	0.3820

E. Effect of Supply Capabilities in Developmental Sampling Programs

If the uses of the new products were such that developmental samples were distributed to potential industrial users for evaluation, what effect did the supply capabilities on a commercial basis of the firm have on the user's decision to attempt to evaluate their potential uses in his laboratory?

	Number of Responses	Group	Percentage
Moderately to marked beneficial effect, since firm able to supply most or all user requirements	19	1	70.37
Slight beneficial effect, since firm able to supply good portion of user requirements, or no noticeable effect	8	2	29.63
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

The capability of the firm to supply significant amounts of product to meet user needs at the time the firm was promoting sampling programs was directly related to the growth characteristics of the product. One stimulus to evaluation interest in prospective commercial laboratories—that of stressing the availability of commercial quantities on call—appeared to be a necessary if not sufficient condition for profitable product performance.

TABLE 8-90

NONPARAMETRIC STATISTICAL TESTS OF EFFECT OF SUPPLY CAPABILITIES IN DEVELOPMENTAL SAMPLING PROGRAMS (RESEARCH CODE VARIABLE 75) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
5	Rate of Growth of Net Sales (2)	Bhapkar V 4.6784	0.0305
6	Rate of Growth of Net Profits (2)	Bhapkar V 6.1875	0.0129
154	Critical Turning Point for Present Value Calculations (2)	Bhapkar V 3.4803	0.0621

F. Existence of Licensing Arrangements

In regard to possible licensing arrangements, they were:

	Number of Responses	Group	Percentage
Not considered	26	1	96.30
Investigated as possibilities only	0		0.00
Were acquired by other firms	1	2	3.70
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

Licensing agreements are rapidly becoming important revenue sources both in domestic and international markets; but such trends were not reflected in the present study (covering the 1955-1964 period) sufficiently for statistical analysis.

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TABLE 8-91

NONPARAMETRIC STATISTICAL TESTS OF LICENSING EXPERIENCES (RESEARCH CODE VARIABLE 79) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
147	Annualized Discounted Present Value Sum (2)	Kruskal-Wallis H 2.3736	0.1234
152	Annualized Net Sales (2)	Kruskal-Wallis H 2.3736	0.1234

G. Export Patterns

The approximate percentages of exports to domestic sales for the new products were:

	Number of Responses	Group	Percentage
Between 0.1% and 9.9%	15	1	55.55
10.0% or more	4	2	14.82
Unknown	0		XXXX
Not applicable since no exporting took place	8	3	29.63
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

In an attempt to generate more volume throughput, chemical manufacturers have sometimes sold new products to subsidiary operations in international markets (usually at prices based on marginal cost transfer structures) generally where domestic operating levels were considerably below established capacities. These efforts to expand marketing horizons to international industrial sectors via exports were quite productive.

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New products having sizable export commitments showed longer sales and profit histories as well as greater annualized sales, profits and discounted present value sum figures. Of course, the profit structures improved whenever plants operated at more optimum levels. And significant revenues from export markets over the life cycles of a number of industrial chemical products generated those higher operating cash flows responsible for more favorable critical turning points in net present values.

TABLE 8-92

NONPARAMETRIC STATISTICAL TESTS OF EXPORT PATTERNS (RESEARCH CODE VARIABLE 116) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
8	Timing of Sales Cycle (3)	Kruskal-Wallis H 9.8179	0.0074
9	Timing of Profit Cycle (3)	Kruskal-Wallis H 8.5357	0.0140
10	Payback Period (3)	Kruskal-Wallis H 3.3971	0.1829
11	Equivalent Rate of Return (3)	Kruskal-Wallis H 3.9202	0.1408
147	Annualized Discounted Present Value Sum (3)	Kruskal-Wallis H 6.6737	0.0355
149	Performance Index (3)	Kruskal-Wallis H 3.6614	0.1603
152	Annualized Net Sales (3)	Bhapkar V 13.4473	0.0012
153	Annualized Net Profits (Losses) After Taxes (3)	Bhapkar V 7.4593	0.0240
154	Critical Turning Point for Present Value Calculations (3)	Kruskal-Wallis H 5.1614	0.0757

H. Extent of Plant Capacity Utilization

The percentages of actual operating to existing capacity were on the average:

	Number of Responses	Group	Percentage
Less than 50%	8	1	29.63
Between 50.0% and 69.9%	5	2	18.52
Between 70.0% and 89.9%	5	3	18.52
Between 90.0% and 99.9%	6	4	22.22
100% or more	3	5	11.11
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

Optimum capacity utilization fell somewhere between 70% and 90%, depending on the product and the existing competitive condition: the profit histories of most products under study suggested that the real threats to profit attainment occurred with either slight production over-capacity (less than 10% idle capacity present) or some undercapacity. Competitive pressures in these cases were more severe, causing far greater damage to the earnings stream. Marked overcapacities over prolonged periods of time depressed the equivalent rate of return, profitability ratio, and annualized discounted present value sum figures which in turn discouraged market entry and plant expansion.

TABLE 8-93

NONPARAMETRIC STATISTICAL TESTS OF EXTENT OF PLANT CAPACITY UTILIZATION[1] (RESEARCH CODE VARIABLE 126) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
9	Timing of Profit Cycle (5)	Kruskal-Wallis H 8.2586	0.0826
10	Payback Period (5)	Bhapkar V 15.9995	0.0030
11	Equivalent Rate of Return (5)	Kruskal-Wallis H 13.3095	0.0099
12	Profitability Ratio (5)	Kruskal-Wallis H 12.4173	0.0145
13	Return on Investment (5)	Kruskal-Wallis H 9.2884	0.0543
147	Annualized Discounted Present Value Sum (5)	Kruskal-Wallis H 10.1263	0.0384
154	Critical Turning Point for Present Value Calculations (5)	Bhapkar V 17.5961	0.0015

[1]Measured on an individual product basis at the firm level.

I. Fruits of Research and Development

In regard to the fruits of the research activities related to the new products, the results were:

	Number of Responses	Group	Percentage
Development of new products and/ or discovery of their potential uses	10	1	40.00
Development of new products and discovery of their potential uses in addition to uncovering important technical knowledge in the areas	9	2	36.00
Development of new products or family of new products, discovery of their potential uses and important technical knowledge, and the uncovering of new leads for further important research in the areas	6	3	24.00
Not applicable	2		XXXX
	27		100.0

The evidence rejected the hypothesized relationship between research output and performance; a more comprehensive analytical cost-benefit procedure would be needed to identify such a relationship.

TABLE 8-94

NONPARAMETRIC STATISTICAL TESTS OF FRUITS OF RESEARCH AND DEVELOPMENT (RESEARCH CODE VARIABLE 74) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
6	Rate of Growth of Net Profits (3)	Kruskal-Wallis H 4.1762	0.1239
8	Timing of Sales Cycle (3)	Kruskal-Wallis H 3.3042	0.1917

J. Intensity of the Selling Effort

The strategies concerning the number of sales calls per unit of time in product promotion work were as follows:

	Number of Responses	Group	Percentage
Increased	2	1	7.41
Not changed	23	2	85.19
Decreased	2	3	7.41
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

Few companies deliberately experimented with various sales strategies; though product management knew of specific situations in which select sales-call ratios were altered, they had neither planned nor directed the changes. The field sales force had the final decision on such matters. Certainly prospects should be selected and frequency of calls based on known or estimated business potentials, though all too often such decisions reflect only the personality traits of purchasing agents or the idiosyncrasies of field representatives. Management must control manpower development more effectively to properly implement sales strategies. An inadequate distribution of response patterns relating the intensity of the selling effort to performance was largely responsible for the inconclusive statistical results.

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TABLE 8-95

NONPARAMETRIC STATISTICAL TESTS OF STRATEGY CONCERNING NUMBER OF SALES CALLS PER UNIT OF TIME (RESEARCH CODE VARIABLE 41) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
10	Payback Period (3)	Kruskal-Wallis H 2.8975	0.2349
147	Annualized Discounted Present Value Sum (3)	Kruskal-Wallis H 2.8337	0.2425

K. Investment Patterns

(1) Median Cumulative Investment Requirements

The median cumulative investment requirements required throughout the product life cycles under study:

	Number of Responses	Group	Percentage
$323,000 or less	9	1	33.33
Between $323,000 and $2,500,000	10	2	37.03
$2,500,000 or more	8	3	29.63
	27		100.0
Median	1,279,500.0		
Mean	2,339,360.4		
Standard Deviation	2,912,418.6		

The financial risks associated with new product behavior seemed unrelated to the total investment required to give the manufacturer direct supply capability, though the expected relationships between cumulative

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investment requirements and sales and profit data were substantiated: since higher investment levels usually indicated a broader production base, products with higher authorized investment levels typically registered larger sales and profit figures. But the efficiencies in producing and marketing new chemical products varied so greatly that no other relationship between performance and aggregate investment requirements was statistically significant.

TABLE 8-96

NONPARAMETRIC STATISTICAL TESTS OF MEDIAN CUMULATIVE INVESTMENT REQUIREMENTS (RESEARCH CODE VARIABLE 53) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
152	Annualized Net Sales (3)	Bhapkar V 19.2412	0.0001
153	Annualized Net Profits (Losses) After Taxes (3)	Kruskal-Wallis H 12.5968	0.0018

(2) Median Annual Incremental Investment Requirements

The median annual incremental investment requirements required throughout the product life cycles under study:

	Number of Responses	Group	Percentage
$32,500 or less	9	1	33.33
Between $32,500 and $135,550	9	2	33.33
$135,550 or more	9	3	33.33
	27		100.0

Median	84,000.0
Mean	149,141.1
Standard Deviation	184,357.6

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Statistical tests of performance and incremental investment requirements yielded a somewhat different pattern. Even though the ability to expand production at a heightened pace allowed for greater sales attainment through time, such policies consistently applied over the product life cycle created capital demands far greater than the cash flows generated through market participation and consequently a deferred earnings record over long periods of time, as the inferior present value sum and equivalent rate of return results in the sample reveal.

TABLE 8-97

NONPARAMETRIC STATISTICAL TESTS OF MEDIAN ANNUAL INCREMENTAL INVESTMENT REQUIREMENTS (RESEARCH CODE VARIABLE 54) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (3)	Bhapkar V 18.2454	0.0001
3	Aggregate Net Sales (3)	Bhapkar V 13.5347	0.0012
4	Aggregate Net Profits (Losses) After Taxes (3)	Kruskal-Wallis H 4.1728	0.1241
8	Timing of Sales Cycle (3)	Kruskal-Wallis H 6.3991	0.0408
11	Equivalent Rate of Return (3)	Bhapkar V 6.0054	0.0497
149	Performance Index (3)	Bhapkar V 5.2616	0.0720
154	Critical Turning Point for Present Value Calculations (3)	Bhapkar V 4.8970	0.0864

L. Merger Activities

Mergers, combinations, or the like may directly assist the various functional areas of the business to exploit more completely the marketing opportunities for the new products. The following tactics were used by the respondents:

	Number of Responses	Group	Percentage
Not considered	21	1	77.78
Possibilities explored	6	2	22.22
Formal completion of one or more	0		0.00
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

Many chemical manufacturers regularly explore how possible mergers, combinations, and acquisitions may relate to corporate growth and the creation of more productive, financially rewarding business efforts, often in specific attractive marketing opportunities. Product behavior which fell far below expectations usually precipitated active seeking of merger opportunities, which thus became a defensive weapon used to help reverse poor performance—though no firm statistical conclusions could be drawn.

TABLE 8-98

NONPARAMETRIC STATISTICAL TESTS OF MERGER OR COMBINATION EXPERIENCES (RESEARCH CODE VARIABLE 92) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
147	Annualized Discounted Present Value Sum (2)	Bhapkar V 2.9665	0.0850
152	Annualized Net Sales (2)	Kruskal-Wallis H 2.8605	0.0908

M. Mode of Production

The following listed responses covering production facilities of new products were indicated as representative:

	Number of Responses	Group	Percentage
Separate production facilities	13	1	48.15
Common production facilities	14	2	51.85
	27		100.0

One would expect higher annualized sales in products produced separately, simply because such facilities usually reflect larger potential throughputs capable of being marketed. Since profitability and return measures were statistically invariant across this grouped variable, chemical manufacturers have probably failed to tap the flexibilities and efficiencies of common production facilities as often as they should.

TABLE 8-99

NONPARAMETRIC STATISTICAL TESTS OF MODE OF PRODUCTION (RESEARCH CODE VARIABLE 129) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
152	Annualized Net Sales (2)	Kolmogorov-Smirnov D 0.5549	0.0315
153	Annualized Net Profits (Losses) After Taxes (2)	Kruskal-Wallis H 2.4113	0.1205

N. Plant Capacity Experiences for Family of Related Products

In regard to the firm and its plant facilities to supply the new products and yet remain to supply the needed demands for related products, there was on the average:

	Number of Responses	Group	Percentage
Marked overcapacity, i.e., greater than 20% idle capacity present	3	1	15.79
Moderate overcapacity, i.e., between 5% and 20% idle capacity present	7	2	36.84
Slight overcapacity, i.e., less than 5% idle capacity present	5	3	26.32
No overcapacity or some under-capacity present	4	4	21.05
Not applicable	8	5	XXXX
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

The main problem in balancing production schedules to meet the multiple demand requirements of related products lies in selecting alternative marketing opportunities so as to maximize the overall profit structure. To measure how far decision makers recognize the need to impose price and supply constraints on component products, this study examined the supply characteristics of those new products included after the demands for all related products were met. Profitability measures differed within this grouping, though not as we would expect: those products experiencing marked overcapacities returned higher profits. We may thus conclude that business decisions to produce and market new chemical products were not wholly independent of the projected economic effects of related products.

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TABLE 8-100

NONPARAMETRIC STATISTICAL TESTS OF PLANT CAPACITY EXPERIENCES FOR FAMILY OF RELATED PRODUCTS (RESEARCH CODE VARIABLE 66) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
6	Rate of Growth of Net Profits (5)	Bhapkar V 10.6269	0.0311
10	Payback Period (5)	Kruskal-Wallis H 8.9458	0.0625
11	Equivalent Rate of Return (5)	Kruskal-Wallis H 10.4859	0.0330
13	Return on Investment (5)	Kruskal-Wallis H 8.0921	0.0883
147	Annualized Discounted Present Value Sum (5)	Bhapkar V 19.7136	0.0006
149	Performance Index (5)	Kruskal-Wallis H 9.7052	0.0457
154	Critical Turning Point for Present Value Calculations (5)	Kruskal-Wallis H 9.9223	0.0418

O. Product Concept Acceptance

The general ability of manufacturer representatives to get across the product concept associated with new products and their promotion was rated as:

	Number of Responses	Group	Percentage
Moderately to highly effective	14	1	51.85
Slightly effective to ineffective	13	2	48.15
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

Since industrial buyers tend to make larger purchases than individual consumers, they will presumably evaluate product performance and cost more rationally before making any final purchasing commitments. Thus, the industrial purchasing decision may often hinge on the accurate and effective communication of relevant information from seller to buyer; an understanding of the product concept by users is vitally important in gaining product acceptance. Traditionally within the chemical industry, field coverage is assigned this task.

Where the field representatives' communication of the product concept was rated moderately to highly effective, the performance record of a new product tended to outpace others in timing of the profit cycle and the critical turning point for present value calculations; that is, products experienced profit contributions over a greater number of years during their lifespans, while fewer years were required for products to take on positive net present values. The performance records of products having effective product concept acceptances seemed further to reflect both superior growth rates in profits and in annualized profit results (though the evidence was not conclusive).

TABLE 8-101

NONPARAMETRIC STATISTICAL TESTS OF PRODUCT CONCEPT ACCEPTANCE (RESEARCH CODE VARIABLE 111) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
6	Rate of Growth of Net Profits (2)	Bhapkar V 3.0727	0.0796
9	Timing of Profit Cycle (2)	Kruskal-Wallis H 5.0113	0.0252
153	Annualized Net Profits (Losses) After Taxes (2)	Bhapkar V 2.9915	0.0837
154	Critical Turning Point for Present Value Calculations (2)	Bhapkar V 4.2057	0.0403

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P. Production Run Information

(1) Length of Production Run

The length of the product run for new products on the average was:

	Number of Responses	Group	Percentage
Not on a continuous basis	13	1	48.15
On a continuous basis	14	2	51.85
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

Statistical tests on performance and the length of production runs revealed few significant divergencies. Though not conclusive, those products not scheduled on a continuous basis were more profitable, either because existing capital equipment could be transferred to producing other chemical products, resulting in a better allocation of available resources, or because of selective pricing schemes for lower volume specialty products in different application areas having higher margins.

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TABLE 8-102

NONPARAMETRIC STATISTICAL TESTS OF LENGTH OF PRODUCTION RUN (RESEARCH CODE VARIABLE 125) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
8	Timing of Sales Cycle (2)	Kruskal-Wallis H 2.5696	0.1089
11	Equivalent Rate of Return (2)	Kruskal-Wallis H 2.1193	0.1455
147	Annualized Discounted Present Value Sum (2)	Bhapkar V 2.9915	0.0837
149	Performance Index (2)	Kruskal-Wallis H 2.4113	0.1205
152	Annualized Net Sales (2)	Kolmogorov-Smirnov D 0.7802	0.0005
153	Annualized Net Profits (Losses) After Taxes (2)	Bhapkar V 3.3431	0.0675

(2) Number of Annual Production Runs Scheduled

The number of production runs experienced in the manufacturing of new products was:

	Number of Responses	Group	Percentage
One (with the production being on a continuous basis)	13	1	48.15
One (with the production not being on a continuous basis) to five	8	2	29.63
Greater than five	6	3	22.22
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

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As the demand for a new industrial chemical product gathered momentum, the investment decisions made previously placed definite short-lived limitations on the supply capabilities of the firm. The following performance patterns seemed most decisive. Predictably higher sales and aggregate profit records were established by those products which imposed explicit demands in using separate production facilities. Cash flow patterns, reflecting the time value of money, showed inferior results with products produced on a continuous basis because of the lesser flexibility in plant scheduling. If the utilization rates were high, on the other hand, costly bottlenecks could mar performance. A limited market demand relative to established capacity raised the perplexing issue of whether to accept a substantially reduced output level (generally rather inefficient) in order to prevent a costly shutdown in operations.

TABLE 8-103

NONPARAMETRIC STATISTICAL TESTS OF NUMBER OF ANNUAL PRODUCTION RUNS SCHEDULED (RESEARCH CODE VARIABLE 127) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (3)	Bhapkar V 7.9251	0.0190
3	Aggregate Net Sales (3)	Kruskal-Wallis H 13.5870	0.0011
4	Aggregate Net Profits (Losses) After Taxes (3)	Bhapkar V 8.7892	0.0123
8	Timing of Sales Cycle (3)	Bhapkar V 7.7209	0.0211
9	Timing of Profit Cycle (3)	Kruskal-Wallis H 6.2166	0.0447
12	Profitability Ratio (3)	Kruskal-Wallis H 4.0869	0.1296
154	Critical Turning Point for Present Value Calculations (3)	Kruskal-Wallis H 4.4447	0.1084

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Q. Promotional Media Strategy

Were actions taken to change promotional media?

	Number of Responses	Percentage
Yes	0	0.00
No	27	100.0
	27	100.0

(NOTE: This is an analysis of an action taken in a given time period when compared with the previous year in the analysis; the median response of all recorded years for any product selected.)

Observations in the field clearly suggested that promotional activities were employed defensively to justify media involvement. Most campaigns were thoroughly nonselective, underwriting a shotgun approach in efforts to communicate with potential buyers. No advertising research sought to measure or control responses. All this considered, we can understand why marketing plans rarely included provisions for shifting promotional media to improve the returns on any given promotional expenditure. In any event, the inadequate response distribution for this variable prevented statistical analysis.

R. Promotional Outlay Trends

The promotional outlay trends for the new products under study were:

	Number of Responses	Group	Percentage
Tantamount to a marked rise, since growth rates for promotional outlays at least equal to that of sales	4	1	14.82
Moderate rise, since growth rates of promotional outlays less than that of sales, but remaining positive in increments	7	2	25.92
No change in absolute amounts for promotional outlays	9	3	33.33
Actual decline in absolute amounts or no appropriation for promotional outlays	7	4	25.92
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

One marketing dimension often overlooked or misconstrued, the momentum of demand created by tailored promotional campaigns, may carry over as a valuable resource as long as the original promotional efforts continue to be reinforced. Statistical tests of the influence of promotional outlays were quite conclusive: where promotional outlays grew faster, the annualized net sales, profits, profitability ratio, and annualized discounted present value sum were superior on the average. The critical turning point in present value sum patterns—that is, the point at which a new product adds to earnings after discounted operating flows are matched against discounted investment flows—was generally lower, the greater the relative commitments of promotional funds over the product life cycle. Clearly promotional strategies were instrumental in gaining profitable yet sustainable rates of product acceptance for new industrial chemical products.

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TABLE 8-104

NONPARAMETRIC STATISTICAL TESTS OF OUTLAY TRENDS FOR PRODUCT PROMOTION (RESEARCH CODE VARIABLE 88) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
6	Rate of Growth of Net Profits (4)	Bhapkar V 12.2744	0.0065
9	Timing of Profit Cycle (4)	Bhapkar V 6.8884	0.0755
10	Payback Period (4)	Kruskal-Wallis H 4.6956	0.1955
11	Equivalent Rate of Return (4)	Kruskal-Wallis H 7.6616	0.0536
12	Profitability Ratio (4)	Kruskal-Wallis H 8.3888	0.0386
13	Return on Investment (4)	Kruskal-Wallis H 6.4447	0.0919
147	Annualized Discounted Present Value Sum (4)	Kruskal-Wallis H 14.5469	0.0023
152	Annualized Net Sales (4)	Kruskal-Wallis H 9.8027	0.0203
153	Annualized Net Profits (Losses) After Taxes (4)	Kruskal-Wallis H 10.4853	0.0149
154	Critical Turning Point for Present Value Calculations (4)	Kruskal-Wallis H 9.7115	0.0212

S. Relative Marketing Commitment

Actual marketing expenditures for the new products under study on an annual basis were:

	Number of Responses	Group	Percentage
Less than 5% of net sales	16	1	59.26
Between 5% and 12% of net sales	7	2	25.93
Greater than 12% of net sales	3	3	11.11
Tie situation[1]	1	4	3.70
	27		100.0

(NOTE: Marketing expenditures as all direct and allocated costs, including fixed selling, advertising, purchased marketing research and distribution costs, incurred in the marketing effort to promote the sale of the new products; the median response of all recorded years for any product selected.)

[1]A tie between group 1 and 2 existed when selecting the median response in one product situation, so it was necessary to create an additional class.

By spreading marketing expenditures over larger production outputs, a higher created demand level served to lower unit marketing costs; in practice, higher absolute marketing expenditures were often allocated where sales revenues were high and relative marketing costs were low. Higher equivalent rate of return and annualized present value sum figures, however, came with moderately heavy marketing appropriations, thus suggesting an optimum level of marketing expenditures ranging between 5% and 12% of net sales. Establishing leadership early in the product life cycle helped enhance future market and profit positions, usually through selective and innovative promotional programs.

TABLE 8-105

NONPARAMETRIC STATISTICAL TESTS OF RELATIVE MARKETING COSTS (RESEARCH CODE VARIABLE 23) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
2	Accounting Rate of Return (4)	Bhapkar V 6.5452	0.0879
3	Aggregate Net Sales (4)	Kruskal-Wallis H 8.5985	0.0351
8	Timing of Sales Cycle (4)	Kruskal-Wallis H 5.5406	0.1362
9	Timing of Profit Cycle (4)	Bhapkar V 7.0270	0.0710
11	Equivalent Rate of Return (4)	Bhapkar V 9.9547	0.0190
12	Profitability Ratio (4)	Bhapkar V 8.4689	0.0373
13	Return on Investment (4)	Bhapkar V 6.5452	0.0879
147	Annualized Discounted Present Value Sum (4)	Bhapkar V 10.7737	0.0130

T. Research and Development Expenditure Patterns

(1) Aggregate Research and Development Expenditures

The aggregate research and development expenditures committed in the commercialization of the new products under study were:

	Number of Responses	Group	Percentage
Less than $17,600	5	1	18.52
Between $17,600 and $126,000	5	2	18.52
Between $126,000 and $170,000	5	3	18.52
Between $170,000 and $500,000	6	4	22.22
$500,000 or more	6	5	22.22
	27		100.0
Median	150,000.0		
Mean	453,544.0		
Standard Deviation	782,652.9		

Performance related in no simple manner to research and development expenditures. Despite the limited statistical evidence, however, it appeared generally a danger to commit either too much or too little money to specific projects. Thus, those products that were supported by aggregate research and development expenditures of anywhere between $17,600 and $500,000 tended to produce higher aggregate profits, longer profit cycles, shorter payback periods, higher equivalent rates of return and profitability ratios, and shorter critical turning points for present value calculations than products with expenditures at either extreme. Aggregate discounted present values were maximized with expenditures of between $126,000 and $170,000. The risk associated with research and development funding, not always an increasing function of expenditure levels, was instead reduced only with an optimum expenditure level that was somehow dependent on product type.

TABLE 8-106

NONPARAMETRIC STATISTICAL TESTS OF AGGREGATE RESEARCH AND DEVELOPMENT EXPENDITURES (RESEARCH CODE VARIABLE 21) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (5)	Bhapkar V 18.6194	0.0009
2	Accounting Rate of Return (5)	Bhapkar V 8.1548	0.0861
3	Aggregate Net Sales (5)	Kruskal-Wallis H 8.2159	0.0840
4	Aggregate Net Profits (Losses) After Taxes (5)	Kruskal-Wallis H 10.5598	0.0320
6	Rate of Growth of Net Profits (5)	Kruskal-Wallis H 7.9360	0.0940
9	Timing of Profit Cycle (5)	Kruskal-Wallis H 12.4726	0.0142
10	Payback Period (5)	Kruskal-Wallis H 9.8386	0.0432
11	Equivalent Rate of Return (5)	Bhapkar V 12.3025	0.0152
12	Profitability Ratio (5)	Bhapkar V 11.0247	0.0263
13	Return on Investment (5)	Bhapkar V 8.3142	0.0807
154	Critical Turning Point for Present Value Calculations (5)	Kruskal-Wallis H 10.2967	0.0357

(2) Strategy Concerning Research and Development in Related Areas

The commitments in research and development activities in related areas were:

	Number of Responses	Group	Percentage
Increased	5	1	18.52
Not changed or decreased	22	2	81.48
	27		100.0

(NOTE: These are changes in any given year over the last period in the analysis; the median response of all recorded years for any product selected.)

The sales trends of new industrial chemical products appeared to influence research and development activities in related areas. Industrial chemical firms were willing to make research and development commitments in areas associated with new products having superior growth rates. And although statistical evidence was inconclusive, trends in profitability seemed to influence future research and development efforts similarly.

TABLE 8-107

NONPARAMETRIC STATISTICAL TESTS OF STRATEGY CONCERNING RESEARCH AND DEVELOPMENT IN RELATED AREAS (RESEARCH CODE VARIABLE 51) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
5	Rate of Growth of Net Sales (2)	Kruskal-Wallis H 4.5039	0.0338
6	Rate of Growth of Net Profits (2)	Kruskal-Wallis H 2.4920	0.1144

U. Source of Product Discovery

The original source of the product discovery was:

	Number of Responses	Group	Percentage
Research conducted by firm personnel	18	1	66.67
Research conducted by private individuals	0		0.00
Research conducted by nonprofit institutions	0		0.00
Research conducted by educational institutions	0		0.00
Research conducted by governmental agencies	0		0.00
Research conducted by other industrial firms	9	2	33.33
	27		100.0

As the capital devoted to research by public and private organizations increases, the commercial development process for producing new industrial chemical products can stem from a number of possible discovery sources. A tabulation of discovery sources for products included in the study exposes the tightly structured developmental approach prevalent within the chemical industry; apparently the possibilities of applying important research originally conducted by governmental, educational, and nonprofit institutions have been largely ignored. But as expected, product behavior varied little with the actual source of the product discovery.

TABLE 8-108

NONPARAMETRIC STATISTICAL TESTS OF SOURCE OF PRODUCT DISCOVERY (RESEARCH CODE VARIABLE 132) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
5	Rate of Growth of Net Sales (2)	Bhapkar V 2.9877	0.0839
10	Payback Period (2)	Kruskal-Wallis H 1.6534	0.1985

V. Strategy Concerning Sales Force Size

The sales forces covering the marketing of the new products were:

	Number of Responses	Group	Percentage
Increased	1	1	3.70
Not changed	26	2	96.30
Decreased	0		0.00
	27		100.0

(NOTE: These are changes in any given year over the last period in the analysis; the median response of all recorded years for any product selected.)

Since field representation generally employed nonspecialists who had multiproduct responsibilities, manpower requirements were projected on the basis of expected developments for a composite of existing products, not on the basis of any single new product entry. Thus, no unique patterns emerged; and because of an inadequate response distribution, statistical procedures produced no significant relationships.

TABLE 8-109

NONPARAMETRIC STATISTICAL TESTS OF STRATEGY CONCERNING SALES FORCE SIZE (RESEARCH CODE VARIABLE 39) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
8	Timing of Sales Cycle (2)	Kruskal-Wallis H 2.6608	0.1028
9	Timing of Profit Cycle (2)	Kruskal-Wallis H 2.6924	0.1008

W. Subjective Measure of Success or Failure: A Management Evaluation

Evaluations of the success or failure of the new products were shown as:

	Number of Responses	Group	Percentage
Highly successful	5	1	18.52
Moderately successful	14	2	51.85
Slightly successful	4	3	14.81
Indifferent or failure	4	4	14.81
	27		100.0

(NOTE: The outcome of the product behavior against expected objectives set for the product by management evaluated.)

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Respondents were asked to subjectively rank the relative success of a new industrial chemical product against the predetermined objectives set by the firm. In the pilot phase of this investigative work, respondents were asked to specify the criteria for evaluation. The universal reply was profitability. But since such a direct approach would inevitably bias the responses, statistical tests were instead run on these subjective responses to determine which performance criteria actually correlated with judgments of success. Aggregate net sales correlated most closely with subjective judgments of product success, with the timing of the profit cycle a close second. In descending order of correlation, other performance criteria rated fairly high were as follows: timing of sales cycle, aggregate net profits, and annualized net profits. Having the least agreements with success evaluations were return and discounted cash flow measures. But since such sophisticated financial techniques are used less as inputs in product decisions by top management, it is not surprising to find their acceptance rates rather low.

TABLE 8-110

SPEARMAN RANK CORRELATION TESTS OF SUBJECTIVE MEASURE OF SUCCESS OR FAILURE (RESEARCH CODE VARIABLE 122) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable	Test Statistic (Significance: one-tail)
1	Discounted Present Value Sum	-0.3222 (0.0506)
2	Accounting Rate of Return	-0.3567 (0.0339)
3	Aggregate Net Sales	-0.5995 (0.0005)
4	Aggregate Net Profits (Losses) After Taxes	-0.5455 (0.0016)
5	Rate of Growth of Net Sales	-0.0586 (0.3859)
6	Rate of Growth of Net Profits	-0.0294 (0.4484)
7	Rate of Growth of Losses	0.6325 (0.1838)
8	Timing of Sales Cycle	-0.5565 (0.0013)
9	Timing of Profit Cycle	-0.5714 (0.0009)
10	Payback Period	0.3685 (0.0293)
11	Equivalent Rate of Return	-0.3633 (0.0313)
12	Profitability Ratio	-0.3824 (0.0245)
13	Return on Investment	-0.3580 (0.0334)
17	Rate of Plant Capacity Utilization	-0.1503 (0.2272)
20	Market Share Statistics	-0.1195 (0.2763)

(Continued)

TABLE 8-110

SPEARMAN RANK CORRELATION TESTS OF SUBJECTIVE MEASURE OF SUCCESS OR FAILURE (RESEARCH CODE VARIABLE 122) AGAINST SELECTED PERFORMANCE CRITERIA

(Continued)

Research Code Variable Number	Variable	Test Statistic (Significance: one-tail)
147	Annualized Discounted Present Value Sum	-0.1195 (0.2763)
149	Performance Index	-0.3765 (0.0265)
152	Annualized Net Sales	-0.5687 (0.0010)
153	Annualized Net Profits (Losses) After Taxes	-0.5244 (0.0025)
154	Critical Turning Point for Present Value Calculations	0.4943 (0.0044)

TABLE 8-111

NONPARAMETRIC STATISTICAL TESTS OF SUBJECTIVE MEASURE OF SUCCESS OR FAILURE (RESEARCH CODE VARIABLE 122) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
2	Accounting Rate of Return (4)	Bhapkar V 8.1945	0.0422
5	Rate of Growth of Net Sales (4)	Kruskal-Wallis H 0.8569	0.8358
6	Rate of Growth of Net Profits (4)	Kruskal-Wallis H 4.8156	0.1858
7	Rate of Growth of Losses (4)	Kruskal-Wallis H 1.8000	0.8333
8	Timing of Sales Cycle (4)	Kruskal-Wallis H 9.3232	0.0253
9	Timing of Profit Cycle (4)	Kruskal-Wallis H 9.2001	0.0267
10	Payback Period (4)	Bhapkar V 7.4922	0.0578
11	Equivalent Rate of Return (4)	Bhapkar V 6.5610	0.0873
12	Profitability Ratio (4)	Bhapkar V 7.5543	0.0562
13	Return on Investment (4)	Kruskal-Wallis H 8.1324	0.0434
147	Annualized Discounted Present Value Sum (4)	Kruskal-Wallis H 5.9363	0.1148
149	Performance Index (4)	Bhapkar V 7.5573	0.0561
152	Annualized Net Sales (4)	Kruskal-Wallis H 9.7837	0.0205
153	Annualized Net Profits (Losses) After Taxes (4)	Kruskal-Wallis H 8.3630	0.0391
154	Critical Turning Point for Present Value Calculations (4)	Kruskal-Wallis H 10.5711	0.0143

X. Suitability of Existing Marketing Personnel

The suitability of existing marketing personnel to promote the new products was:

	Number of Responses	Group	Percentage
Moderately suitable to unsuitable, with the requirement of adding a number of new personnel	15	1	55.56
Highly suitable, with the requirement of adding no additional personnel	12	2	44.44
	27		100.0

(NOTE: This is an evaluation at the time of product introduction.)

The time it took to train new personnel to successfully represent a new product and the company varied on a product basis, with typical estimates ranging from several weeks to two years. How far the marketing function might be impaired through inadequate field coverage was suspected to relate to the suitability of the existing marketing structure at the time of market introduction. But this suitability bore no statistical relation to ultimate product performance.

TABLE 8-112

NONPARAMETRIC STATISTICAL TESTS OF SUITABILITY OF EXISTING MARKETING PERSONNEL (RESEARCH CODE VARIABLE 91) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (2)	Bhapkar V 2.8543	0.0911
8	Timing of Sales Cycle (2)	Kruskal-Wallis H 2.6787	0.1017

Y. Technological Specialty Experiences

The technological specialties (i.e., various professionally trained individuals) critical to the success of overcoming any technological barriers existing in the research and development programs for new products were:

	Number of Responses	Group	Percentage
Present in the firm	25	1	92.59
Absent from the firm, but considered a nominal factor, i.e., unimportant to the success or failure of the development program	2	2	7.41
	27		100.0

Large chemical manufacturers either had adequate manpower resources for conducting selected research and development assignments or found little difficulty in their procurement. Consequently, this characteristic showed no variation suggesting a possible determinant of product behavior.

TABLE 8-113

NONPARAMETRIC STATISTICAL TESTS OF TECHNOLOGICAL SPECIALTY EXPERIENCES (RESEARCH CODE VARIABLE 72) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
5	Rate of Growth of Net Sales (2)	Kruskal-Wallis H 1.9286	0.1649
6	Rate of Growth of Net Profits (2)	Kruskal-Wallis H 1.7950	0.1803

Z. Type of Distribution Channel

The types of distribution channels selected for the new products were:

	Number of Responses	Group	Percentage
Direct sale to users	19	1	70.37
Direct sale to users and through distributors with major part sold by the former	6	2	22.22
Direct sale to users and through distributors with equal parts being sold by each	1	3	3.70
Direct sale to users and through distributors with major part being sold by the latter	1	3	3.70
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

The dominant pattern in distribution (70% of the new products) was a direct basis, at least during the time periods under analysis. All products entered the market with some exclusive direct sale capabilities. When labor specialization offers improvements in channel service, competitive pressures may require greater division of the existing distribution structure. Historically, the distribution policies which handle major product flows on a direct sale basis while allowing distributors to handle small lot purchases tend to be more profitable. Industrial chemical products with some distributor sales appeared to have higher discounted present value sums, although the statistical evidence was inconclusive. On the other hand, the few new products which depended heavily on distributor-generated sales demonstrated inferior performance.

TABLE 8-114

NONPARAMETRIC STATISTICAL TESTS OF TYPE OF DISTRIBUTION CHANNEL (RESEARCH CODE VARIABLE 119) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (3)	Bhapkar V 5.8621	0.0533
8	Timing of Sales Cycle (3)	Kruskal-Wallis H 4.5159	0.1046

AA. Type of Fixed Capital Employed

The type of fixed capital equipment used in the production of the new products was typically:

	Number of Responses	Group	Percentage
Single-purpose	5	1	18.52
Combination of single-purpose and multipurpose	11	2	40.74
Multipurpose	11	3	40.74
	27		100.0

Since the statistical tests across this variable failed to discriminate between continuous and noncontinuous production run experiences, few performance results showed any relation to the types of fixed capital equipment employed in producing new industrial chemical products.

Single-purpose equipment turned out generally to be more productive, presumably because of its relative efficiencies when operating at optimum production levels. Any selection of multipurpose equipment probably reflected higher relative risks in capital appropriations, even when contingency plans were immediately available.

TABLE 8-115

NONPARAMETRIC STATISTICAL TESTS OF TYPE OF FIXED CAPITAL EMPLOYED (RESEARCH CODE VARIABLE 124) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
1	Discounted Present Value Sum (3)	Kruskal-Wallis H 3.2883	0.1932
3	Aggregate Net Sales (3)	Kruskal-Wallis H 7.4644	0.0239
4	Aggregate Net Profits (Losses) After Taxes (3)	Kiefer T 3.0842	0.0475
9	Timing of Profit Cycle (3)	Kruskal-Wallis H 3.6026	0.1651
154	Critical Turning Point for Present Value Calculations (3)	Kruskal-Wallis H 4.7768	0.0918

BB. Types of Marketing Representatives Utilized

Several types of marketing representatives may have been used to gain and maintain product acceptance. The following strategies were used:

	Number of Responses	Group	Percentage
Regular sales force	17	1	62.96
Combination of regular sales force and special marketing development groups	8	2	29.63
Marketing development groups	2	3	7.41
	27		100.0

(NOTE: The median response of all recorded years for any product selected.)

The organizational structure handling the technical and marketing efforts in developing a new product varied within the industry, and even at various departmental, business, and product levels within the same organization; and some chemical manufacturers reviewed each marketing program before deciding on the type of field coverage best suited for the situation. Sometimes an existing marketing structure was scrapped in favor of a radically different plan. Often in that case the regular sales force took over operational control from the development people once a significant sales volume was reached. But no statistical evidence suggested that one type of representative structure outperformed another; instead, product acceptance more likely varied with the extent and caliber of marketing representation.

TABLE 8-116

NONPARAMETRIC STATISTICAL TESTS OF TYPES OF MARKETING REPRESENTATIVES UTILIZED (RESEARCH CODE VARIABLE 131) AGAINST SELECTED PERFORMANCE CRITERIA

Research Code Variable Number	Variable (Number of k-Classes)	Test Statistic	Significance
3	Aggregate Net Sales (3)	Kruskal-Wallis H 1.3601	0.5066
8	Timing of Sales Cycle (3)	Kruskal-Wallis H 3.6833	0.1586

Types of Sales Patterns

Three basic configurations emerged in the sales patterns for new industrial chemical products where error could be held within a tolerable level for representative forms of sales distributions, using the following suggested classification scheme: (I) Conventional, (II) Linear, and (III) Rapid Penetration.

TABLE 8-117

IDENTIFIED SHAPES OF SALES PATTERNS

Type		Frequency	Percentage
I	Conventional Product Life Cycle Model	11	40.74
II	Linear Model	4	14.81
III	Rapid Penetration Model	12	44.44
		27	100.0

The most common shape appearing from the products comprising our research sample was the rapid penetration model, a product life cycle having strong initial market acceptance. This pattern typically culminated successful efforts in tailoring a specific chemical product to a largely known, but unmet market need. Early recognition of end-use applications in the development stage was essential if the production and marketing capabilities of the firm were to keep pace with each other. When, later in the product's history, its displacement of competing chemical products in given applications was virtually complete, growth was sustained only by expanding the markets for the finished products themselves. If profitability remained above average through the product's maturity, other manufacturers were typically attracted to its marketing, forcing industry-wide overcapacity and price weakening. Once strong competitive pressures were felt, declining revenues for the chemical product at the industry level usually signaled a reduction in earnings at the firm level even to the point of loss in cases where competitive forces became destructive.

Nearly as many product histories displayed a conventional product life cycle shape as took the form of the rapid penetration model. The shape and stages of market development for this concept, already adequately discussed in Chapter II, will not be further elaborated. The remaining model had a form easily treated—a straight line. Even though the linear model characterized only four of the 27 product cases studied, any other description of these four would have markedly distorted the research findings.

Most important, the three types revealed no measurable statistical differences at the 0.05 level in all performance variables with two exceptions, trends in sales data and the payback period (Variables 5 and 10 in Table 8-118). Of course, the growth rates of net sales differed among the three shapes of sales distributions since the shapes were determined by the realized sales through time. On the average, the linear model showed the most spectacular sales growth, followed by the conventional product life model; the rapid penetration model demonstrated a far less dramatic growth record than the other two.

Plant and equipment facilities appeared to be utilized more optimally from the first for those products where demand tracked a high penetration pattern, as long as the existing plant capacities were of the proper order of magnitude. Since it was not really feasible to construct separate production facilities on a sliding scale fitted to meet expected changes in demand over time, the typical payback period for this type of demand model was statistically shorter as suggested by the mean rank results of Variable 10 disclosed in Table 8-118.

The commentary appearing below is based solely on empirical research and, not having passed the rigors of statistical inference, cannot be generalized. The inability to adequately score most of the variables tested against the three general sales configurations for this pass was a serious limiting factor in analyzing statistically important relationships. However, the mean rank in each group for any variable after the data are pooled is reported in Table 8-118; this relationship shows the average ranked position of the scored data in any group relative to the overall experience of all products on that variable and is cited as documentation for the trends in outcomes described in the discussion. The data are grouped similarly to that reported in the previous section which treated the possible determinants of product performance. The actual scores assigned to the responses were the same reference numbers shown in the research document next to the individual questions (see Appendix D). The scored data were then ranked from high negative values to high positive values in ascending numerical order and corrected for ties for the purpose of calculating the mean ranks for each group. In the start at least, nonlinear sales distributions generated an over-extension of industry-wide capability to supply the products than did linear sales distributions; linear growth patterns did not spur expectations to the point of oversupply.

Products following the linear model had below average shares of the market through time. Competition took the form of a direct confrontation with a fairly large number of other products, but marketing resources were not strained to the point of spiraling marketing and distribution costs. Price was less a determinant of market penetration in the rapid penetration and linear models than in the conventional model, where internal marketing strategies more often than not dictated price declines in attempts to improve market positions. Evaluators gave the impression that price stability in the linear model situation was quite beneficial to product performance.

The rapid penetration model characterized a large proportion of minor consuming industries. Even though product requirements in any such end-use application were limited, a significant number of different end-uses could create a rapid, stable and diverse growth in product demand. Uses were relatively nonspecific, and the lower percentage of users evaluating the products in their laboratories might account for their early arrival at the maturity stage.

Greater technological obstacles blocked the entry of competitors with products displaying a conventional product life cycle pattern, explaining the fewer direct competitors vying on the average for the product demand thus created. But chemical product specifications were better matched with market requirements where linear models appeared than with the other two.

We found no evidence suggesting that recognition by industrial users played any discernible role in product performance. Yet the rapid penetration model products were more easily recognized by users. Those products most innovative from either a technological or a marketing standpoint had product life cycles of the conventional pattern, while the least innovative products followed a linear demand schedule through time.

New chemical products characterized by a linear demand model affected the sales of other commodity or special industrial products more markedly, an important revenue consideration.

Conventional life cycle products required more direct field representation and more company contacts before the sales were concluded than rapid penetration life cycle products, and linear model case histories required less. Products related by process to other products tended to a rapid penetration product life cycle; coproducts and byproducts were naturally carefully evaluated before the initial product was marketed, and the pricing and return decisions were not made solely on the merits of one product alone. And the linear model characterized products whose source of product discovery had been outside the firm, mainly by research personnel employed in laboratories of other industrial firms.

In summary, then, new industrial chemical products with a conventional product life cycle shape had on the average higher plant utilization rates, greater dependence on price as a decision variable, higher technological barriers to entry, more innovation behind the commercial development effort, and higher requirements for field representation. Products with a typical linear demand schedule had higher industry-wide utilization rates, below average market participation, closer matches between product performance and market requirements, greater chance of discovery outside the company, and more apparent synergistic effects on the sales of related products. Finally, the rapid penetration model characterized products having a greater number of consuming industries, more general end-use patterns, fewer user laboratory evaluations, and easier recognition of product advantages.

TABLE 8-118

RANKING RESULTS OF SELECTED VARIABLES AGAINST THE TYPES OF SALES PATTERNS (RESEARCH CODE VARIABLE 150)

Research Code Variable Number	Variable	Type	Rank Sums	Mean Rank
1	Discounted Present Value Sum	I	129.0	11.7
		II	63.0	15.8
		III	186.0	15.5
2	Accounting Rate of Return	I	124.0	11.3
		II	50.0	12.5
		III	204.0	17.0
3	Aggregate Net Sales	I	137.0	12.5
		II	46.0	11.5
		III	195.0	16.3
4	Aggregate Net Profits (Losses) After Taxes	I	144.0	13.1
		II	39.0	9.8
		III	195.0	16.3
5	Rate of Growth of Net Sales	I	178.0	16.2
		II	84.0	21.0
		III	116.0	9.7
6	Rate of Growth of Net Profits	I	99.0	12.4
		II	40.0	20.0
		III	114.0	9.5
7	Rate of Growth of Losses	I	9.0	3.0
		II	1.0	1.0
8	Timing of Sales Cycle	I	185.0	16.8
		II	42.5	10.6
		III	150.5	12.5
9	Timing of Profit Cycle	I	119.0	13.2
		II	29.0	7.3
		III	177.0	14.8
10	Payback Period	I	196.0	17.8
		II	65.0	16.3
		III	117.0	9.8

(Continued)

TABLE 8-118

RANKING RESULTS OF SELECTED VARIABLES AGAINST THE TYPES OF SALES PATTERNS (RESEARCH CODE VARIABLE 150)

(Continued)

Research Code Variable Number	Variable	Type	Rank Sums	Mean Rank
11	Equivalent Rate of Return	I	123.0	11.2
		II	56.0	14.0
		III	199.0	16.6
12	Profitability Ratio	I	127.0	11.5
		II	58.0	14.5
		III	193.0	16.1
13	Return on Investment	I	130.0	11.8
		II	53.0	13.3
		III	195.0	16.3
20	Market Share Statistics	I	174.5	15.9
		II	40.0	10.0
		III	163.5	13.6
22	Mean Yearly Research and Development Expenditures	I	190.5	17.3
		II	52.0	13.0
		III	135.5	11.3
27	Direct Competitive Situation	I	110.0	10.0
		II	76.0	19.0
		III	192.0	16.0
30	Number of Major Consuming Industries	I	154.5	14.0
		II	56.0	14.0
		III	167.5	14.0
31	Number of Minor Consuming Industries	I	122.5	11.1
		II	44.0	11.0
		III	211.5	17.6
32	Specificity of Use	I	134.5	12.2
		II	52.5	13.1
		III	191.0	15.9
45	Strategy Concerning Number of Product Offerings for Same End-Use	I	146.5	13.3
		II	30.5	10.2
		III	174.0	14.5

(Continued)

TABLE 8-118

RANKING RESULTS OF SELECTED VARIABLES AGAINST THE TYPES OF SALES PATTERNS (RESEARCH CODE VARIABLE 150)

(Continued)

Research Code Variable Number	Variable	Type	Rank Sums	Mean Rank
51	Strategy Concerning Research and Development in Related Areas	I	163.0	14.8
		II	25.0	6.3
		III	190.0	15.8
63	Action Regarding Price Changes	I	135.5	12.3
		II	59.5	14.9
		III	183.0	15.3
64	Effect of Action Regarding Price Changes	I	157.0	14.3
		II	68.5	17.1
		III	152.5	12.7
65	Industrial Plant Capacity Experiences	I	137.0	12.5
		II	95.0	23.8
		III	146.0	12.2
76	Percentage of User Laboratory Evaluation	I	119.0	10.8
		II	55.0	13.8
		III	204.0	17.0
78	Duplication Difficulties by Competitors	I	121.5	11.0
		II	62.5	15.6
		III	194.0	16.2
79	Licensing Experiences	I	148.5	13.5
		II	67.5	16.9
		III	162.0	13.5
81	Recognition Experiences of Product Advantages by Users	I	128.0	11.6
		II	47.0	11.8
		III	203.0	16.9
83	Matching of Technological Characteristics with Market Requirements	I	174.0	15.8
		II	26.0	6.5
		III	178.0	14.8

(Continued)

TABLE 8-118

RANKING RESULTS OF SELECTED VARIABLES AGAINST THE TYPES OF SALES PATTERNS (RESEARCH CODE VARIABLE 150)

(Continued)

Research Code Variable Number	Variable	Type	Rank Sums	Mean Rank
84	Degree of Marketing Innovativeness	I	126.0	11.5
		II	70.5	17.6
		III	181.5	15.1
85	Degree of Technological Innovativeness	I	118.0	10.7
		II	78.5	19.6
		III	181.5	15.1
87	Effect on Sales of Related Products	I	140.0	12.7
		II	78.5	19.6
		III	159.5	13.3
89	Dependence on Contact By Company Representatives	I	134.0	12.2
		II	74.0	18.5
		III	170.0	14.2
95	Market Trends	I	118.5	10.8
		II	81.0	20.3
		III	178.5	14.9
113	Number of Contacts Required by Marketing and Technical Personnel	I	181.5	16.5
		II	42.5	10.6
		III	154.0	12.8
126	Extent of Plant Capacity Utilization	I	185.0	16.8
		II	57.5	14.4
		III	135.5	11.3
130	Type of Product	I	123.5	11.2
		II	53.5	13.4
		III	201.0	16.8
132	Source of Product Discovery	I	145.0	13.2
		II	78.5	19.6
		III	154.5	12.9

Shape and Timing of Sales Patterns

In addition to the shape of the product life cycle, we may employ the time elapsed before a maximum in the sales distribution is reached as a criterion for classifying new products. This practice enables us to reduce relative differences within groups still further, quite important to the evaluator. All 27 new industrial chemical products were assigned to one of five groups under the scheme presented in the following table.

TABLE 8-119

IDENTIFIED SHAPES AND TIMINGS OF SALES DISTRIBUTIONS

Group		Number of Assigned Products	Percentage
I	Conventional Product Life Cycle Model: maximum reached in three years or less, followed by declines in sales of two or more consecutive years	6	22.22
II	Extended Conventional Product Life Cycle Model: maximum reached in four years or more	5	18.52
III	Linear Model	4	14.81
IV	Rapid Penetration Model: maximum reached in seven years or less	4	14.81
V	Extended Rapid Penetration Model: maximum reached in eight years or more	8	29.63
		27	100.0

We may now examine the product histories in order to gain a better understanding of the decision variables and how they influence outcomes. The observations discussed in this section are not for the most part based on statistically proven results since most group variables were not effectively scored. The approach used in this commentary is the same used in analyzing the three basic types of sales patterns just covered in the previous section. The mean rank in each group for any variable is listed in Table 8-120. As is true with the three types of sales patterns, the importance of the shape and timing of sales distributions will be statistically supported in some of the multivariate models presented in the next chapter.

1. Group I: Conventional Product Life Cycle Model

The Group I model depicted the introduction of a new product not unique in the marketplace. After factoring in the lag which allowed production facilities to reach full output, the timing of market introduction was vindicated in a spectacular increase in industry demand during the second year. The momentum of expanding product commitments continued for the firm in the third year despite a period of consolidation in industry sales. After industrial demand peaked in the fifth year, its impact on product performance was marked. There were probably no major lagged effects of product movement at the firm level on industry-wide demand, although the evidence was not conclusive. No authorization for even partial disinvestment was issued until after three years of declining product sales simply because the product's future behavior was uncertain. Hedged against a downturn, the product continued to be profitable during the entire decline phase studied with reductions in negative present value sum results being continuous beyond the sixth year, as shown graphically in Figure 8-3.

When matched against achieved sales levels, the research and development expenditure requirements were the largest here of the five groups (see Figure 8-1); though initial investments were heavy, the year 3-8 period required continued support to enhance the marketing effort.

Planned marketing was curtailed after the product's market position changed radically. Coupled with the slack in product acceptance at the firm level, industry-wide weaknesses further discouraged future involvement. Cost-benefit relationships for many research and development investigations remain difficult to quantify. The research and development expenditures were higher with products classed in this group, but so was the productivity of research programs. A greater number of other chemical products and processes was discovered during the routine work, and many chemical phenomena with no immediately perceptible commercial value were explained.

Only the conventional life cycle pattern of demand experienced a successful bolstering of field sales forces through time, a strategy rated by evaluators as quite instrumental in expanding market participation during the growth phase of the product life cycle. Conventional patterns also typified products which the highest average number of users subjected to laboratory evaluation; and user interest in specific applications was quite high and widespread.

Product histories of this group possessed more technological and legal barriers to market entry, yet competitive laboratories often succeeded in overcoming these difficulties and were able to enter products later in the life cycle. Since the conventional life cycle patterned products were not well matched with the requirements of the marketplace, we would expect to see in them the early decline phase associated with this demand pattern, in spite of the high innovation ratings a majority of these products achieved.

Figure 8-1

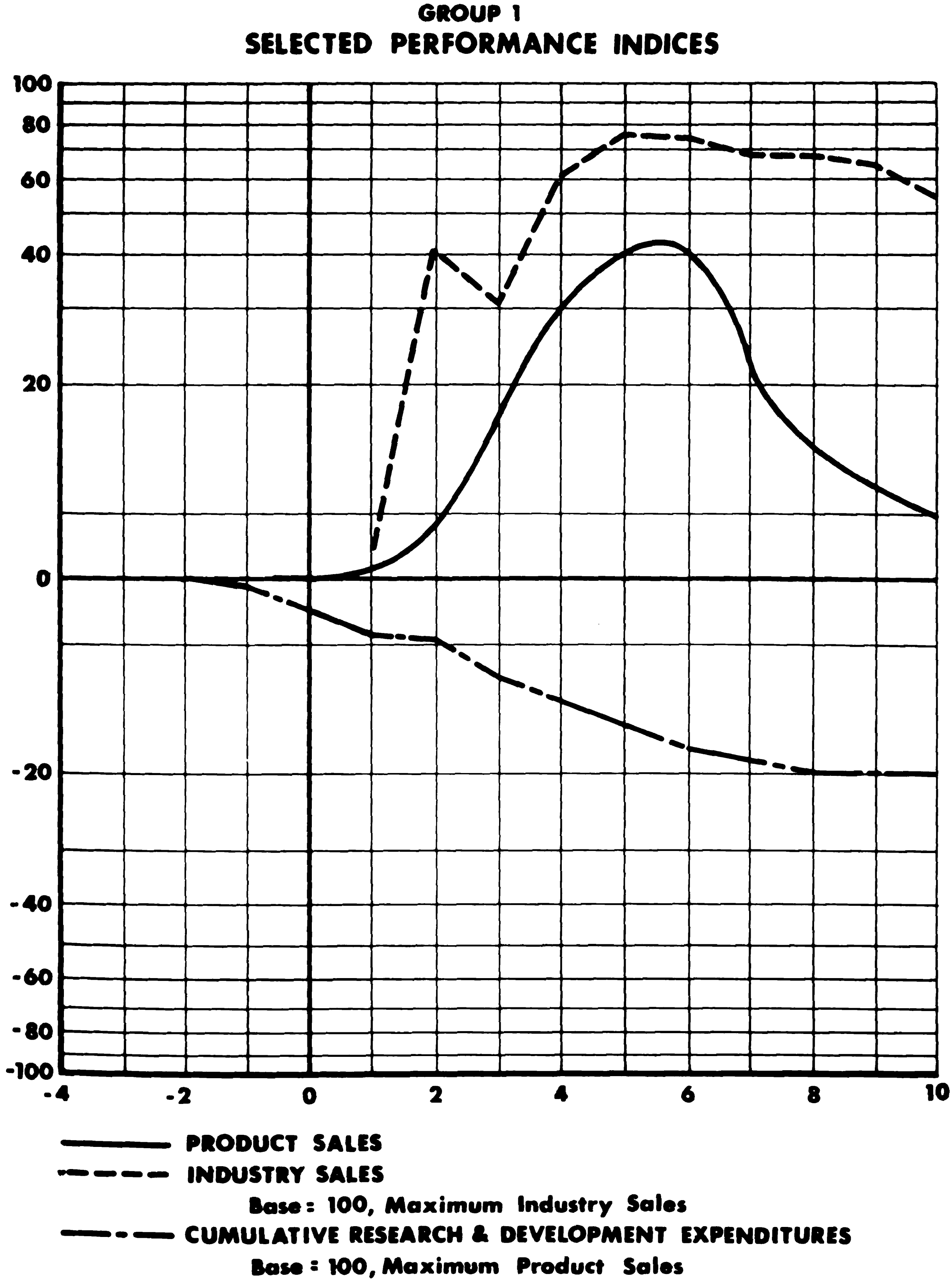

GROUP 1
SELECTED PERFORMANCE INDICES
100
80
60
40
20
0
-20
-40
-60
-80
-100
-4
-2
0
2
4
6
8
10
PRODUCT SALES
INDUSTRY SALES
Base: 100, Maximum Industry Sales
CUMULATIVE RESEARCH & DEVELOPMENT EXPENDITURES
Base: 100, Maximum Product Sales

Figure 8-2

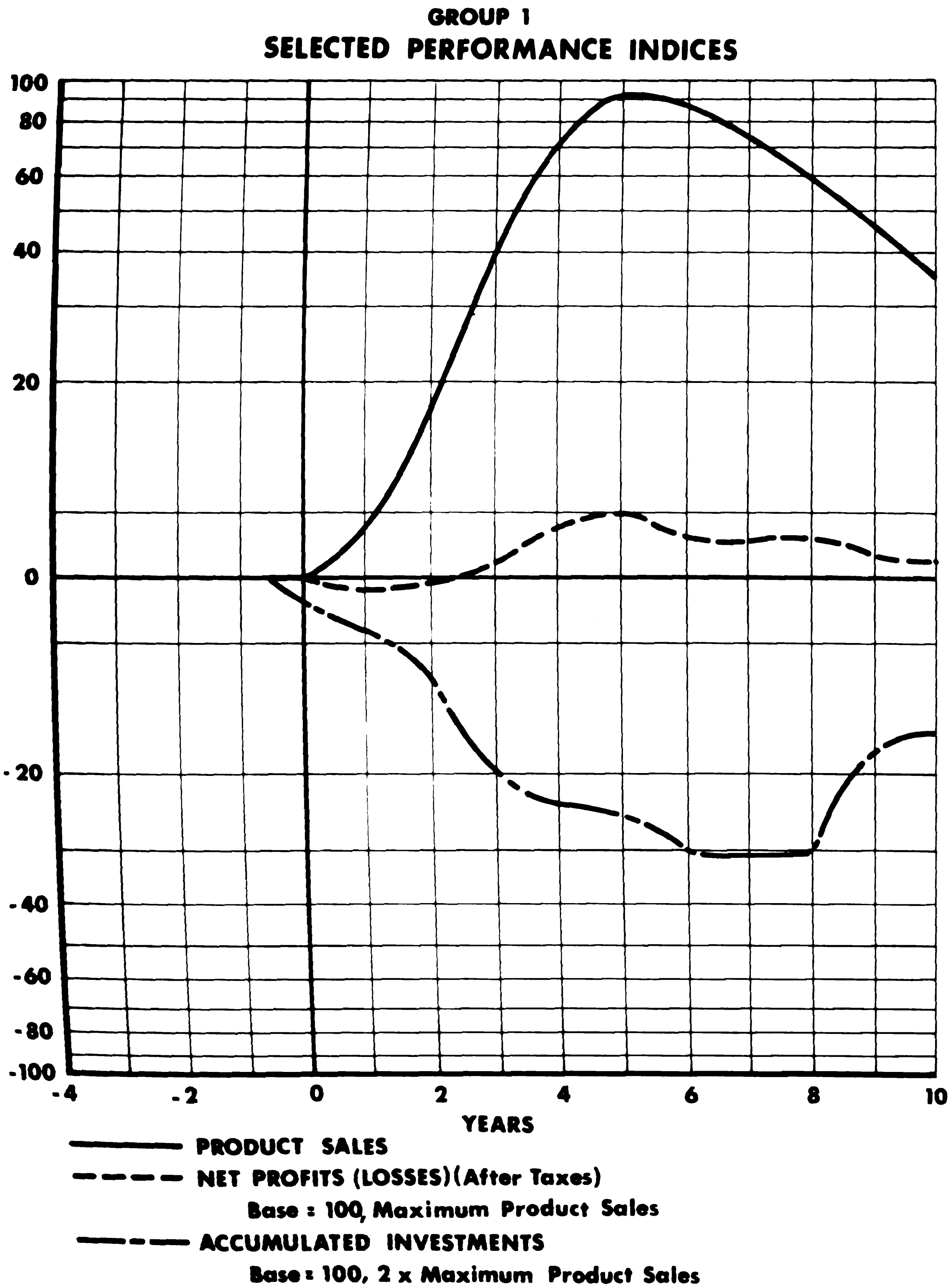
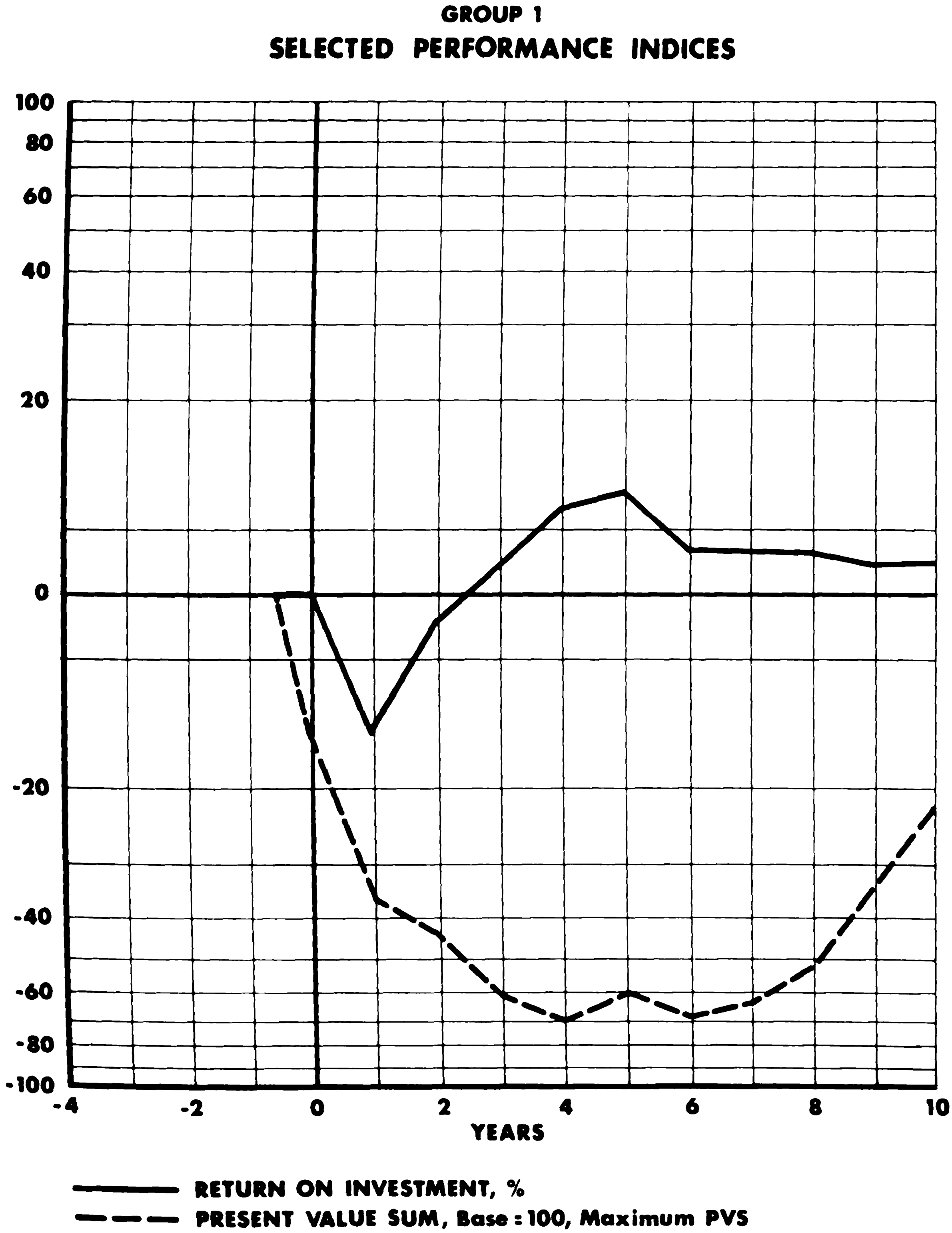

GROUP 1
SELECTED PERFORMANCE INDICES
100
80
60
40
20
0
-20
-40
-60
-80
-100
-4
-2
0
2
4
6
8
10
YEARS
PRODUCT SALES
NET PROFITS (LOSSES)(After Taxes)
Base = 100, Maximum Product Sales
ACCUMULATED INVESTMENTS
Base = 100, 2 x Maximum Product Sales

Figure 8-3


GROUP 1
SELECTED PERFORMANCE INDICES
100
80
60
40
20
0
-20
-40
-60
-80
-100
-4
-2
0
2
4
6
8
10
YEARS
RETURN ON INVESTMENT, %
PRESENT VALUE SUM, Base = 100, Maximum PVS

2. Group II: Extended Conventional Product Life Cycle Model

The firm, not an exclusive marketer of any typical new industrial chemical product included in Group II, managed to maintain a dominant market position throughout the product history. Those noticeable inroads by competitors created few serious long term problems since the firm was capable of regaining all lost ground within any two year interval. An examination of the sales record over the entire product life cycle revealed greatest typical growths in net sales with products having either linear or extended conventional product life cycle patterns; and these products showed no decline phase, giving them a clear edge.

The firm paid an onerous price for maintaining this product leadership. Only after two years from introduction did the product show a positive return on investment, and that a relatively nominal one. Industry production was plagued by continual overcapacity, causing excessive unit manufacturing costs added to the above average marketing costs for initiating and sustaining growth. According to this analysis, profit residuals did not take off until the last two years (see Figure 8-5).

Conventional life cycle products required the most research and development, and it is entirely possible that an acceleration of development work before a product is introduced could enhance product acceptance. A latent market response may appear whenever evaluation of vital research and development commitments depends on the inputs of existing sales performance figures. Certainly any delays in sponsoring needed programs are bound to leave untapped revenue streams, damaging particularly to the growth phase.

Figure 8-4

GROUP 2

SELECTED PERFORMANCE INDICES

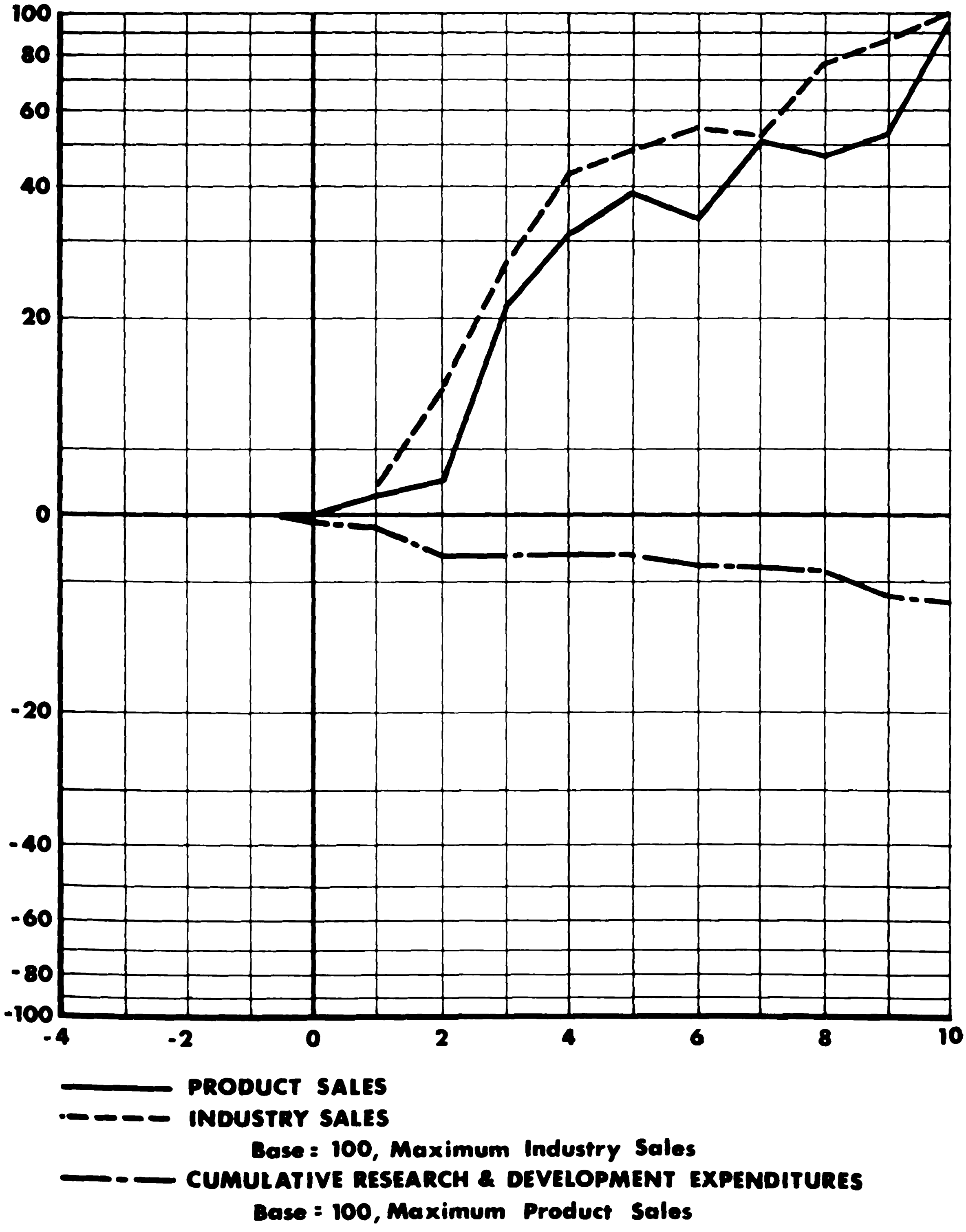


Figure 8-5

GROUP 2

SELECTED PERFORMANCE INDICES

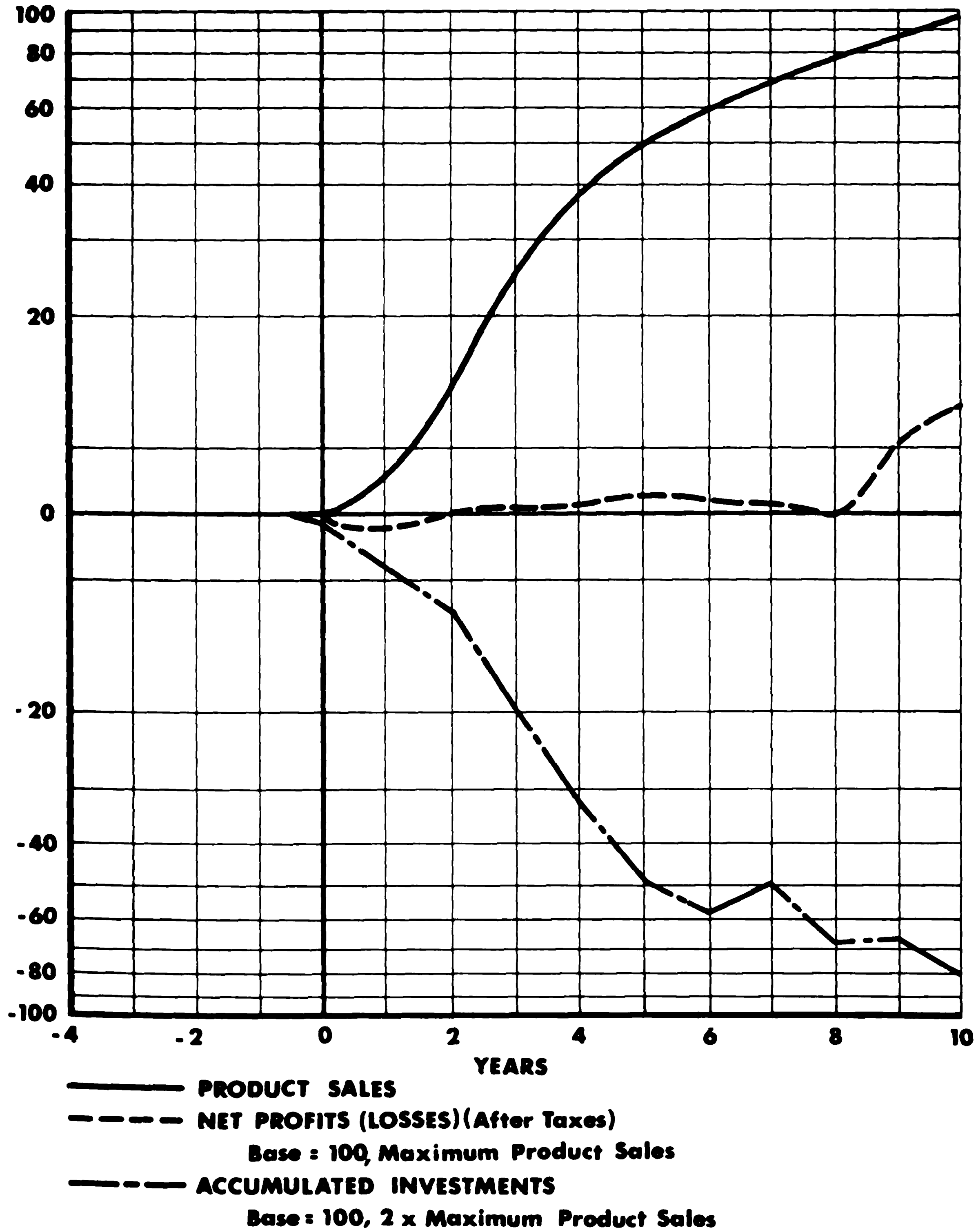
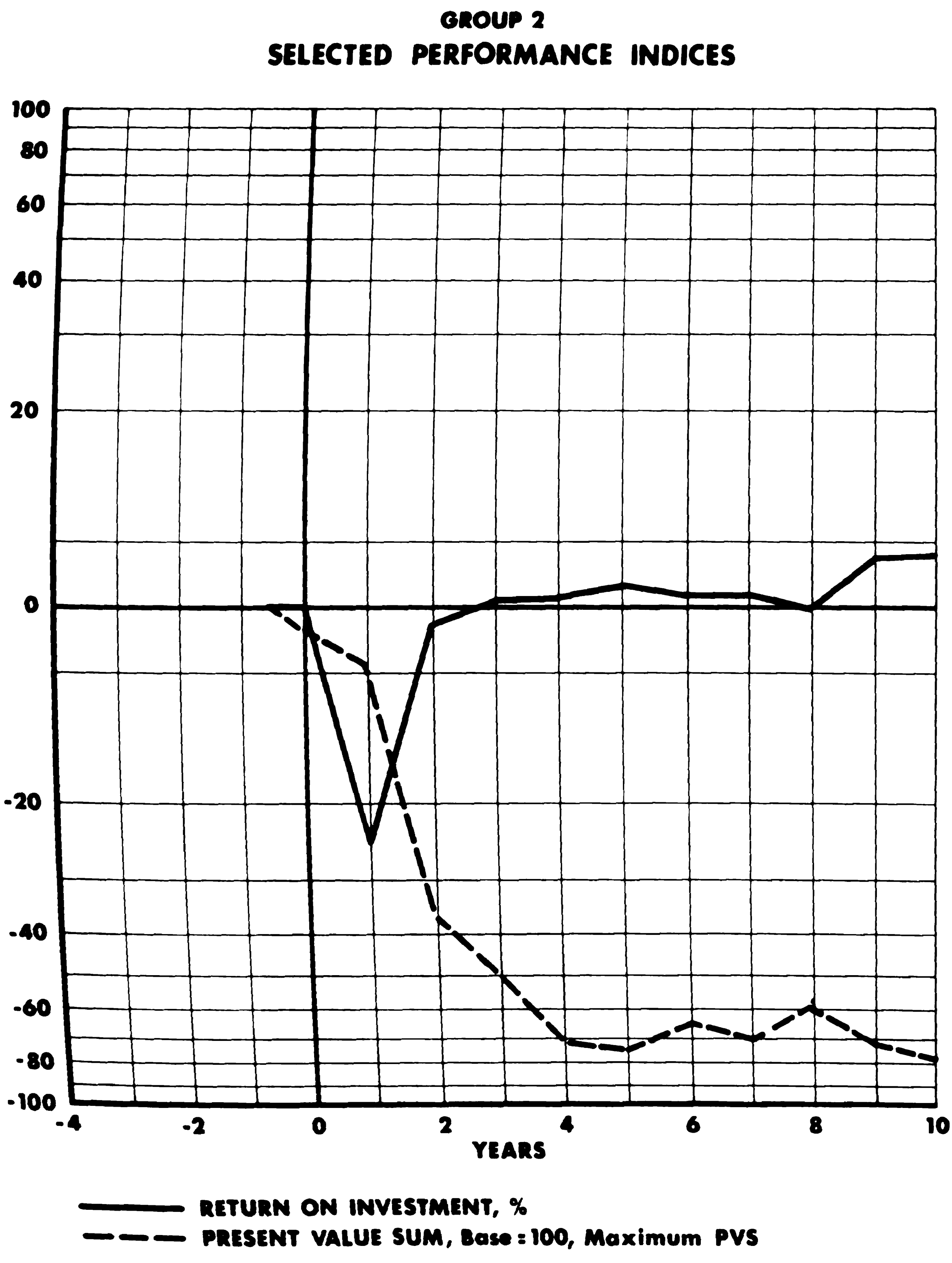


Figure 8-6


GROUP 2
SELECTED PERFORMANCE INDICES
100
80
60
40
20
0
-20
-40
-60
-80
-100
-4
-2
0
2
4
6
8
10
YEARS
RETURN ON INVESTMENT, %
PRESENT VALUE SUM, Base = 100, Maximum PVS

3. Group III: Linear Product Life Cycle Model

In Group III, consistent growth in sales revenues through time allowed those new industrial chemical products demonstrating linear demand relationships (when compared to the performance records of our population) to attain the highest averages in both sales and profit patterns. The challenge to establish a market position in an existing product field placed a substantial drain initially on capital resources. Many manufacturers felt that more business alternatives are open to them if an economical production process is found, since economies of scale come with the capability to obtain large volumes of throughput. Such products usually required a large capital expenditure before the market introductory phase.

The products showed considerable overall success in market penetration: positions between competitive firms seemed to have stabilized by the fifth year, the true competitive strengths and weaknesses of chemical manufacturers in the new product field being established by that time. Initial successes were derived from long-run contractual agreements between buyers and the seller, often established before making the final decision on the capital budgeting proposal necessary to provide the firm with production capability.

Following the strategy of contractual dependence, this type of business, though the most directly competitive, required substantially lower relative marketing expenditures to develop and sustain account business. Products typically generated large volume and high unit dollar value, allowing marketing costs to be spread over a larger unit base. A favorable matching of technological characteristics with market requirements, moreover, contained a lesser need for field representation.

Except for the first several years in the product life cycle, plant utilization was at economical levels. And because firms were willing to accept only average returns on their investments, particularly for commodity type business, the payback periods for this group of products were comparatively longer. But even though research and development expenditures for these new industrial chemical products with linear demand patterns were not too demanding, the attained business with its consistent growth trends did encourage research and development work in related areas so large industrial chemical manufacturers took advantage of their respective resource capabilities by supporting investigative programs having promising commercial value.

Future technological advancements for the firm seemed to depend heavily on the relative profitabilities of its existing investments. But there was little evidence among producing firms of effective long-range planning in investment strategy. Far too often firms were faced with industry-wide plant overutilization, possibly improving relative profit structures in the long run, though they lost many opportunities to obtain additional profitable business. Product management should seek an awareness of likely capacity developments years in advance if it is to formulate effective investment policies. Some firms (the exceptions) did examine historical and expected demand and supply balances rigorously and used these as inputs in the investment decision-making process.

Figure 8-7

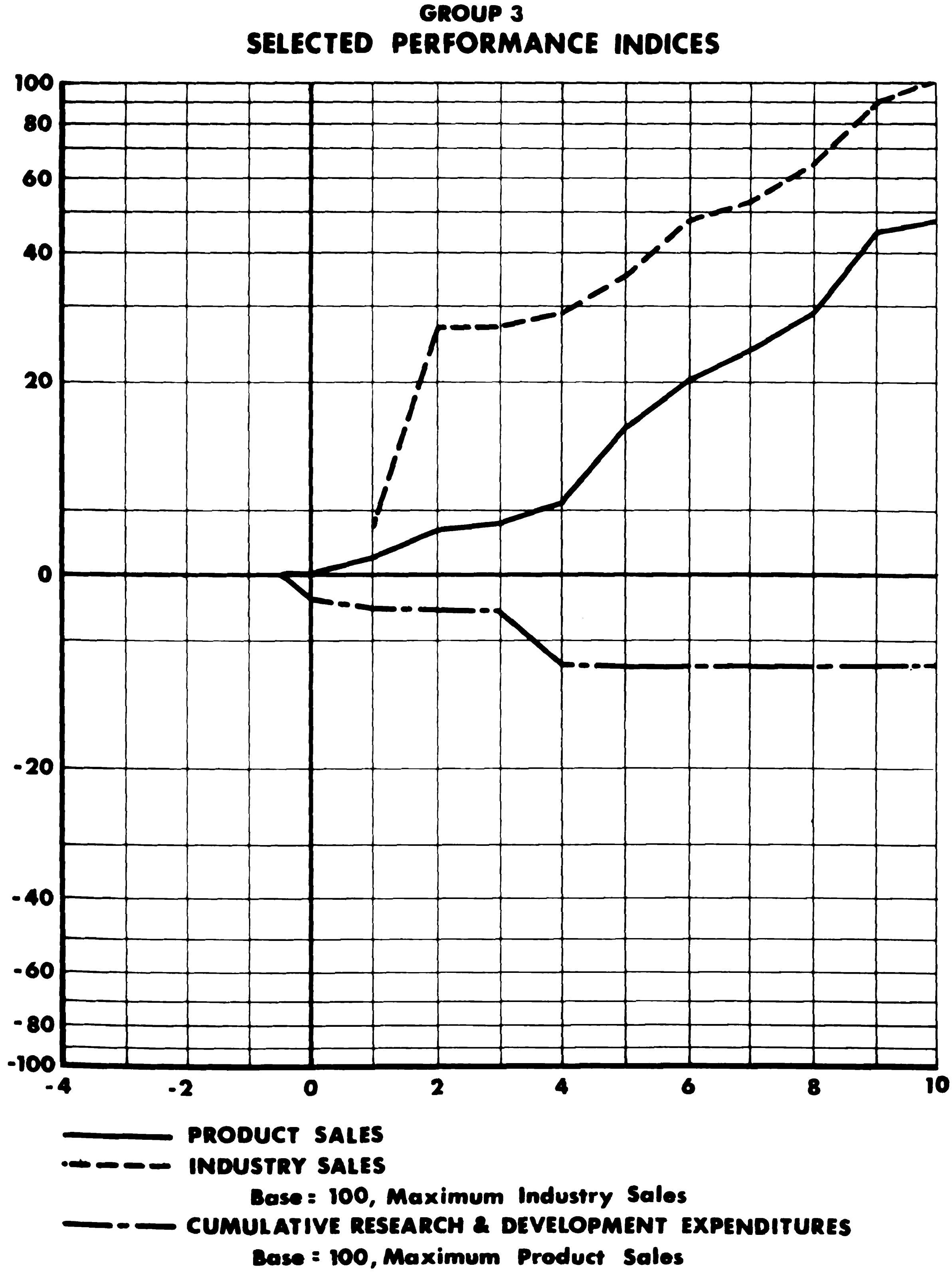

GROUP 3
SELECTED PERFORMANCE INDICES
100
80
60
40
20
0
-20
-40
-60
-80
-100
-4
-2
0
2
4
6
8
10
PRODUCT SALES
INDUSTRY SALES
Base: 100, Maximum Industry Sales
CUMULATIVE RESEARCH & DEVELOPMENT EXPENDITURES
Base: 100, Maximum Product Sales

Figure 8-8

GROUP 3

SELECTED PERFORMANCE INDICES

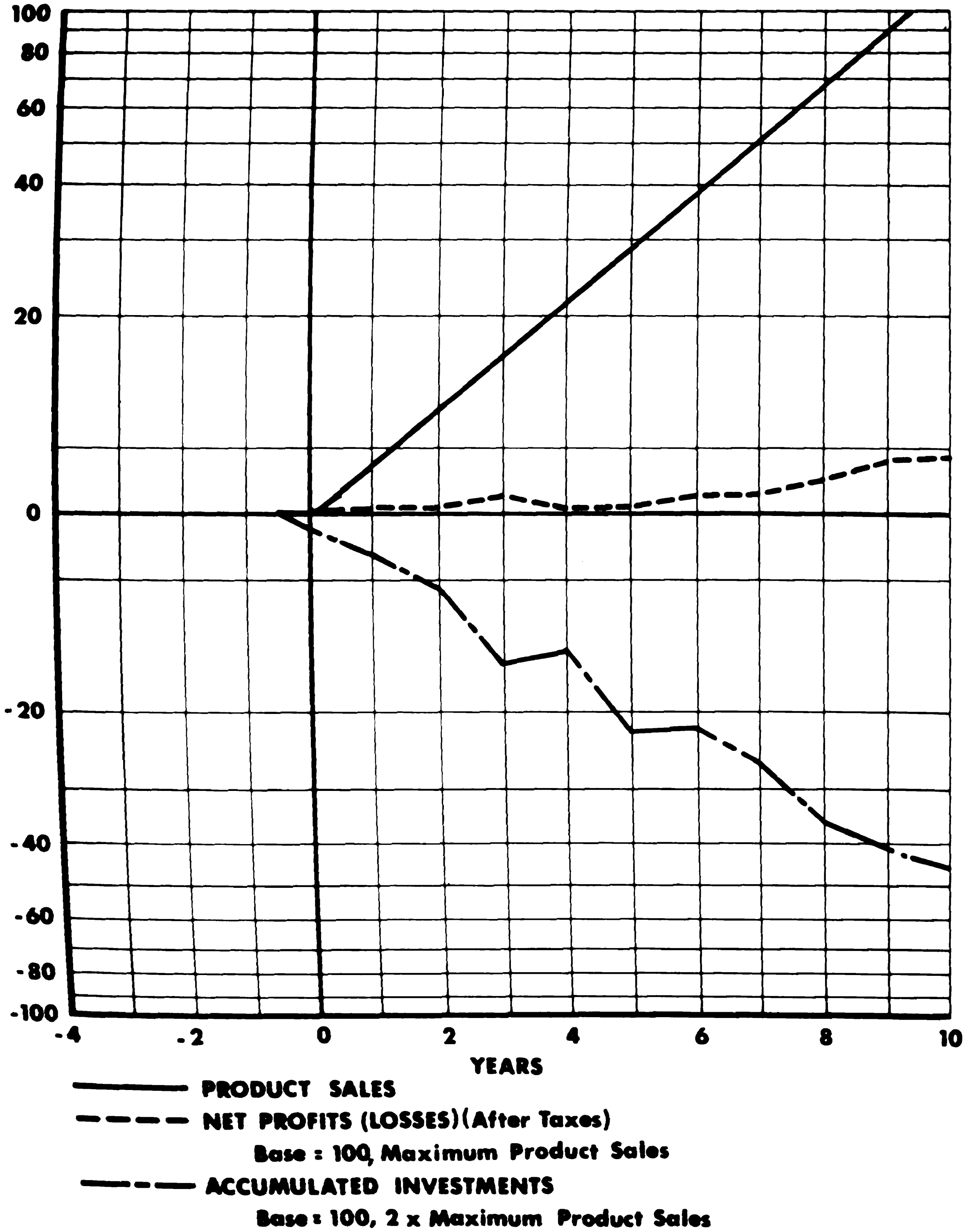
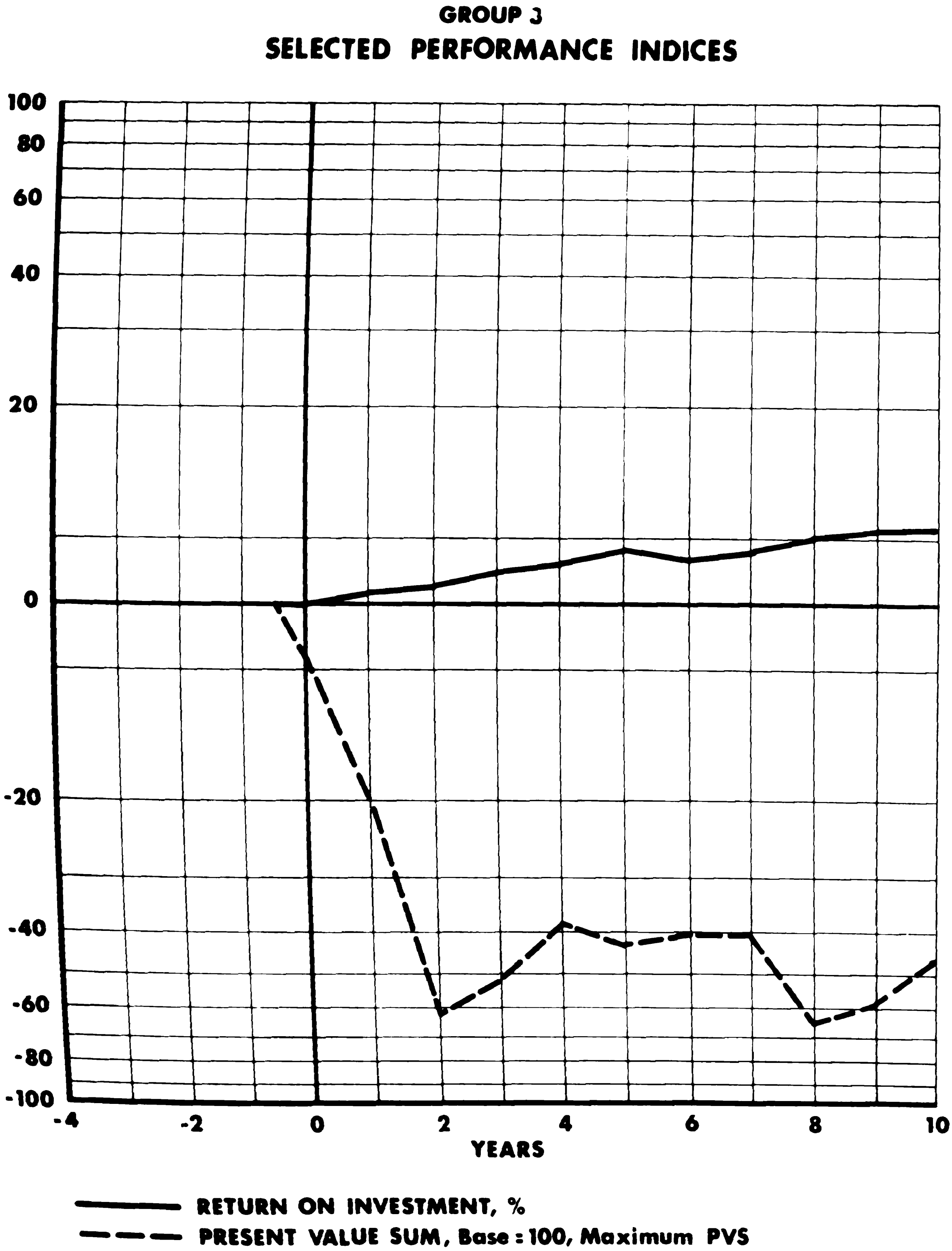


Figure 8-9


GROUP 3
SELECTED PERFORMANCE INDICES
100
80
60
40
20
0
-20
-40
-60
-80
-100
-4
-2
0
2
4
6
8
10
YEARS
RETURN ON INVESTMENT, %
PRESENT VALUE SUM, Base = 100, Maximum PVS

4. Group IV: Rapid Penetration Model

The rapid penetration model, Group IV, attained prompt product usage, with demand typically reaching a maximum by the end of the second year after product introduction. After factoring in all expense items as well as the depreciation charges for needed plant and equipment phased in over a one and one-half year program, the product produced a positive profit residual report the first year and improved on that record the second year. Unfortunately, the length of the rapid growth for both the industry and the product proved to be short-lived. Although timing for the introduction of the new product was correct, no responsible official foresaw the reduction in industry demand coming just three years after all plant facilities came on-stream, a demonstration of the uncertainty involved in new product development work (see Figure 8-10).

On the other hand, Group IV products did produce profitable results in the face of a generally declining market. The average present value sum, although negative, showed consistent reductions in absolute values throughout most of the product history studied. Even after the firm began to lose its market position beyond the sixth year, sales to industrial users continued to show nearly the same levels of return on investment as previously achieved. This was made possible because of a built-in flexibility with the production equipment employed, allowing for at least a partial transfer to the production of other chemical products when the need arose. Thus, this group of products turned in the shortest average payback period. Evaluators were generally influenced more by the length of the decline phase than by any other statistic when describing their relative disappointments in overall product performance.

Large promotional expenditures generated rapid product acceptance. This product possessed as knowns manufacturing processes, product specifications and end-use markets. The product program as originally conceived required no expensive research and development effort nor large capital outlays for plant and equipment. Direct competition presented a series of challenges to product management. Yet it was indirect competition which finally took its toll in product movement; and marked overcapacity at the firm level prevailed throughout most of the time periods covered. Prices were not generally manipulated to improve market position, presumably because of the stress on profitability when operating at inefficient levels. Even so, product displacement was inevitable since product performance did not meet the requirements of the marketplace.

That product advantages were easily recognized by industrial users meant little, because competition could easily duplicate these features. The product generally ranked low on the two scales measuring innovation: technology and marketing.

Figure 8-10

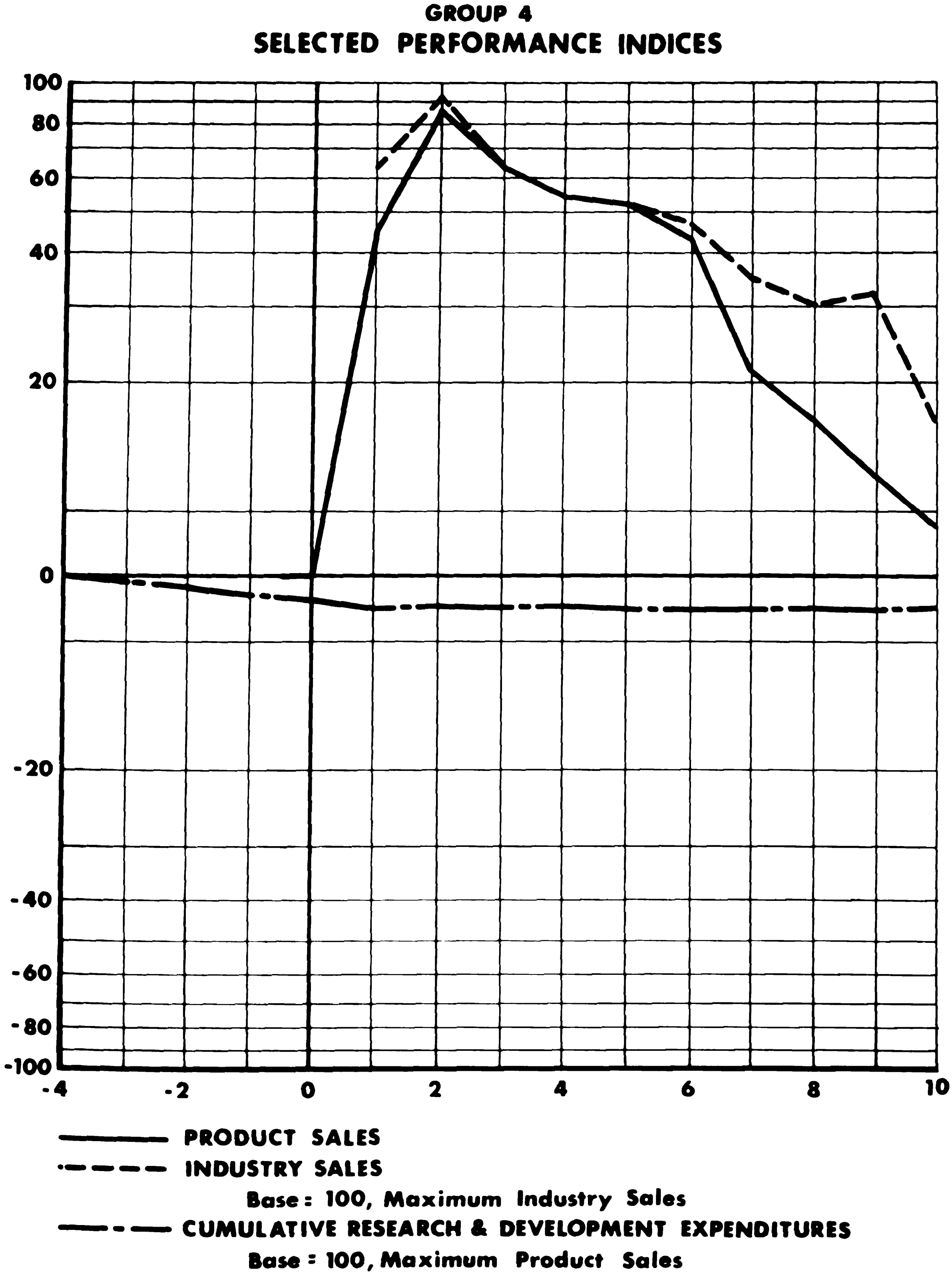

GROUP 4
SELECTED PERFORMANCE INDICES
100
80
60
40
20
0
-20
-40
-60
-80
-100
-4
-2
0
2
4
6
8
10
PRODUCT SALES
INDUSTRY SALES
Base: 100, Maximum Industry Sales
CUMULATIVE RESEARCH & DEVELOPMENT EXPENDITURES
Base = 100, Maximum Product Sales

Figure 8-11

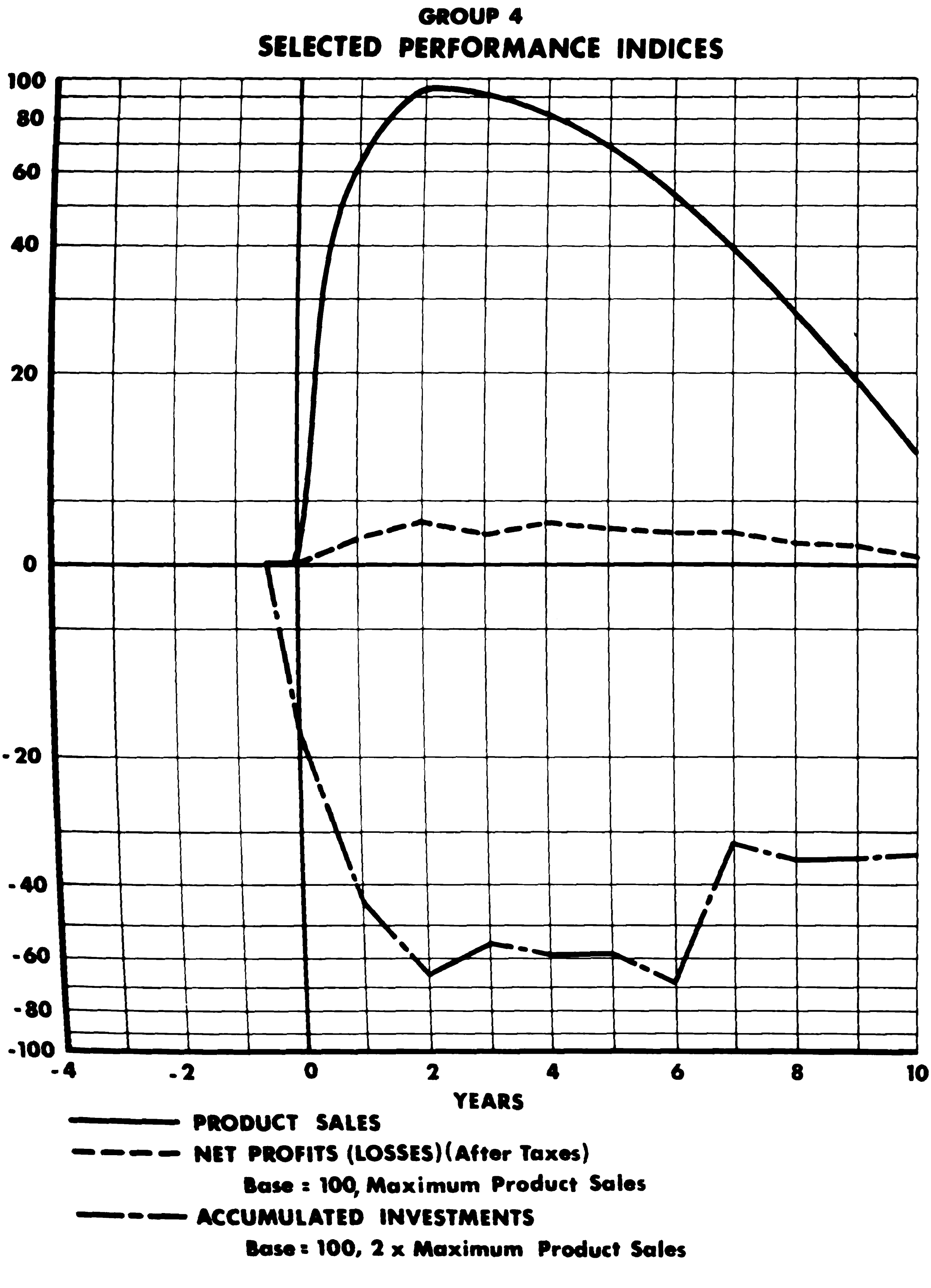
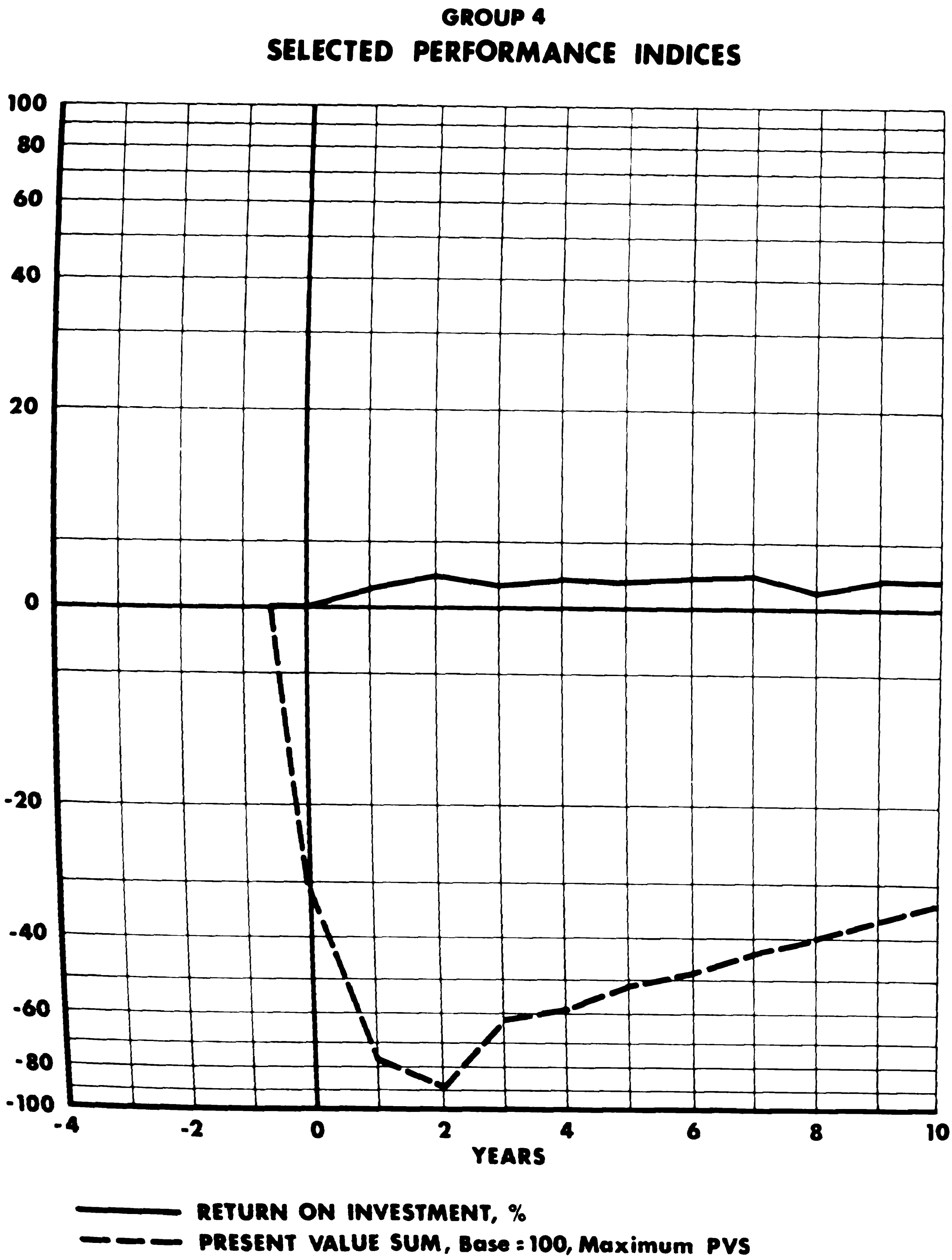

GROUP 4
SELECTED PERFORMANCE INDICES
100
80
60
40
20
0
-20
-40
-60
-80
-100
-4
-2
0
2
4
6
8
10
YEARS
PRODUCT SALES
NET PROFITS (LOSSES) (After Taxes)
Base = 100, Maximum Product Sales
ACCUMULATED INVESTMENTS
Base = 100, 2 x Maximum Product Sales

Figure 8-12


GROUP 4
SELECTED PERFORMANCE INDICES
100
80
60
40
20
0
-20
-40
-60
-80
-100
-4
-2
0
2
4
6
8
10
YEARS
RETURN ON INVESTMENT, %
PRESENT VALUE SUM, Base = 100, Maximum PVS

5. Group V: Extended Rapid Penetration Model

A capital appropriations program closely linked with a realistic assessment of the needs in the marketplace was the key to profitable product management for new industrial chemical products in the extended rapid penetration model, Group V. Technical personnel backing up the selling effort perceived the need for possible improvement in product performance early enough to take effective action. Initial deficiencies did not delay the penetration into the major consuming markets for two reasons: any necessary modifications of product form or the like were instituted early in the product history, and no other chemical product could demonstrate superiority in application.

The ability to balance corporate resources with profitable marketing opportunities, a priceless skill, produced the timely product decisions necessary for the apparent turnabout in present value sum figures, on the average after the fourth year. Significantly, the level of achieved sales was not solely responsible for the performance record, for no differences in aggregate revenue dollars were perceptible among the five groups. The extended rapid penetration model, in fact, was the only group which demonstrated a positive present value sum result within the first ten years of product history (see Figure 8-15). If all nondepreciated asset values were factored out, the median present value sum attained an elsewhere unprecedented index of 74.4 in the tenth year.

Group V products were typically applied in diversified end-uses, thus supporting a broad promotional program for field representation. Occasionally the inability of the chemical manufacturer to supply most or all of its user requirements in a commercial situation reduced the chances the user would evaluate the product in selective in-house laboratory research programs. When this problem arose, profitability tended to decrease.

Single-purpose equipment was more commonly used in the production of extended rapid penetration group chemicals. Since the manufacturing levels were geared to attainable levels of business and at the same time economical and efficient in operation, the returns on employed capital were financially rewarding. The trends of industry and firm product behavior throughout time closely followed each other as depicted graphically in Figure 8-13. The capability to effectively channel product movement into those derived demand situations having greatest growth enhanced profit attainment with the firm achieving a dominant market position. Even so, strong product leadership recognizes the value of a competitive environment, however limited.

Figure 8-13

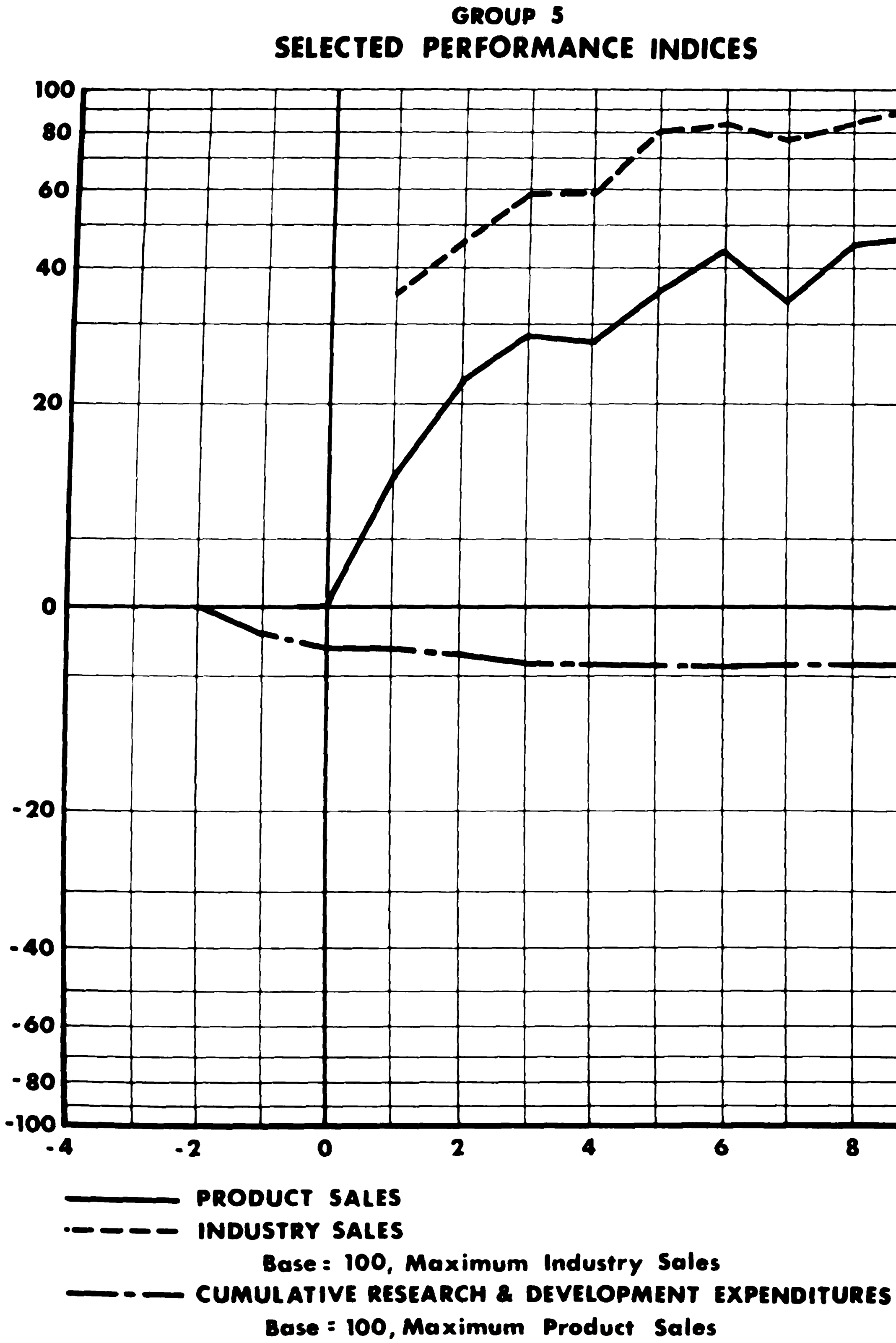

GROUP 5
SELECTED PERFORMANCE INDICES
100
80
60
40
20
0
-20
-40
-60
-80
-100
-4
-2
0
2
4
6
8
10
PRODUCT SALES
INDUSTRY SALES
Base: 100, Maximum Industry Sales
CUMULATIVE RESEARCH & DEVELOPMENT EXPENDITURES
Base = 100, Maximum Product Sales

Figure 8-14

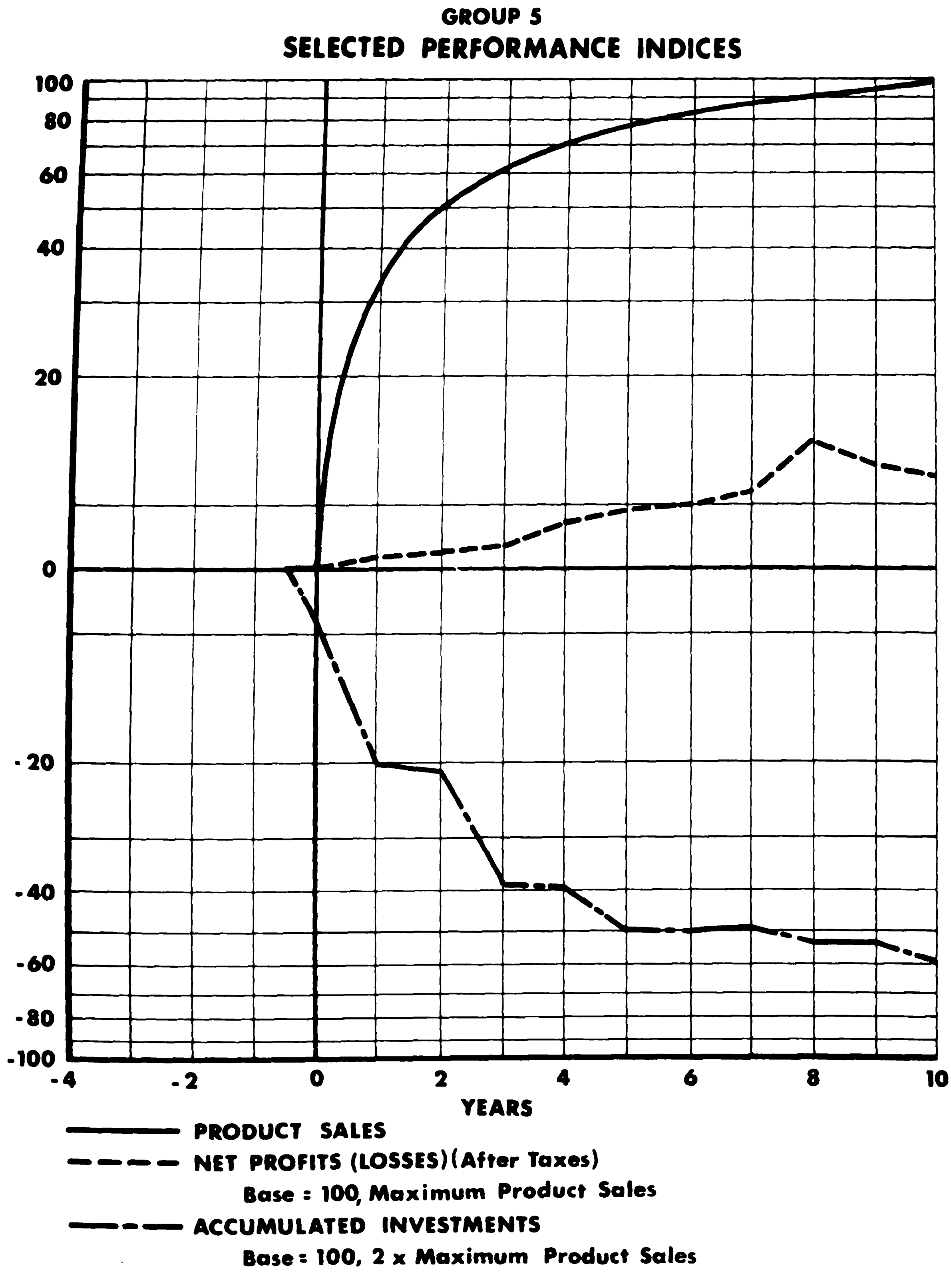

GROUP 5
SELECTED PERFORMANCE INDICES
100
80
60
40
20
0
-20
-40
-60
-80
-100
-4
-2
0
2
4
6
8
10
YEARS
PRODUCT SALES
NET PROFITS (LOSSES)(After Taxes)
Base : 100, Maximum Product Sales
ACCUMULATED INVESTMENTS
Base : 100, 2 x Maximum Product Sales

Figure 8-15

GROUP 5
SELECTED PERFORMANCE INDICES

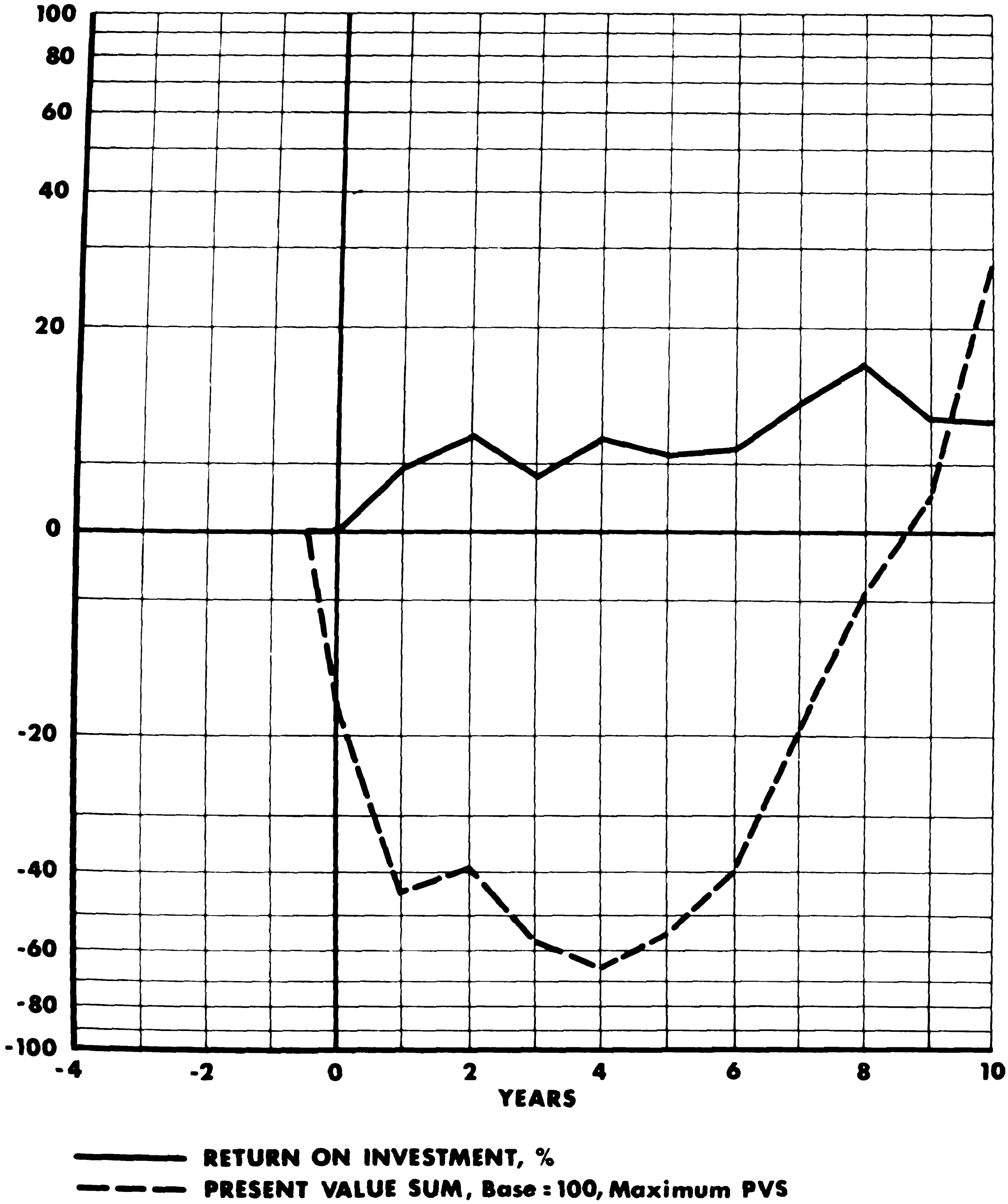


TABLE 8-120

RANKING RESULTS OF SELECTED VARIABLES AGAINST THE SHAPE AND TIMING OF SALES PATTERNS (RESEARCH CODE VARIABLE 151)

Research Code Variable Number	Variable	Type	Rank Sums	Mean Rank
2	Accounting Rate of Return	I	86.0	14.3
		II	38.0	7.6
		III	50.0	12.5
		IV	63.0	15.8
		V	141.0	17.6
3	Aggregate Net Sales	I	72.0	12.0
		II	65.0	13.0
		III	46.0	11.5
		IV	47.0	11.8
		V	148.0	18.5
4	Aggregate Net Profits (Losses) After Taxes	I	82.0	13.7
		II	62.0	12.4
		III	39.0	9.8
		IV	52.0	13.0
		V	143.0	17.9
5	Rate of Growth of Net Sales	I	78.0	13.0
		II	100.0	20.0
		III	84.0	21.0
		IV	18.0	4.5
		V	98.0	12.3
6	Rate of Growth of Net Profits	I	51.0	10.2
		II	48.0	16.0
		III	40.0	20.0
		IV	38.0	9.5
		V	76.0	9.5
7	Rate of Growth of Net Losses	I	2.0	2.0
		II	7.0	3.5
		III	1.0	1.0
8	Timing of Sales Cycle	I	85.0	14.2
		II	100.0	20.0
		III	42.5	10.6
		IV	38.0	9.5
		V	112.5	14.1

(Continued)

TABLE 8-120

RANKING RESULTS OF SELECTED VARIABLES AGAINST THE SHAPE AND TIMING OF SALES PATTERNS (RESEARCH CODE VARIABLE 151)

(Continued)

Research Code Variable Number	Variable	Type	Rank Sums	Mean Rank
9	Timing of Profit Cycle	I	59.5	11.9
		II	59.5	14.9
		III	29.0	7.3
		IV	54.0	13.5
		V	123.0	15.4
10	Payback Period	I	92.0	15.3
		II	104.0	20.8
		III	65.0	16.3
		IV	38.0	9.5
		V	79.0	9.9
11	Equivalent Rate of Return	I	81.0	13.5
		II	42.0	8.4
		III	56.0	14.0
		IV	62.0	15.5
		V	137.0	17.1
12	Profitability Ratio	I	84.0	14.0
		II	43.0	8.6
		III	58.0	14.5
		IV	60.0	15.0
		V	133.0	16.6
13	Return on Investment	I	93.0	15.5
		II	37.0	7.4
		III	53.0	13.3
		IV	59.0	14.8
		V	136.0	17.0
20	Market Share Statistics	I	93.5	15.6
		II	81.0	16.2
		III	40.0	10.0
		IV	51.0	12.8
		V	112.5	14.1
21	Aggregate Research and Development Expenditures	I	92.5	15.4
		II	83.5	16.7
		III	43.0	10.8
		IV	37.5	9.4
		V	121.5	15.2

(Continued)

TABLE 8-120

RANKING RESULTS OF SELECTED VARIABLES AGAINST THE SHAPE AND TIMING OF SALES PATTERNS (RESEARCH CODE VARIABLE 151)

(Continued)

Research Code Variable Number	Variable	Type	Rank Sums	Mean Rank
23	Relative Marketing Costs	I	81.0	13.5
		II	85.0	17.0
		III	34.0	8.5
		IV	85.0	21.3
		V	93.0	11.6
27	Direct Competitive Situation	I	59.5	9.9
		II	50.5	10.1
		III	76.0	19.0
		IV	68.0	17.0
		V	124.0	15.5
28	Indirect Competitive Situation	I	89.5	14.9
		II	72.0	14.4
		III	36.0	9.0
		IV	69.0	17.3
		V	111.5	13.9
31	Number of Minor Consuming Industries	I	61.0	10.2
		II	61.5	12.3
		III	44.0	11.0
		IV	50.0	12.5
		V	161.5	20.2
32	Specificity of Use	I	75.5	12.6
		II	59.0	11.8
		III	52.5	13.1
		IV	52.5	13.1
		V	138.5	17.3
33	Relative Price Changes	I	94.0	15.7
		II	67.5	13.5
		III	59.5	14.9
		IV	44.0	11.0
		V	113.0	14.1
39	Strategy Concerning Sales Force Size	I	63.0	10.5
		II	75.0	15.0
		III	60.0	15.0
		IV	60.0	15.0
		V	120.0	15.0

(Continued)

TABLE 8-120

RANKING RESULTS OF SELECTED VARIABLES AGAINST THE SHAPE AND TIMING OF SALES PATTERNS (RESEARCH CODE VARIABLE 151)

(Continued)

Research Code Variable Number	Variable	Type	Rank Sums	Mean Rank
40	Effect of Strategy Concerning Sales Force Size	I	63.0	10.5
		II	85.0	17.0
		III	68.0	17.0
		IV	55.0	13.8
		V	107.0	13.4
41	Strategy Concerning Number of Sales Calls Per Unit of Time	I	84.0	14.0
		II	70.0	14.0
		III	56.0	14.0
		IV	56.0	14.0
		V	112.0	14.0
51	Strategy Concerning Research and Development in Related Areas	I	96.0	16.0
		II	67.0	13.4
		III	25.0	6.3
		IV	64.0	16.0
		V	126.0	15.8
55	Action Concerning Product Improvements	I	74.0	12.3
		II	74.0	14.8
		III	54.0	13.5
		IV	54.0	13.5
		V	122.0	15.3
65	Industrial Plant Capacity Experiences	I	96.0	16.0
		II	41.0	8.2
		III	95.0	23.8
		IV	36.0	9.0
		V	110.0	13.8
74	Fruits of Research and Development	I	110.5	18.4
		II	58.5	11.7
		III	48.0	12.0
		IV	38.5	9.6
		V	122.5	15.3
75	Effect of Supply Capabilities in Developmental Sampling Programs	I	112.5	18.8
		II	40.0	8.0
		III	44.5	11.1
		IV	48.5	12.1
		V	132.5	16.6

(Continued)

TABLE 8-120

RANKING RESULTS OF SELECTED VARIABLES AGAINST THE SHAPE AND TIMING OF SALES PATTERNS (RESEARCH CODE VARIABLE 151)

(Continued)

Research Code Variable Number	Variable	Type	Rank Sums	Mean Rank
76	Percentage of User Laboratory Evaluation	I	50.0	8.3
		II	69.0	13.8
		III	55.0	13.8
		IV	49.5	12.4
		V	154.5	19.3
78	Duplication Difficulties by Competitors	I	44.5	7.4
		II	77.0	15.4
		III	62.5	15.6
		IV	56.5	14.1
		V	137.5	17.2
81	Recognition Experiences of Product Advantages by Users	I	75.0	12.5
		II	53.0	10.6
		III	47.0	11.8
		IV	87.0	21.8
		V	116.0	14.5
83	Matching of Technological Characteristics with Market Requirements	I	102.5	17.1
		II	71.5	14.3
		III	26.0	6.5
		IV	71.5	17.9
		V	106.5	13.3
84	Degree of Marketing Innovativeness	I	52.0	8.7
		II	74.0	14.8
		III	70.5	17.6
		IV	66.0	16.5
		V	115.5	14.4
85	Degree of Technological Innovativeness	I	51.0	8.5
		II	67.0	13.4
		III	78.5	19.6
		IV	72.5	18.1
		V	109.0	13.6
88	Outlay Trends for Product Promotion	I	96.0	16.0
		II	58.5	11.7
		III	42.5	10.6
		IV	64.0	16.0
		V	117.0	14.6

TABLE 8-120

RANKING RESULTS OF SELECTED VARIABLES AGAINST THE SHAPE AND TIMING OF SALES PATTERNS (RESEARCH CODE VARIABLE 151)

(Continued)

Research Code Variable Number	Variable	Type	Rank Sums	Mean Rank
98	Clarity of Product Demand	I	88.0	14.7
		II	75.5	15.1
		III	50.0	12.5
		IV	64.5	16.1
		V	100.0	12.5
99	Demand Trends in Derived Demand Situations	I	43.0	10.8
		II	40.5	13.5
		III	33.0	11.0
		IV	23.0	11.5
		V	50.5	7.2
117	Maximum Aggregate Investment Requirements	I	71.0	11.8
		II	80.5	16.1
		III	49.5	12.4
		IV	38.0	9.5
		V	139.0	17.4
122	Subjective Measure of Success or Failure	I	87.5	14.6
		II	75.5	15.1
		III	53.0	13.3
		IV	72.0	18.0
		V	90.0	11.3
124	Type of Fixed Capital Employed	I	105.0	17.5
		II	50.5	10.1
		III	69.0	17.3
		IV	80.0	20.0
		V	73.5	9.2
126	Extent of Plant Capacity Utilization	I	100.5	16.8
		II	84.5	16.9
		III	57.5	14.4
		IV	36.0	9.0
		V	99.5	12.4
127	Number of Annual Production Runs Scheduled	I	112.5	18.8
		II	44.0	8.8
		III	50.0	12.5
		IV	76.0	19.0
		V	95.5	11.9

TABLE 8-120

RANKING RESULTS OF SELECTED VARIABLES AGAINST THE SHAPE AND TIMING OF SALES PATTERNS (RESEARCH CODE VARIABLE 151)

(Continued)

Research Code Variable Number	Variable	Type	Rank Sums	Mean Rank
149	Performance Index	I	84.0	14.0
		II	41.0	8.2
		III	58.0	14.5
		IV	61.0	15.3
		V	134.0	16.8

CHAPTER IX

PROPOSED RESULTS OF MULTIVARIATE MODELS

Introduction

The exploratory research efforts we have discussed up until now have examined numerous relationships, defined in the form of hypotheses, both for their historical significance and for predictive content relative to performance. Even though we have focused on the conventional product life cycle, our scope was considerably expanded to include a variety of possible demand determinants, any of which might add to life cycle theory.

Having now weighed many notions about the behavior of new industrial chemical products, we are ready to examine the feasibility of building statistical models of product performance by selectively screening the important relationships to evaluate possible multivariate models. In doing this, we may often need to reaggregate the response patterns for a number of independent variables; any changes over previously reported breakdowns are noted explicitly in the appropriate listing of variables section of the chapter.

Multivariate Model of Performance Variable 10, Payback Period

1. Criterion: Minimize the least squares sum as long as each remaining contributing variable meets a significance level of .05 or less.

2. Model:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + b_{12}X_{12} + b_{13}X_{13} + b_{14}X_{14} + b_{15}X_{15} + b_{16}X_{16} + b_{17}X_{17}$$

3. Presentation of Selected Statistical Calculations

ANALYSIS OF VARIANCE FOR OVERALL REGRESSION

	Sum of Squares	Degrees of Freedom	Mean Square	F Statistic	Significance of F Statistic
Regression (about mean)	15.24935	17	0.89702	82.99	<0.0005
Error	0.06485	6	0.01081		
Total (about mean)	15.31421	23			

Standard Error of Estimate* 0.1040

Number of Observations 24

Coefficient of Multiple Determination R^2 .. 0.9958

Multiple Correlation Coefficient R 0.9979

*This term is a measure of dispersion of observations from the estimated regression line.

Variable Code Number	Regression Coefficient	Beta Weight	F Statistic for Regression Coefficient	Significance of F Statistic	R^2 Delete
Constant	1.8155		46.09	< 0.001	
21-1	0.5768	0.293	6.00	0.050	0.992
32-1	-2.3396	-0.969	182.50	< 0.001	0.867
54-1	0.2315	0.126	6.37	0.045	0.991
66-1	-3.1752	-1.315	548.41	< 0.001	0.609
66-2	-2.2588	-1.224	394.41	< 0.001	0.717
66-3	-2.4554	-1.146	439.43	< 0.001	0.686
66-4	-2.6892	-1.255	100.05	< 0.001	0.925
78-1	-1.3959	-0.794	208.35	< 0.001	0.849

(Continued)

Presentation of Selected Statistical Calculations (Continued)

Variable Code Number	Regression Coefficient	Beta Weight	F Statistic for Regression Coefficient	Significance of F Statistic	R^2 Delete
92-1	1.4818	0.803	139.17	< 0.001	0.898
96-1	-1.0173	-0.579	182.02	< 0.001	0.867
96-2	0.9656	0.400	14.55	0.009	0.986
101-1	1.4237	0.664	25.07	0.002	0.978
101-2	2.4610	1.251	54.83	< 0.001	0.957
101-3	1.8114	0.982	52.52	< 0.001	0.959
101-4	1.1446	0.651	16.03	0.007	0.984
107-1	1.0462	0.488	85.93	< 0.001	0.935
126-1	-1.0679	-0.543	15.10	0.008	0.985

4. Listing of Variables and Scoring Routines Used in the Model

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used[1]
21--	Aggregate Research and Devel- opment Expenditures	Less than $17,600	0
21-1		Between $17,600 and $126,000	1
21--		Over $126,000	0
32--	Specificity of Use	Slightly to highly specific	0
32--		Indifferent or so-so	0
32-1		Slightly to highly general	1
54--	Median Annual Incremental Investments	Less than $10,000	0
54-1		Between $10,000 and $51,000	1
54--		At least $51,000	0

(Continued)

Listing of Variables and Scoring Routines Used in the Model (Continued)

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used[1]
66-1	Plant Capacity Experiences for Family of Related Products	Marked overcapacity, i.e., greater than 20% idle capacity present	1
66-2		Moderate overcapacity, i.e., between 5 and 20% idle capacity present	1
66-3		Slight overcapacity, i.e., between 0 and 5% idle capacity present	1
66-4		No undercapacity or overcapacity present	1
66--		Slight to marked undercapacity, i.e., some expansion required to meet market demands	0
78--	Duplication Difficulties by Competitors	Slightly easy to extremely difficult	0
78-1		Moderately easy	1
78--		Very easy	0
92--	Merger or Combination Experiences	Not considered	0
92-1		Possibilities explored and/or formal completion of one or more	1
96-1	Effect of Hidden Price Concessions on Purchasing Decisions	Strong positive effect	1
96-2		Slight to moderately positive effect	1
96--		Indifferent to strong negative effect	0
101-1	Number of Purchasers	One to five	1
101-2		Six to ten	1
101-3		Eleven to twenty	1
101-4		Twenty-one to one-hundred	1
101--		Over one-hundred	0
107-1	Level of Product Loyalty	Very strong	1
107--		Strong	0
107--		Moderately strong to none	0

Listing of Variables and Scoring Routines Used in the Model (Continued)

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used[1]
126--	Extent of Plant Capacity Utilization	Less than 60%	0
126-1		60 to 79%	1
126--		Over 79%	0

[1]In applying historical data to the estimated parameters, multiply selected parameters by the response number of all respective variables whose response patterns were identified as listed, using zero entries for situations where unmatched, not applicable, or unknown.

5. Analysis of Proposed Model

TABLE 9-1

HISTORICAL FIT OF MODEL FOR VARIABLE 10

Observation Number	Observed Payback Period (Arbitrary Origin)	Calculated Payback Period (Arbitrary Origin)	Difference
1	1.3473	1.3180	0.0293
2	2.6891	2.7184	-0.0293
3	0.6865	0.7014	-0.0149
4	1.1690	1.2136	-0.0446
5	1.0978	1.0664	0.0314
6	0.7129	0.7839	-0.0710
7	0.5006	0.5195	-0.0189
8	0.8020	0.7839	0.0181
9	0.4865	0.4517	0.0348
10	0.9026	0.9026	0.0000
11	0.7575	0.8015	-0.0440
12	0.7465	0.7410	0.0055
13	0.6057	0.5484	0.0573
14	0.3251	0.3343	-0.0092
15	3.5931	3.6269	-0.0338
16	1.1290	1.1659	-0.0369
17	2.0147	1.9428	0.0719
18	1.4266	1.4030	0.0236
19	0.3586	0.3651	-0.0065
20	0.8838	0.8624	0.0214
21	0.3054	0.3402	-0.0348
22	1.9889	2.1024	-0.1135
23	2.2599	2.1024	0.1575
24	1.0030	0.9965	0.0065

The extent of plant utilization, for the industrial chemical products under study and for families of related products as well, was linked most directly with the payback period. Balancing material requirements between chemical intermediates and upgraded products, a challenging problem of optimization, revealed the need for managerial improvement. Depending upon the type of product, unit average manufacturing costs were usually lower within the operating range of 80 and 95 percent, occasionally with nearly flat curves within this range.

Whenever the number of open accounts purchasing an industrial chemical product increased more rapidly than planned, expectations of further expansion often encouraged greater capital investment in plant facilities, a plausible explanation of why products with widespread buying groups had longer payback periods. Products more generalized in usage tended to have longer payback periods. The flows and end-use patterns were difficult to trace when industrial users maintained a cloak of secrecy over their operations. Regardless, additional knowledge about product behavior could have been generated in the field, but such expanded commitments were not always economically justifiable.

Other predictor variables contributed significantly to reducing variance in the model: merger experiences, difficulties of duplication by competitive firms, hidden price concessions in product selling, and the levels of product loyalty, research expenditures, and incremental plant expansions. The overall fit of the historical data was surprisingly good, approaching the highest attainable multiple correlation statistic value of one. All estimated values were closely approximated in actual payback experiences. It is realized that a high proportion of independent variables relative to the number of observations in the sample is largely responsible for the large R^2 value reported; however, the fact remains that the individual significance tests for the variables included were conclusive and warranted their retention in the model.

Multivariate Model of Performance Variable 11, Equivalent Rate of Return

1. Criterion: Minimize the sum of absolute deviations for all variables thought to have made significant contributions based on previously employed screening procedures.

2. Model:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} b_{11}X_{11} + b_{12}X_{12} + b_{13}X_{13} + b_{14}X_{14} b_{15}X_{15}$$

3. Presentation of Selected Statistical Calculations

Research Code Number	Average	Standard Deviation	Regression Coefficient	Beta Weight
Constant			1.9990	
20	58.333	38.327	0.0101	0.031
22	66839.111	91870.372	-0.0001	-0.413
27	2.259	2.640	-1.0217	-0.215
84	0.148	2.349	0.8970	0.168
87	0.611	0.881	2.9487	0.207
98	2.056	1.389	2.2044	0.244
99	1.537	1.184	1.4354	0.135
102	0.852	1.322	0.2112	0.022
107	4.130	1.542	-1.3114	-0.161
116	1.056	1.129	2.4495	0.221

(Continued)

Presentation of Selected Statistical Calculations (Continued)

Research Code Number	Average	Standard Deviation	Regression Coefficient	Beta Weight
124	2.815	1.178	-2.4749	-0.232
125	4.926	2.464	-0.3859	-0.076
134	5.000	4.057	0.7165	0.232
150	2.037	0.940	7.7337	0.579
151	3.111	1.577	-4.5294	-0.569

4. Listing of Variables and Scoring Routines Used in the Model

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used[2]
20	Market Share Statistics	Expressed as a percentage	Attained Penetration
22	Mean Yearly Research and Development Expenditures	Expressed in dollars	Dollar Expenditures
27	Direct Competitive Situation	Expressed as a number	Attained Number
84	Degree of Marketing Innovativeness	Highly innovative	3
		Moderately innovative	2
		Slightly innovative	1
		Indifferent or so-so	0
		Slightly duplicative	-1
		Moderately duplicative	-2
		Highly duplicative	-3

(Continued)

Listing of Variables and Scoring Routines Used in the Model (Continued)

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used[2]
87	Effect on Sales of Related Products	Strong detrimental effect, since essentially replaced an existing product or products with no increase in net profitability	-3
		Moderate detrimental effect, since moderate decreases in sales of related products were experienced	-2
		Slight detrimental effect, since slight decreases in sales of related products were experienced	-1
		No effect, since not related to other products	0
		Slight beneficial effect, since slight increases in sales of related products were experienced	1
		Moderate beneficial effect, since moderate increases in sales of related products were experienced	2
		Strong beneficial effect, since significantly large increases in sales of related products were experienced	3
98	Clarity of Product Demand	Clearly understood	3
		Moderately understood	2
		Slightly understood	1
		Indifferent or so-so	0
		Slightly misunderstood	-1
		Moderately misunderstood	-2
		Clearly misunderstood	-3

(Continued)

Listing of Variables and Scoring Routines Used in the Model (Continued)

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used[2]
99	Demand Trends in Derived Demand Situations	Strongly increased, i.e., annual growth rate exceeding 10%	3
		Moderately increased, i.e., annual growth rate between 3 and 10%	2
		Slightly increased, i.e., annual growth rate of 3% or less	1
		No change in market demands	0
		Slightly decreased, i.e., annual decay rate of 3% or less	-1
		Moderately decreased, i.e., annual decay rate between 3 and 10%	-2
		Strongly decreased, i.e., annual decay rate exceeding 10%	-3
102	Seasonal Patterns	Highly seasonal	6
		Seasonal	5
		Moderately seasonal	4
		Moderately to slightly seasonal	3
		Slightly seasonal	2
		Very slightly seasonal	1
		Nonseasonal	0
107	Level of Product Loyalty	Very strong	6
		Strong	5
		Moderately strong	4
		Moderately weak	3
		Weak	2
		Very weak	1
		No loyalty existing	0

(Continued)

Listing of Variables and Scoring Routines Used in the Model (Continued)

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used[2]
116	Export Patterns	Over 50%	6
		Between 40 and 50%	5
		Between 30 and 40%	4
		Between 20 and 30%	3
		Between 10 and 20%	2
		Between 1 and 10%	1
		Not applicable since no exporting took place	0
124	Type of Fixed Capital Employed	Single-purpose equipment	1
		Combination of single-purpose and multipurpose with major being single-purpose	2
		Combination of single-purpose and multipurpose with major being multipurpose	3
		Multipurpose equipment	4
125	Length of Production Run	Less than one week	1
		Between one and two weeks	2
		Greater than two weeks but less than one month	3
		Between one and two months	4
		Greater than two months but less than four months	5
		Four months or greater but not on a continuous basis	6
		On a continuous basis	7
134	End-Use Patterns	Monomeric material in polymer system	1
		Chemical additive in polymer system	2
		Chemical additive in rubber manufacturing	3
		Chemical additive in gasoline manufacturing	4

(Continued)

Listing of Variables and Scoring Routines Used in the Model (Continued)

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used[2]
134	End-Use Patterns	Chemical additive in soap and detergent manufacturing	5
		Process chemical in mining	6
		Food preservative	7
		Process chemical in water treatment	8
		Industrial solvent	9
		Chemical intermediate, not elsewhere classified	10
		Chemical intermediate in fibers	11
		Chemical additive in fibers	12
150	Types of Sales Patterns	Conventional product life cycle model	1
		Linear growth model	2
		Rapid penetration model	3
151	Shape and Timing of Sales Patterns	Conventional product life cycle model	1
		Conventional product life cycle (extended) model	2
		Linear growth model	3
		Rapid penetration model	4
		Rapid penetration (extended) model	5

[2]In applying historical data to the estimated parameters, multiply selected parameters by the response numbers of all respective variables whose response patterns were identified as listed, using zero entries for situations where unmatched, not applicable, or unknown.

5. Analysis of Proposed Model

TABLE 9-2

HISTORICAL FIT OF MODEL FOR VARIABLE 11

Observation Number	Observed Equivalent Rate of Return (Arbitrary Origin)	Calculated Equivalent Rate of Return (Arbitrary Origin)	Difference
1	0.0282	0.0282	0.0000
2	-4.2541	-4.2541	0.0000
3	6.9556	11.2739	-4.3183
4	-0.9485	-0.9485	0.0000
5	-2.0307	-2.0307	0.0000
6	-0.8453	-0.8453	0.0000
7	8.8317	-0.9930	9.8247
8	-1.8506	-1.8506	0.0000
9	-15.9511	-6.7161	-9.2350
10	9.5290	-2.8579	12.3869
11	0.8036	0.8036	0.0000
12	3.5799	3.5799	0.0000
13	-0.0705	-0.0705	0.0000
14	5.3850	5.3850	0.0000
15	18.1053	1.4353	16.6700
16	-5.8196	-3.1083	-2.7113
17	-3.0677	-2.2002	-0.8675
18	-22.8241	-22.8241	0.0000
19	-4.5307	-4.5307	0.0000
20	-1.2363	-1.2363	0.0000
21	25.7175	13.5207	12.1968
22	-20.7254	-2.8867	-17.8387
23	7.8522	-3.7410	11.5932
24	37.3016	13.2631	24.0385
25	-6.7158	-6.7158	0.0000
26	-7.2249	-7.2249	0.0000
27	-3.7134	-3.7134	0.0000

The predominating determinant of the equivalent rate of return was the shape of the sales distribution, though this was not fully established in nonparametric tests. Both the linear and rapid penetration models of demand appeared to increase resistance to profit erosion.

In terms of the monies spent each year on research and development, firms tended to overspend in areas where market acceptance had been unexpectedly low. Chemical marketers could undoubtedly realize substantial gains by coordinating marketing research opportunity studies with the research and development effort. It seemed unnecessary to plan industrial marketing concept studies before sanctioning specific scientific programs, though research into demand was important before these programs blossomed into major resource commitments. Product management needed to understand the product in its competitive environment and the demand upon which its survival had been based to make sound decisions. Such inputs were quite useful in optimizing marketing and financial strategies.

Multipurpose production facilities with their greater flexibility and greater efficiency were related in this model to equivalent rate of return outcomes. The degree to which customer contacts stressed technical service in addition to marketing also correlated directly with new industrial chemical product acceptance. And though they influenced performance less, the level of product loyalty, effect on sales of related products, level of marketing innovation, extent of market penetration, seasonal and export patterns, and the length of production runs all related to the equivalent rate of return.

It is unfortunate a large number of variables were needed to achieve good historical fit, however, most of the variables had relative beta weights sufficiently high to warrant their inclusion. Incidentally, had the model been applied as it now stands, using its estimated parameter values, a wrong decision would have been made in only three cases out of the twenty-seven studied.

Multivariate Model of Performance Variable 13, Return on Investment

1. Criterion: Minimize the least squares sum as long as each remaining contributing variable meets a significance level of .05 or less.

2. Model:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + b_{12}X_{12} + b_{13}X_{13} + b_{14}X_{14}$$

3. Presentation of Selected Statistical Calculations

ANALYSIS OF VARIANCE FOR OVERALL REGRESSION

	Sum of Squares	Degrees of Freedom	Mean Square	F Statistic	Significance of F Statistic
Regression (about mean)	50.91334	14	3.63667	24.17	< 0.0005
Error	1.80539	12	0.15045		
Total (about mean)	52.71872	26			

Standard Error of Estimate	0.3879
Number of Observations	27
Coefficient of Multiple Determination R^2 ..	0.9658
Multiple Correlation Coefficient R	0.9827

Variable Code Number	Regression Coefficient	Beta Weight	F Statistic for Regression Coefficient	Significance of F Statistic	R^2 Delete
Constant	2.0931		44.50	$<$0.001	
66-1	2.5390	0.571	73.57	$<$0.001	0.756
66-2	-0.5766	-0.160	5.74	0.034	0.949
75-1	-1.3246	-0.471	31.03	$<$0.001	0.877
75-2	-2.3371	-0.594	38.67	$<$0.001	0.855
76-1	0.6511	0.204	9.34	0.010	0.939
76-2	0.7261	0.202	7.06	0.021	0.946
76-3	2.0874	0.391	22.49	$<$0.001	0.902
78-1	-2.6707	-0.501	52.20	$<$0.001	0.817
78-2	2.4529	0.769	42.90	$<$0.001	0.843
78-3	0.8028	0.252	9.09	0.011	0.940
89-1	-2.4727	-0.879	42.80	$<$0.001	0.844
89-2	-1.6498	-0.570	41.61	$<$0.001	0.847
107-1	0.8651	0.283	13.32	0.003	0.928
107-2	-0.8750	-0.222	11.15	0.006	0.934

4. Listing of Variables and Scoring Routines Used in the Model

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used
66-1	Plant Capacity Experiences for Family of Related Products	Marked overcapacity, i.e., greater than 20% idle capacity present	1
66--		Moderate overcapacity, i.e., between 5 and 20% idle capacity present	0
66-2		Slight overcapacity, i.e., between 0 and 5% idle capacity present	1
66--		No overcapacity or some under-capacity present	0
75-1	Effect of Supply Capabilities in Developmental Sampling Programs	Marked beneficial effect, since firm able to supply all user requirements	1
75-2		Moderate beneficial effect, since firm able to supply most user requirements	1
75--		Slight beneficial to marked detrimental effect, since firm able to supply at most only a good portion of user requirements	0
76--	Percentage of User Laboratory Evaluation	100%	0
76-1		Between 80 and 99%	1
76-2		Between 60 and 79%	1
76--		Between 40 and 59%	0
76-3		Between 20 and 39%	1
76--		Less than 20%	0
76--		Not applicable since no sample distribution attempted	0
78-1	Duplication Difficulties by Competitors	Extremely difficult	1
78-2		Moderately difficult	1
78--		Slightly difficult to slightly easy	0
78-3		Moderately easy	1
78--		Very easy	0

(Continued)

Listing of Variable and Scoring Routines Used in the Model (Continued)

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used
89-1	Dependence on Contacts by Company Representatives	Strongly dependent	1
89-2		Moderately dependent	1
89--		Slightly dependent to strongly not dependent	0
107--	Level of Product Loyalty	Very strong	0
107-1		Strong	1
107--		Moderately strong	0
107-2		Moderately to very weak	1
107--		No loyalty	0

5. Analysis of Proposed Model

TABLE 9-3

HISTORICAL FIT OF MODEL FOR VARIABLE 13

Observation Number	Observed Return on Investment (Arbitrary Origin)	Calculated Return on Investment (Arbitrary Origin)	Difference
1	0.5150	0.7084	-0.1934
2	-0.0880	-0.4317	0.3437
3	1.2620	1.6336	-0.3716
4	0.3900	0.5726	-0.1826
5	0.2170	-0.0785	0.2955
6	0.4600	0.5179	-0.0579
7	1.6820	1.2723	0.4097
8	0.5570	0.6217	-0.0647

(Continued)

TABLE 9-3

HISTORICAL FIT OF MODEL FOR VARIABLE 13

(Continued)

Observation Number	Observed Return on Investment (Arbitrary Origin)	Calculated Return on Investment (Arbitrary Origin)	Difference
9	-2.5600	-2.3992	-0.1608
10	1.7000	1.6577	0.0423
11	0.4970	0.7625	-0.2655
12	0.9370	1.1860	-0.2490
13	0.4570	0.6014	-0.1444
14	1.1530	1.4748	-0.3218
15	2.8220	2.5730	0.2490
16	-0.1200	-0.1066	-0.0134
17	0.9040	0.7487	0.1553
18	-1.8000	-1.9608	0.1608
19	0.1790	0.6350	-0.4560
20	0.6790	0.7509	-0.0719
21	3.8140	3.5896	0.2244
22	-1.0700	-1.4579	0.3879
23	1.7400	1.5713	0.1687
24	4.1620	3.9388	0.2232
25	0.2130	0.4433	-0.2303
26	0.1400	0.4433	-0.3033
27	0.2510	-0.1753	0.4263

New industrial chemical products showing higher returns on investment had depended more heavily on field contact work before the final sale was achieved. Indeed, many operating firms have recognized the value of direct marketing to bulk industrial users, usually establishing a priority system based on known or estimated material consumption requirements.

Although the degree of difficulty for product duplication by competitors seemed an important contributor to performance, the signs and magnitudes of the coefficients are inconsistent, suggesting that products can be quite profitable even without barriers of entry. The variable next in importance, a firm's immediate supply capability at the time developmental samples are being distributed to potential users, appeared to be a defensive factor, since evaluating firms expected rapid access to commercial quantities after approving the chemical compounds for consumption. Other relevant variables included the percentage of users evaluating chemical samples in their own laboratories and the level of product loyalty.

The finalized suggested model of return on investment data attained the relatively high coefficient of multiple determination of 0.966. More important, the calculated values obtained from the model, when matched against the overall cost of capital to the firm, would have led to a wrong decision in just one of the twenty-seven product situations investigated, thus fitting the historical data surprisingly well.

<u>Multivariate Model of Performance Variable 147, Annualized Discounted Present Value Sum</u>

1. <u>Criterion</u>: Minimize the sum of absolute deviations for all variables thought to have made significant contributions based on previously employed screening procedures.

2. Model: $Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11}$

3. Presentation of Selected Statistical Calculations

Research Code Number	Average	Standard Deviation	Regression Coefficient	Beta Weight
Constant			0.0000	
19	10.19	2.79	-30.4828	-0.04
82	4.39	1.74	17.9658	0.02
87	0.61	0.88	52.9994	0.02
98	2.06	1.39	-10.4582	-0.01
99	1.54	1.18	36.4808	0.02
107	4.13	1.54	2.1794	$<$ 0.01
124	2.81	1.18	21.4118	0.01
125	4.93	2.46	-54.2328	-0.06
131	1.44	0.64	36.7547	0.01
150	2.04	0.94	60.1625	0.03
151	3.11	1.58	34.5536	0.03

4. Listing of Variables and Scoring Routines Used in the Model

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used
19	Cost of Capital	Expressed as a percentage at the time of market entry	Calculated Cost of Capital
82	Number of Annual Purchases by Buyers	One	1
		Two to three	2
		Four to six	3

(Continued)

Listing of Variables and Scoring Routines Used in the Model (Continued)

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used
82	Number of Annual Purchases by Buyers (Continued)	Seven to eight	4
		Nine to ten	5
		Eleven to twelve	6
		Over twelve	7
87	Effect on Sales of Related Products	Strong detrimental effect, since essentially replaced an existing product or products with no increase in net profitability	-3
		Moderate detrimental effect, since moderate decreases in sales of related products were experienced	-2
		Slight detrimental effect, since slight decreases in sales of related products were experienced	-1
		No effect	0
		Slight beneficial effect, since slight increases in sales of related products were experienced	1
		Moderate beneficial effect, since moderate increases in sales of related products were experienced	2
		Strong beneficial effect, since significantly large increases in sales of related products were experienced	3
98	Clarity of Product Demand	Clearly understood	3
		Moderately understood	2
		Slightly understood	1
		Indifferent or so-so	0
		Slightly misunderstood	-1
		Moderately misunderstood	-2
		Clearly misunderstood	-3

(Continued)

Listing of Variables and Scoring Routines Used in the Model (Continued)

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used
99	Demand Trends in Derived Demand Situations	Strongly increased, i.e., annual growth rate exceeding 10%	3
		Moderately increased, i.e., annual growth rate between 3 and 10%	2
		Slightly increased, i.e., annual growth rate of 3% or less	1
		No change in market demands	0
		Slightly decreased, i.e., annual decay rate of 3% or less	-1
		Moderately decreased, i.e., annual decay rate between 3 and 10%	-2
		Strongly decreased, i.e., annual decay rate exceeding 10%	-3
107	Level of Product Loyalty	Very strong	1
		Strong	2
		Moderately strong	3
		Moderately weak	4
		Weak	5
		Very weak	6
		No loyalty existing	7
124	Type of Fixed Capital Employed	Single-purpose equipment	1
		Combination of single-purpose and multipurpose with major part being single-purpose	2
		Combination of single-purpose and multipurpose with major part being multipurpose	3
		Multipurpose equipment	4
125	Length of Production Run	Less than one week	1
		Between one and two weeks	2
		Greater than two weeks but less than one month	3

(Continued)

Listing of Variables and Scoring Routines Used in the Model (Continued)

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used
125	Length of Production Run (Continued)	Between one and two months	4
		Greater than two months but less than four months	5
		Four months or more but not on a continuous basis	6
		On a continuous basis	7
131	Types of Marketing Representa-tives Utilized	Regular sales force	1
		Combination of regular sales force and special market development groups	2
		Market development groups	3
150	Types of Sales Patterns	Conventional product life cycle model	1
		Linear growth model	2
		Rapid penetration model	3
151	Shape and Timing of Sales Patterns	Conventional product life cycle model	1
		Conventional product life cycle (extended) model	2
		Linear growth model	3
		Rapid penetration model	4
		Rapid penetration (extended) model	5

5. Analysis of Proposed Model

TABLE 9-4

HISTORICAL FIT OF MODEL FOR VARIABLE 147

Observation Number	Observed Annualized Discounted Present Value Sum (Arbitrary Origin)	Calculated Annualized Discounted Present Value Sum (Arbitrary Origin)	Difference
1	1.4870	1.4870	0.0000
2	-133.4740	229.6887	-363.1627
3	1043.5750	222.5978	820.9772
4	-207.4260	-207.4260	0.0000
5	-281.9800	151.6445	-433.6245
6	-16.0290	-16.0290	0.0000
7	308.1870	308.1870	0.0000
8	-250.1810	-250.1810	0.0000
9	-431.7680	-224.1310	-207.6370
10	62.8400	62.8400	0.0000
11	259.7150	-237.1411	496.8561
12	757.2240	57.3867	699.8373
13	-78.8090	-78.8090	0.0000
14	4363.6530	-22.8750	4386.5280
15	7357.5550	87.6966	7269.8584
16	-274.7360	-274.7360	0.0000
17	-1166.0340	-431.9488	-734.0852
18	-1992.2620	-544.9363	-1447.3257
19	-664.7500	-548.4621	-116.2879
20	-12.9770	-12.9770	0.0000
21	353.1850	-89.2949	442.4799
22	-15.3010	-15.3010	0.0000
23	19.7790	19.7790	0.0000
24	546.5060	361.2436	185.2624
25	-1165.0130	-200.4648	-964.5482
26	-5293.1570	-209.1825	-5083.9745
27	-746.2710	-285.6182	-460.6528

New chemical products requiring short production runs can be quite profitable if companies schedule production efficiently, for this was the factor most important in explaining the discounted annualized present value sum. Because the sign of the coefficient was negative, a plausible explanation probably lies with some joint distributive phenomenon. This study handled only financial risk factors because of the limitations of data and methodology; but an examination of other risks could have reduced the spread of present value sum outcomes.

In the context of this model, firms deviated from the valuation principle in project selection, i.e., firms having higher costs of capital did not tend to select higher cut-off points. But the discount rate nevertheless emerged as a significant variable in the estimation process. Both the shape and timing of the product revenue cycle also affected annualized present values.[1] The rapid penetration model with a demand life cycle continuing to increase beyond seven years had the edge in those profitability measures which took into account the time value of money. Other important determinants, finally, included the strategy of product offerings in similar end-use areas, number of annual purchases by buyers, effect on sales of related products, clarity of product demand, demand trends in derived demand situations, level of product loyalty, and the types of fixed capital and field representation employed.

In all statistical runs of input data across this variable, multicollinearity interfered with prediction whenever performance variables were included as predictors. The final version reported here has a relatively poor fit in terms of absolute deviations, but still wrong decisions would have been made in just five of the twenty-seven product situations had conclusions been drawn based on accurate assessments of inputs suggested by this model of product behavior.

[1] Various patterns of demand found to exist in the research sample are identified in Chapter VIII.

Multivariate Model of Performance Variable 152, Annualized Net Sales

1. Criterion: Minimize the least squares sum as long as each remaining contributing variable meets a significance level of .05 or less.

2. Model:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + b_{12}X_{12} + b_{13}X_{13} + b_{14}X_{14} + b_{15}X_{15} + b_{16}X_{16} + b_{17}X_{17}$$

3. Presentation of Selected Statistical Calculations

ANALYSIS OF VARIANCE FOR OVERALL REGRESSION

	Sum of Squares	Degrees of Freedom	Mean Square	F Statistic	Significance of F Statistic
Regression (about mean)	678.208×10^2	17	398.946×10^1	23.09	<0.0005
Error	15.547×10^2	9	172.747		
Total (about mean)	693.755×10^2	26			

Standard Error of Estimate 415.629

Number of Observations 27

Coefficient of Multiple Determination R^2 .. 0.9776

Multiple Correlation Coefficient R 0.9887

Presentation of Selected Statistical Calculations (Continued)

Variable Code Number	Regression Coefficient	Beta Weight	F Statistic for Regression Coefficient	Significance of F Statistic	R^2 Delete
Constant	4045.272		116.530	< 0.001	
23-1	-3822.921	-1.089	112.096	< 0.001	0.698
53-1	-2253.535	-0.616	31.030	< 0.001	0.900
53-2	-893.478	-0.217	5.472	0.044	0.964
54-1	-2347.419	-0.609	46.835	< 0.001	0.861
54-2	-1075.241	-0.279	10.757	0.010	0.951
54-3	-2599.683	-0.576	48.828	< 0.001	0.856
73-1	-4008.272	-0.472	51.301	< 0.001	0.850
73-2	-1919.650	-0.425	28.985	< 0.001	0.905
76-1	-1635.268	-0.362	21.320	0.001	0.925
76-2	1470.940	0.240	8.296	0.018	0.957
86-1	3460.722	0.898	77.208	< 0.001	0.785
98-1	2437.498	0.478	28.337	< 0.001	0.907
116-1	-871.551	-0.272	12.158	0.007	0.947
117-1	-2337.083	-0.566	47.437	< 0.001	0.859
118-1	-1738.990	-0.451	32.145	< 0.001	0.898
120-1	1181.183	0.306	18.007	0.002	0.933
120-2	3486.068	0.953	123.500	< 0.001	0.670

4. Listing of Variables and Scoring Routines Used in the Model

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used
23--	Relative Marketing Costs	Less than 5% of net sales	0
23-1		Between 5 and 12% of net sales	1
23--		Greater than 12% of net sales	0
53--	Median Cumulative Investment Require-ments	Less than $420,000	0
53-1		Between $420,000 and $2,300,000	1
53-2		Between $2,300,000 and $5,000,000	1
53--		Greater than $5,000,000	0
54--	Median Annual Incremental Investment Require-ments	Less than $10,000	0
54-1		Between $10,000 and $51,000	1
54-2		Between $51,000 and $130,000	1
54-3		Between $130,000 and $300,000	1
54--		Greater than $300,000	0
73-1	Research and Develop-ment Har-nessing Experiences	Highly difficult	1
73--		Moderately difficult to moderately easy	0
73-2		Very easy	1
76-1	Percentage of User Laboratory Evaluation	100%	1
76--		Between 40 and 99%	0
76-2		Between 20 and 39%	1
76--		Less than 20%	0
86--	Effect of Product Quality on Source Selection	Highly important	0
86-1		Moderately important	1
86--		Slightly important to highly unimportant	0
98--	Clarity of Product Demand	Moderately to clearly understood	0
98-1		Slightly understood	1
98--		Indifferent to clearly misunder-stood	0

(Continued)

Listing of Variables and Scoring Routines Used in the Model (Continued)

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used
116--	Export Patterns	10% or more	0
116-1		Less than 10%	1
116--		None	0
117--	Maximum Aggregate Investment Require-ments	Less than $200,000	0
117-1		Between $200,000 and $1,000,000	1
117--		Greater than $1,000,000	0
118--	Mean Cumulative Investment Require-ments	Less than $500,000	0
118-1		Between $500,000 and $2,000,000	1
118--		Greater than $2,000,000	0
120-1	Trends in Gross Margins	Increased	1
120--		Not changed	0
120-2		Decreased	1

5. Analysis of Proposed Model

TABLE 9-5

HISTORICAL FIT OF MODEL FOR VARIABLE 152

Observation Number	Observed Annualized Net Sales (Arbitrary Origin)	Calculated Annualized Net Sales (Arbitrary Origin)	Difference
1	566.000	158.689	407.311
2	425,429	942,580	-517.151
3	2567.200	2652.777	-85.577
4	1912.800	2280.243	-367.443
5	623.500	871.731	-248.231

(Continued)

TABLE 9-5

HISTORICAL FIT OF MODEL FOR VARIABLE 152

(Continued)

Observation Number	Observed Annualized Net Sales (Arbitrary Origin)	Calculated Annualized Net Sales (Arbitrary Origin)	Difference
6	63.833	222.351	-158.518
7	474.429	270.750	203.679
8	767.250	854.977	-87.727
9	37.000	37.000	0.000
10	78.571	153.029	-74.458
11	1147.556	985.371	162.185
12	1067.857	1205.846	-137.989
13	4121.429	4312.370	-190.941
14	4364.000	4536.450	-172.450
15	6300.000	6162.011	137.989
16	300.111	359.490	-59.379
17	3253.125	3104.871	148.254
18	168.250	42.235	126.015
19	1054.091	920.186	133.905
20	321.857	179.754	142.103
21	552.664	541.953	10.711
22	34.933	222.351	-187.418
23	76.517	62.585	13.932
24	660.444	499.785	160.659
25	1067.000	861.742	205.258
26	3854.700	3173.721	680.979
27	1560.875	1806.571	-245.696

The commitment of marketing expenditures towards any realizing of specific marketing opportunities, clearly important as a demand-creating force, weighed most heavily in the proposed statistical model of annualized net sales data, as revealed by its effect on the coefficient of multiple determination when removing the variable from the model: the R^2 dropped from .989 to .698 (see R^2 delete value presented in Section 3). Firms have been willing to accept lower gross margins for new product development in order to expand business to significantly higher revenue levels. Thus within the context of the model, decreasing gross margins generally indicated changes in demand which produced higher levels of sales, even if that business was relatively less profitable. Whenever product quality on source selection was a factor in selecting the manufacturer, the material requirements of buyers were usually enough above average to ensure higher demand levels. Other useful factors retained in the model included the clarity of product demand, research and development harnessing experiences, percentage of users evaluating the product in their own laboratories, and the extent of exporting.

Limited capital investments in production facilities established obvious upper limits on the amount of throughput that could be processed in a given time period, a problem only when demand outstripped the capability to supply. Moderate expansions in plant facilities were integrated much more readily and efficiently than major upheavals, which can strain all processes until completed; on the other hand, minuscule expansions usually represented greater utilization of capital equipment and not actual expansions of on-line facilities.

With a high coefficient of multiple determination, .978, this model translated much historical data into meaningful relationships which served to explain sales performance. Because of the wide spread in the values of sales data, some entries in the residuals column could yet stand reduction, this despite the high calculated R^2 value obtained in the model. Correlation measures tend to disguise these discrepancies under such operating numerical conditions.

Multivariate Model of Performance Variable 153, Annualized Net Profits After Taxes

1. Criterion: Minimize the least squares sum as long as each remaining contributing variable meets a significance level of .05 or less.

2. Model:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + b_{12}X_{12} + b_{13}X_{13} + b_{14}X_{14} + b_{15}X_{15} + b_{16}X_{16} + b_{17}X_{17} + b_{18}X_{18} + b_{19}X_{19} + b_{20}X_{20} + b_{21}X_{21} + b_{22}X_{22}$$

3. Presentation of Selected Statistical Calculations

ANALYSIS OF VARIANCE FOR OVERALL REGRESSION

	Sum of Squares	Degrees of Freedom	Mean Square	F Statistic	Significance of F Statistic
Regression (about mean)	2189.813	22	99.537	1577.58	< 0.0005
Error	0.252	4	0.063		
Total (about mean)	2190.065	26			

Standard Error of Estimate 7.943

Number of Observations 27

Coefficient of Multiple Determination R^2 .. 0.9999

Multiple Correlation Coefficient R 0.9999

Variable Code Number	Regression Coefficient	Beta Weight	F Statistic for Regression Coefficient	Significance of F Statistic	R^2 Delete
Constant	-313.142		326.263	< 0.001	
21-1	-413.395	-0.603	900.870	< 0.001	0.974
53-1	-1052.943	-1.436	1624.272	< 0.001	0.953
73-1	-467.568	-0.430	1266.861	< 0.001	0.963
75-1	632.563	1.104	1601.984	< 0.001	0.954
86-1	551.038	0.804	2322.426	< 0.001	0.933
90-1	1088.078	1.201	4038.012	< 0.001	0.884
95-1	1551.807	2.388	1989.239	< 0.001	0.943
95-2	-390.962	-0.431	659.914	< 0.001	0.981
96-1	-522.351	-0.804	817.955	< 0.001	0.976
98-1	-580.958	-0.894	991.768	< 0.001	0.971
99-1	372.226	0.573	2153.744	< 0.001	0.938
99-2	241.366	0.400	393.622	< 0.001	0.989

(Continued)

Presentation of Selected Statistical Calculations (Continued)

Variable Code Number	Regression Coefficient	Beta Weight	F Statistic for Regression Coefficient	Significance of F Statistic	R^2 Delete
99-3	-351.139	-0.387	861.403	< 0.001	0.975
101-1	398.055	0.543	562.887	< 0.001	0.984
103-1	1028.346	1.582	1356.016	< 0.001	0.961
103-2	79.274	0.138	20.231	0.011	0.999
117-1	-373.036	-0.545	908.722	< 0.001	0.974
117-2	-1015.947	-1.483	1313.661	< 0.001	0.962
117-3	463.703	0.632	1098.206	< 0.001	0.968
122-1	82.780	0.145	117.337	< 0.001	0.997
124-1	-941.609	-1.375	1978.706	< 0.001	0.943
124-2	-43.758	-0.075	24.025	0.008	0.999

4. Listing of Variables and Scoring Routines Used in the Model

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used
21--	Aggregate Research and Development Expenditures	Less than $500,000	0
21-1		$500,000 or more	1
53--	Median Cumulative Investment Requirements	Less than $5,000,000	0
53-1		$5,000,000 or more	1
73--	Research and Development Harnessing Experiences	Slightly easy to highly difficult	0
73-1		Moderately easy	1
73--		Very easy	0

(Continued)

Listing of Variables and Scoring Routines Used in the Model (Continued)

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used
75-1	Effect of Supply Capabilities in Developmental Sampling Programs	Marked beneficial effect, since firm able to supply all user requirements	1
75--		Moderately beneficial to detrimental effect, since firm at best able to supply most of user requirements	0
86--	Effect of Product Quality on Source Selection	Highly important	0
86-1		Moderately important	1
86--		Slightly important to unimportant	0
90--	Effect of Industrial Advertising on Manufacturer Selection	Strong positive effect	0
90-1		Moderately positive effect	1
90--		Slightly positive to negative effect	0
95-1	Market Trends	Strongly increasing, i.e., annual growth rate exceeding 10%	1
95--		Moderately increasing, i.e., annual growth rate exceeding 3% but less than 10%	0
95-2		Slightly increasing, i.e., annual growth rate of 3% or less	1
95--		No change or decreasing	0
96-1	Effect of Hidden Price Concessions on Purchasing Decisions	Strong positive effect	1
96--		Moderately positive to negative effect	0
98--	Clarity of Product Demand	Clearly understood	0
98-1		Moderately understood	1
98--		Slightly understood to misunderstood	0

(Continued)

Listing of Variables and Scoring Routines Used in the Model (Continued)

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used
99-1	Demand Trends in Derived Demand Situations	Strongly increased, i.e., annual growth rate exceeding 10%	1
99-2		Moderately increased, i.e., annual growth rate between 3% and 10%	1
99-3		Slightly increased, i.e., annual growth rate of 3% or less	1
99--		Not changed or decreased	0
101--	Number of Purchasers	Five or less	0
101-1		Six to ten	1
101--		Eleven or more	0
103-1	Cyclical Patterns	Cyclical	1
103-2		Noncyclical	1
103--		Unknown	0
117--	Maximum Aggregate Investment Require-ments	Less than $1,000,000	0
117-1		Between $1,000,000 and $2,500,000	1
117-2		Between $2,500,000 and $6,000,000	1
117-3		Greater than $6,000,000	1
122--	Subjective Measure of Success or Failure	Highly successful	0
122-1		Moderately successful	1
122--		Slightly successful or failure	0
124--	Type of Fixed Capital Employed	Single-purpose equipment	0
124-1		Combination of single-purpose and multipurpose equipment with major being single-purpose	1
124--		Combination of single-purpose and multipurpose equipment with major being multipurpose	0
124-2		Multipurpose equipment	1

5. Analysis of Proposed Model

TABLE 9-6

HISTORICAL FIT OF MODEL FOR VARIABLE 153

Observation Number	Observed Annualized Net Profits After Taxes (Arbitrary Origin)	Calculated Annualized Net Profits After Taxes (Arbitrary Origin)	Difference
1	43.600	41.597	2.003
2	-1.000	-4.855	3.855
3	314.600	313.475	1.125
4	132.200	133.614	-1.414
5	38.667	42.522	-3.855
6	7.360	7.498	-0.138
7	66.380	67.451	-1.071
8	48.000	44.906	3.094
9	-38.896	-37.064	-1.832
10	12.660	7.734	4.926
11	172.733	172.144	0.589
12	185.929	185.222	0.707
13	398.469	399.176	-0.707
14	935.810	935.329	0.481
15	1159.600	1160.671	-1.071
16	-13.496	-18.099	4.603
17	385.250	381.758	3.492
18	-198.150	-196.662	-1.488
19	37.184	38.672	-1.488
20	9.636	5.053	4.583
21	87.596	94.600	-7.004
22	-2.504	3.798	-6.302
23	5.518	3.798	1.720
24	99.387	98.124	1.263
25	23.466	23.402	0.064
26	34.937	36.715	-1.778
27	60.324	64.681	-4.357

In this multivariate model, the market trend situation for new industrial chemical products contributed most to variance reduction, a strongly increasing market with an annual growth rate exceeding 10% significantly strengthening profit structures. Such market growth tended to stabilize market participation as well, regardless of the types of competitive behavior through which participants attempted to create an aura of product differentiation, with supply and service capabilities assuming great importance. On the other hand, a market expanding at a rate of 3% or less also strengthened profits in terms of it generating significant earnings. Cyclical structures did not appear to weaken performance on the average. Quite on the contrary, since most periods witnessed strong economic gains for the types of products included in the analysis, a progressive economic climate facilitated good profit achievement.

The next variable thought to relate to attained profit levels of business was the maximum aggregate investment requirement. Rather mixed profit experiences at varying investment levels netted only one investment class of aggregate investments over $6 million with a positive coefficient in the equation. Of course, this considers just absolute profit dollars, not necessarily a measure of efficiency of capital deployment. Thus above average profits appeared possible with plants having higher throughputs, given favorable capacity utilization and process economics.

The type of fixed capital influenced profitability, with single-purpose equipment depressing performance more than multipurpose. Attained profit levels directly correlated with any industrial advertising judged to be at least moderately effective. And the capability to furnish commercial quantities of product to potential industrial users at the time when on-site laboratory evaluations were proposed often motivated users toward actual evaluation and thence toward more immediate and widespread adoption, a direct correlate of earnings. Other variables incorporated in this model include the clarity of demand, effect of quality on source selection, hidden price concessions, total research and development commitment, market trends for derived demand situations, number of purchasers, harnessing experiences for research and development programs, and relative success ratings, all different enough not to depend on chance alone.

The performance characteristic of annualized net profits after taxes achieved an excellent historical fit: the signs of the actual figures matched their corresponding calculated values in all cases but one. We do not expect perfect predictive capability in any prescriptive model; still, this model helped greatly to sift out many relevant factors from the product histories.

Multivariate Model of Performance Variable 154, Critical Turning Point for Present Value Calculations

1. Criterion: Minimize the least squares sum as long as each remaining contributing variable meets a significance level of .05 or less.

2. Model:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + b_{12}X_{12} + b_{13}X_{13} + b_{14}X_{14} + b_{15}X_{15} + b_{16}X_{16} + b_{17}X_{17}$$

3. Presentation of Selected Statistical Calculations

ANALYSIS OF VARIANCE FOR OVERALL REGRESSION

	Sum of Squares	Degrees of Freedom	Mean Square	F Statistic	Significance of F Statistic
Regression (about mean)	806.570	17	47.45	13.80	0.002
Error	20.627	6	3.44		
Total (about mean)	827.196	23			

Standard Error of Estimate 1.854

Number of Observations 24

Coefficient of Multiple Determination R^2 .. 0.9751

Multiple Correlation Coefficient R 0.9875

Presentation of Selected Statistical Calculations (Continued)

Variable Code Number	Regression Coefficient	Beta Weight	F Statistic for Regression Coefficient	Significance of F Statistic	R^2 Delete
Constant	36.153		57.522	< 0.001	
21-1	8.370	0.579	15.219	0.008	0.912
21-2	7.464	0.474	16.412	0.007	0.907
31-1	3.490	0.288	7.467	0.034	0.944
31-2	-4.629	-0.358	7.557	0.033	0.944
88-1	-3.104	-0.256	6.069	0.049	0.950
90-1	-15.559	-0.733	23.471	0.003	0.878
104-1	5.685	0.477	22.243	0.003	0.883
107-1	14.792	1.188	22.629	0.003	0.881
107-2	6.442	0.363	11.467	0.015	0.927
109-1	-7.895	-0.445	19.249	0.005	0.895
111-1	-23.533	-1.941	31.202	0.001	0.845
111-2	-30.867	-2.135	31.983	0.001	0.842
111-3	-13.226	-1.091	15.858	0.007	0.909
114-1	-8.627	-0.724	13.997	0.010	0.917
114-2	-17.701	-1.370	34.570	0.001	0.831
116-1	6.055	0.508	14.265	0.009	0.916
123-1	-7.838	-0.578	16.017	0.007	0.909

4. Listing of Variables and Scoring Routines Used in the Model

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used
21--	Aggregate Research and Development Expenditures	Less than $170,000	0
21-1		Between $170,000 and $500,000	1
21-2		Greater than $500,000	1
31--	Number of Minor Consuming Industries	None	0
31-1		One to two	1
31-2		Three or more	1
88--	Outlay Trends for Product Promotion	Marked rise, since growth rates for promotional outlays significantly greater than that of sales	0
88-1		Marked to moderate rise, since growth rates for promotional outlays slightly greater than that of sales	1
88--		Concomitant rise, since growth rates of promotional outlays equal to that of sales, to declining outlays, or no outlays	0
90-1	Effect of Industrial Advertising on Manufacturer Selection	Strong positive effect	1
90--		Moderately positive to strongly negative effect	0
104--	Trade Relations	Extremely good	0
104-1		Moderately good	1
104--		Slightly good to weak	0
107--	Level of Product Loyalty	Very strong	0
107-1		Strong	1
107--		Moderately strong	0
107-2		Moderately to very weak	1
107--		None	0

(Continued)

Listing of Variables and Scoring Routines Used in the Model (Continued)

Research Code Number	Variable	Median Response Breakdown Included	Response Number Used
109--	Degree of Backward Integration	Very slight move, i.e., less than 5% of customers	0
109-1		Slight move to highly marked move, i.e., at least 5% of customers	1
111-1	Product Concept Acceptance	Highly effective	1
111-2		Moderately effective	1
111-3		Slightly effective	1
111--		Indifferent to ineffective	0
114-1	Relative Technical Service Require-ments	Fraction value less than 0.5	1
114-2		Fraction value between 0.5 and 1.5	1
114--		Fraction value greater than 1.5	0
116--	Export Patterns	Over 10%	0
116-1		Between 1 and 10%	1
116--		None	0
123--	Basing of Research and Devel-opment Program	Research-based	0
123-1		Marketing-based	1

5. Analysis of Proposed Model

TABLE 9-7

HISTORICAL FIT OF MODEL FOR VARIABLE 154

Observation Number	Observed Sign Change (in years)	Calculated Sign Change (in years)	Difference
1	11.000	11.000	0.000
2	20.000	18.959	1.041
3	8.800	7.558	1.242
4	13.900	13.161	0.739
5	14.200	13.958	0.242
6	6.200	6.400	-0.200
7	5.800	7.183	-1.383
8	10.800	11.329	-0.529
9	8.200	8.793	-0.593
10	9.400	8.807	0.593
11	7.500	6.144	1.356
12	3.700	2.829	0.871
13	17.400	17.912	-0.512
14	16.000	15.197	0.803
15	16.200	16.951	-0.751
16	20.000	21.362	-1.362
17	12.100	12.228	-0.128
18	5.100	5.364	-0.264
19	21.000	20.773	0.227
20	10.200	12.146	-1.946
21	2.200	2.943	-0.743
22	16.800	15.725	1.075
23	24.500	23.189	1.311
24	17.500	18.587	-1.087

The general ability of a typical manufacturer representative to get across the product application concept related most directly to the time period required for a product to attain positive discounted net earnings. Effective and convincing selling can unquestionably accelerate product acceptance then, and significantly reduce the time period required to achieve this sign change for the average new product. And industrial chemical products requiring little or no technical service support relative to marketing coverage also recovered operating cash faster. Major technical problems affecting user application should clearly be resolved before introduction if product management desires the earliest possible market acceptance.

The level of product loyalty throughout the product life cycle, another variable pertinent to this model, suggested through irregular calculated beta weights some possible joint distributive effects. Positive product response to industrial advertising also helped reduce the time required before present value sums changed sign. Despite the ambiguity of relationships between the basing of research and development programs and various performance characteristics, so did marketing-based research and development programs. Other variables retained in the model included export patterns, trade relation experiences, total research and development commitment, number of minor consuming industries, and the extent of customer backward integration.

Estimations of the years required before products began to add to earnings on a discounted net cumulative cash flow basis approximated the actual results, using calculated parameters over the relevant variables. The multiple correlation coefficient of .988 suggested a very high association between actual and predicted values. The largest calculated deviation was 1.95 years; and most calculated values followed the historical record quite closely.

CHAPTER X

SUMMARY AND FURTHER COMMENTS ON THE INDUSTRIAL CHEMICAL COMMERCIAL DEVELOPMENT PROCESS

This exploratory study of new product decisions, centering on the familiar concept of the product life cycle, has sought to isolate patterns of performance and the determinants of product behavior. The previous two chapters have presented the major research findings; the following commentary summarizes the research findings and makes some final observations about the new industrial chemical product process, implications for product management, limitations of the study, and possibilities of further research.

Screening Chemical Entities for End-Use Characteristics

Because of the typical diversity of end-use applications for new chemical products—the same compound used in a specific pharmaceutical formulation designed to treat microbial infections may easily be employed as an intermediate in chemical synthesis as well—no single chemical manufacturer can possibly conduct all the research necessary to identify every worthwhile commercial application, even after identification of the chemical structure has eliminated particular possibilities. Thus the chemical industry has increasingly encouraged concurrent research by potential users in areas of mutual interest. So the major impetus to continuous development depends on creating and sustaining the investigational involvement of users, though evaluations of potentially interesting chemical structures based on personal intrigue are not enough. The extent of their involvement is critical to the investment decision because it will dictate the rate and timing of possible product acceptance and, in turn, of resource allocation.

Resistance to screening chemical structures for commercial value might be overcome through research agreements which could help shape interfirm working relationships among scientists. Interaction between the appropriate decision-making bodies at both management and operating levels could establish joint programs of mutual interest, which would help establish selection and an efficient deployment of existing resources. To secure the most efficient utilization of talent, such research agreements might involve the chemical manufacturer with carefully selected, qualified research bodies in nonoverlapping areas of expertise. No particular research body need be affiliated with a specific manufacturing area, but such an arrangement would promote more rapid product acceptance once performance characteristics and preferences had been ascertained. Obviously the emphasis placed on such research agreements would depend on assessments of the productivity of research and the contributions of potential new product business to interindustry flows.

An Assessment of New Product Activities for Industrial Chemicals from a Financial Viewpoint

Even though new industrial chemical products are important revenue producers, the empirical evidence suggests we not expect any abrupt change in the earnings pattern of a given chemical manufacturer based on an announcement of a new product venture: the prudent investor would not anticipate immediate gains on the basis of such announcements. The relative profitability in any year of the new industrial chemical products studied ranged from a loss of $0.03 per share to a gain of $0.21 per share. In general, new chemical product ventures have added to discounted earnings growth in the long run, but such realization typically required at least five years. With just a few notable exceptions, then, business strategies within established product lines had by far the greatest immediate impact on financial performance; new product expectations remain long term because large capital expenditures are usually involved and the pricing variable is often tempered by existing substitute product offerings available in the marketplace.

The Appropriate Time Horizon in New Product Proposal Evaluations for Industrial Chemical Products

Given the patterns of known product behavior presented in the research findings, it appears that more than five years are required to adequately project the performance of a new industrial chemical product. The ranking of discounted present value sum figures through time was not in itself stable. Using a relatively short time horizon for selecting product entries and determining their relative emphasis in development could induce substantial managerial errors. And the profit structure ranged widely with varying levels of product acceptance. Even though distant cash flow changes produce considerably smaller changes when discounted, they did influence ranking outcomes frequently. As market participation shifted in various stages of the product life cycle, the investment situation rarely remained static. The need for new, transferred and carry-forward investments—unique to given product situations—clearly affected both capital expenditure allocations and working capital requirements.

Discounted net cash measures test the relative success of product management both in assessing new product opportunities and in implementing investment and marketing strategies. Since the time dimension frequently influences performance, imaginative managerial evaluation must project the competitive environment far into the future. The Spearman rank coefficients of discounted present value sum figures over time (presented in Table 10-1) substantiate the volatility of product ranking behavior, pointing out the capability to simulate the impact of varying time horizons on the new product selection process.

TABLE 10-1

RANK CORRELATION COEFFICIENTS OF
DISCOUNTED PRESENT VALUE SUM FIGURES[1] THROUGH TIME

10	0.2448	0.3071	0.2503	0.3987	0.4860	0.5086	0.6380	0.8333	0.9463
9	0.3529	0.4335	0.4396	0.5806	0.6569	0.6771	0.8010	0.9444	
8	0.4017	0.4573	0.5830	0.7265	0.7876	0.7937	0.8871		
7	0.5513	0.5983	0.8101	0.9249	0.9499	0.9701			
6	0.5989	0.6294	0.8541	0.9713	0.9860				
5	0.5855	0.5910	0.8578	0.9780					
4	0.5873	0.5897	0.8901						
3	0.7808	0.7271							
2	0.9481								
Year	1	2	3	4	5	6	7	8	9

[1]Provisions for the release of working capital and nondepreciated fixed assets at the end of each period under study have not been incorporated in the calculations; but forecasted data for the inputs in the capital budgeting model are included, if needed, to give a complete series.

Time horizons are rarely set at the economic life of the product in new product evaluations within the chemical industry for they typically exceed ten years. But an evaluation of the impact of varying time horizons on new product rank orders can provide a more sophisticated approach in selecting an appropriate time horizon—one based on actual experience.

The degree of association between discounted net cash flow positions in a given year and in subsequent years is approximated by the Spearman rank correlation coefficients listed in Table 10-1. The value of updated information is dramatically illustrated by the change in the relative error achieved by lengthening the time horizon; see for instance the Spearman correlation coefficient values in the row marked year 10, the last period in the analysis. Ranking results of discounted present value sum figures improved most sharply at the end of year 10 with time horizons of four and eight years, their respective Spearman rank correlation coefficients changing from 0.2503 and 0.6380 to 0.3987 and 0.8333. We could easily predict the unsatisfactory results attained with a limited time horizon of less than six years (if our empirical data are representative). But rankings of discounted present value sums shifted only nominally after eight years, an appropriate time horizon judging from the product experiences of new industrial chemicals. If one includes the time it takes to get plant facilities on-stream nowadays, up to eleven years are necessary to adequately pass judgment on new product proposals.

The Selection of New Product Entries

The movement of broad product categories seldom indicates the value of specific new product opportunities: any product that can attain rapid acceptance, either through the creation of primary demand or product substitution, bespeaks its own future and not necessarily that of a broad product market. The sales behavior of new chemical products nevertheless seems to relate to the industrial growth of specific markets, the successful product transferring its momentum via a predominant revenue contribution to industry-wide growth. Apparently the profitability of new product decisions responded as well to the consumption patterns of final goods. Evaluations of derived demand situations and interindustry flows are therefore essential before final new product investment decisions are made.

The Meaning of Identified Product Life Cycle Structures to Product Management

The isolation of whatever stable patterns new product performance may reveal, one primary research objective in this study, constitutes a necessary prelude to any projections of demand through time based on such patterns. But since demand is one critical input in the evaluation process, we should be able to improve forecasting procedures by identifying the variations in sales patterns and what may cause them.

We have already reported the three basic shapes of sales patterns appearing in the collected product histories. The pattern most frequently encountered, the rapid penetration model, did not follow conventional product life cycle theory. In scrutinizing proposals for industrial chemical products, management should expect to witness comparable patterns in demand projections to those disclosed in this study if the research findings are in fact representative beyond the periods of observation. And the extended rapid penetration model alone attained an overall positive present value at the end of ten years of product coverage. So clearly a capital appropriations program must entail a sustainable level of business for profitable product attainment. The timing of investment additions, itself critical to profit performance, could damage the future earnings stream when capital expenditures necessary for future supply capabilities are delayed; even so, the existing cash flow experiences of these responding firms had provided little economic incentive for immediate plant expansions.

A Tactical Position on Lead Time

Product management within the chemical field relies heavily on the apparent lead that a product has in the marketplace before competitive entry, and thus value launching a new product as soon as possible. The study has investigated differences in penetration between adaptive and innovative new products.

Many unique industrial chemical products introduced because patent protection was expected to be effective managed to maintain virtual market dominance in the time period under study. But even where lead periods lacked effective patent protection, product acceptance reached sufficient momentum for innovative products to maintain the high median attained market share level of 70%. Where direct competitive product offerings existed when a new product was introduced, the market penetration of the adaptive products tended to stabilize at levels ranked in order of market entry, though actual outcomes did vary with the relative promotional commitments of competing firms. Where perceptions of performance by industrial users varied greatly, actual product performance characteristics usually played the key role.

The efficiencies of returns new industrial chemical products showed on investments reflected in attained market positions. Firms having either little or virtual market control (i.e., less than 40% or 100% of the market) had poorer return records than the dominant oligopolistic participants. The degree to which adaptive products expanded primary demand remained unknown; but a limited number of competitive entrants probably enhanced overall product acceptance.

Identifying the Structural Characteristics of New Industrial Chemical Products Which Relate to Performance

A number of definite relationships between performance and product behavior were isolated in this attempt to identify what factors may be responsible for relative product performance. Obviously, many unimpressive sales records could have been prevented if balanced assessments had been made at the time the initial capital budgeting decisions were made. To evaluate new products successfully, then, requires analysis of the market structure, of potential buyer behavior, and of relevant product characteristics including the technology involved. Such an assessment will point to the controllable variables, and hopefully suggest alternate product strategies within the enterprise which can affect product behavior.

Having applied standard statistical methodology to the empirical data, we may propound tentatively the following determinants of industrial chemical product behavior:

1. Factors relating to performance which were generally supported by empirical research

   A. Market Structure

      (1) Demand Trends in Derived Demand Situations.
      (2) Duplication Difficulties by Competitors.

B. Buyer Behavior

(1) Dependence on Contacts by Company Representatives.
(2) Level of Product Loyalty.
(3) Effect of Industrial Advertising on Manufacturer Selection.

C. Related Intrafirm Experiences

(1) Outlay Trends for Product Promotion.
(2) Export Patterns.
(3) Plant Capacity Utilization.
(4) Number of Annual Production Runs Scheduled.
(5) Investment Patterns.
(6) Relative Marketing Costs.
(7) Research and Development Expenditures.

2. Factors relating to performance which were partially supported by empirical research

A. Market Structure

(1) Market Trends.
(2) Market Share Statistics.
(3) Minimum Corporate Asset Size of Competitors Required to Compete Effectively.
(4) Competitive Situation.
(5) Industrial Plant Capacity Experiences.
(6) Number of Consuming Industries.

B. Buyer Behavior

(1) Number of Purchasers.
(2) Trade Relations.
(3) Degree of Backward Integration.
(4) Effect of Product Quality on Source Selection.
(5) Extent of User Laboratory Evaluation.
(6) Number of Annual Purchases by Buyers.
(7) Effect on Sales of Related Products.

C. Product Characteristics

(1) Standard Industrial Classification (SIC) System Code.
(2) Price Movements.
(3) Research and Development Harnessing Experiences.
(4) Relative Technical Service Requirements.
(5) Type of Product Demand.
(6) Trends in Gross Margins.
(7) Cyclical Patterns.
(8) Matching of Technological Characteristics with Market Requirements.
(9) Specificity of Use.
(10) Degree of Marketing Innovativeness.
(11) Seasonal Patterns.
(12) End-Use Patterns.
(13) Sales Distribution Patterns.

D. Related Intrafirm Experiences

(1) Product Concept Acceptance.
(2) Basing of Research and Development Program.
(3) Mode of Production.
(4) Effect of Supply Capabilities in Developmental Sampling Programs.
(5) Action Concerning Product Improvements.
(6) Length of Production Run.
(7) Strategy Concerning Research and Development in Related Areas.
(8) Type of Fixed Capital Employed.
(9) Cost of Capital.
(10) Merger or Combination Experiences.
(11) Clarity of Product Demand.
(12) Types of Marketing Representatives Utilized.

These patterns reflect the experiences of industrial chemicals marketed by large chemical manufacturers during a select time period. Since there is every reason to suspect one bias or another at the firm level, an analysis of individual firm behavior is essential before generalizing from this study to operational predictions by product management in a particular firm.

On Structuring Multivariate Models of Performance

In using validated determinants of new product behavior to suggest plausible explanations of product performance, no single performance measure appeared in itself to be an adequate definition of the outcome. Performance itself means many things to many people, major groups within the chemical industry differing widely on organizational objectives. We need, therefore, to describe new product outcomes in terms of a number of performance characteristics, such as the following which our rank correlation statistics (computed among many performance descriptions from the collected data) found were not completely interchangeable with other characteristics: annualized sales, annualized net profits, equivalent rate of return, annualized discounted present value sum, market penetration, and the number of years required for a sign change on the discounted present value sum statistic.

Constructing a number of multivariate models depicting performance had the effect of integrating the financial and marketing disciplines; in each instance, sufficient historical data contained enough predictive value to produce a relatively good fit. These model structures, their interpretations, and implications for product management are discussed in Chapter IX.

Limitations of the Study

While one would prefer to overlook portions of the exploratory research which were structurally unsound, the study as a whole gains in our critically delineating the possible weaknesses which could limit its ultimate contribution. Any theoretical or empirical study should indeed be subjected to such scrutiny because (1) all results are contingent on the adequacy of the research design and its implementation, and (2) further research can seek to eliminate the weaknesses once they are identified.

This longitudinal analysis of new industrial chemical products marketed by major chemical manufacturers made no attempt to include all manufacturers having significant industrial chemical sales. A rather low participation rate of 24% certainly suggests another possible source of bias. Random selection of products studied sought to circumvent the problem, but such efforts may or may not have succeeded. Beyond any doubt, however, most of the chemical firms who elected not to participate declined because of insufficient continuity in their available information and experience at the time the inquiry was made and not for other reasons.

The research drew solely on those key industrial respondents who were in unique positions to evaluate product behavior. Of course, none of these people could have had precise recall capabilities on all aspects of product movement covering up to ten years without direct access to adequate documentation; far too often such documentation had not been assembled before preparation began for the interview. Specific data on a number of variables, e.g., those describing buyer behavior, would have best been supplied by groups outside the participating organizations, but time and budgetary constraints prevented full exploration of these possibilities. The data included in the study represent just the official interpretations of product case histories by major chemical marketers.

Quite possibly the relationships between performance and many determinants of product behavior are too complex to be captured by simple association phenomena. No other screening approach was attempted in isolating the determinants of performance, an omission compounded by the likelihood that some relevant variables were not explicitly examined. The writer alone bears full responsibility for any deficiencies and omissions. To model new product behavior further requires the estimation of structural parameters. Although there are a number of existing estimation procedures available which could have been appropriately utilized, this work was limited to multivariate linearized models, and little was discovered about the true effects of nonlinearity, product interdependence, and multicollinearity pervading typical marketing problems. Apparently the transformation of data into dummy variables in the scoring routines considerably reduced the illusive impact of multicollinearity.

Our emphasis on long term gains in the analytical new product decision process probably misrepresents actual managerial behavior. Some balance between short and long term considerations in the future should advance product management practices significantly.

The current market experiences of new industrial chemical products will undoubtedly dictate some structural shifts needed before the developed performance models can help resolve major problems in the research and development process. A more expansive data bank combined with creative field research should improve the performance record of products introduced in future markets.

Possible Directions of Future Research

This research demonstrated that the sales and profit structures of new industrial chemical products tended to follow specific patterns and it identified tentative forms of these patterns. Product management might well check the consistency of the firm's historical record against the proposals submitted. Clearly more research into the dynamics of new product behavior is essential before we may generalize about the possible longitudinal configurations of performance results. Different levels of aggregated data defined over relevant operating forces, and studied simultaneously whenever appropriate, should lead to a better understanding of new product behavior. We have learned much about new industrial chemical product structures through this research work. But more precise, comprehensive documentation of the determinants of new product behavior must necessarily precede any real payoff even from the present investigation.

Few corporations today employ the rigorous approach to marketing research investigations, test marketing, and experimentation whereby they might reduce the marketing and financial risks associated with new product investments. And the study reflected the need for improved forecasting techniques. Even though the average forecasting error on each performance measure was not estimated because of retrieval problems, the collected discounted present value sum data revealed the seriousness of this problem: over half of the new products studied had negative cash flows at the end of ten years, after provisions were made for the release of working capital and nondepreciated fixed assets at the end of the last period in the analysis. We may doubt that these new product proposals would have been accepted by product management had these outcomes been projected when the initial capital budgeting decisions were made. It would be worthwhile to evaluate forecasting errors in order to establish both a heuristic adjustment technique and a model for determining confidence intervals for adjusted forecasts.

Obviously the investigating of new product behavior is not limited to one product class. Expanded studies in other key product areas can significantly increase the knowledge base of the participating firm and its capacity to achieve corporate growth and product leadership.

APPENDICES

APPENDIX A

LISTING OF VARIABLES

Research Code Variable Number	Variable Title
1	Discounted Present Value Sum
2	Accounting Rate of Return
3	Aggregate Net Sales
4	Aggregate Net Profits (Losses) After Taxes
5	Rate of Growth of Net Sales
6	Rate of Growth of Net Profits
7	Rate of Growth of Net Losses
8	Timing of Sales Cycle
9	Timing of Profit Cycle
10	Payback Period
11	Equivalent Rate of Return
12	Profitability Ratio
13	Return on Investment
14	Payback Period
15	Aggregate Net Profits (Losses) After Taxes
16	Maximum Aggregate Investment Requirements
17	Extent of Plant Capacity Utilization
18	Aggregate Research and Development Expenditures
19	Cost of Capital
20	Market Share Statistics
21	Aggregate Research and Development Expenditures
22	Mean Yearly Research and Development Expenditures
23	Relative Marketing Costs
24	Process Patent Protection
25	Product Patent Protection
26	Use Patent Protection
27	Direct Competitive Situation
28	Indirect Competitive Situation

Research Code Variable Number	Variable Title
29	End-Use Patterns
30	Number of Major Consuming Industries
31	Number of Minor Consuming Industries
32	Specificity of Use
33	Relative Price Changes
34	Causes of Marked Price Declines
35	Strategy Concerning Retail Margins
36	Effect of Strategy Concerning Retail Margins
37	Strategy Concerning Wholesale Margins
38	Effect of Strategy Concerning Wholesale Margins
39	Strategy Concerning Sales Force Size
40	Effect of Strategy Concerning Sales Force Size
41	Strategy Concerning Number of Sales Calls Per Unit of Time
42	Effect of Strategy Concerning Number of Sales Calls Per Unit of Time
43	Strategy Concerning Number of Distribution Outlets
44	Effect of Strategy Concerning Number of Distribution Outlets
45	Strategy Concerning Number of Product Offerings for Same End-Use
46	Effect of Strategy Concerning Number of Product Offerings for Same End-Use
47	Strategy Concerning Product Promotion Expenditures
48	Effect of Strategy Concerning Product Promotion Expenditures
49	Strategy Concerning Capacity Requirements
50	Effect of Strategy Concerning Capacity Requirements
51	Strategy Concerning Research and Development in Related Areas
52	Effect of Strategy Concerning Research and Development in Related Areas
53	Median Cumulative Investment Requirements
54	Median Annual Incremental Investment Requirements
55	Action Concerning Product Improvements
56	Effect of Action Concerning Product Improvements
57	Action Regarding Distribution Channel Changes

Research Code Variable Number	Variable Title
58	Effect of Action Regarding Distribution Channel Changes
59	Action Regarding Cessation of Production
60	Effect of Action Regarding Cessation of Production
61	Action Regarding Promotional Media Changes
62	Effect of Action Regarding Promotional Media Changes
63	Action Regarding Price Changes
64	Effect of Action Regarding Price Changes
65	Industrial Plant Capacity Experiences
66	Plant Capacity Experiences for Family of Related Products
67	Plant Capacity Experiences for Separately Produced Products
68	Product Patent Experiences
69	Process Patent Experiences
70	Use Patent Experiences
71	Supply Characteristics
72	Technological Specialty Experiences
73	Research and Development Harnessing Experiences
74	Fruits of Research and Development
75	Effect of Supply Capabilities in Developmental Sampling Programs
76	Percentage of User Laboratory Evaluation
77	Effect of Reputation and Image of Manufacturer
78	Duplication Difficulties by Competitors
79	Licensing Experiences
80	Effect of Licensing Acquisitions by Other Firms
81	Recognition Experiences of Product Advantages by Users
82	Number of Annual Purchases by Buyers
83	Matching of Technological Characteristics with Market Requirements
84	Degree of Marketing Innovativeness
85	Degree of Technological Innovativeness
86	Effect of Product Quality on Source Selection
87	Effect on Sales of Related Products

Research Code Variable Number	Variable Title
88	Outlay Trends for Product Promotion
89	Dependence on Contacts by Company Representatives
90	Effect of Industrial Advertising on Manufacturer Selection
91	Suitability of Existing Marketing Personnel
92	Merger or Combination Experiences
93	Effect of Merger or Combination Experiences
94	Minimum Corporate Asset Size of Competitors Required to Compete Effectively
95	Market Trends
96	Effect of Hidden Price Concessions on Purchasing Decisions
97	Type of Product Demand
98	Clarity of Product Demand
99	Demand Trends in Derived Demand Situations
100	Number of Product Sources by Buyers
101	Number of Purchasers
102	Seasonal Patterns
103	Cyclical Patterns
104	Trade Relations
105	Reciprocity Agreement Experiences
106	Effect of Reciprocity Agreements
107	Level of Product Loyalty
108	Degree of Required Deliberation
109	Degree of Backward Integration
110	Effectiveness of Channel for Product Flows
111	Product Concept Acceptance
112	Time to Educate the User
113	Number of Contacts Required by Marketing and Technical Personnel
114	Relative Technical Service Requirements
115	Import Patterns
116	Export Patterns
117	Maximum Aggregate Investment Requirements

Research Code Variable Number	Variable Title
118	Mean Cumulative Investment Requirements
119	Type of Distribution Channel
120	Trends in Gross Margins
121	Valuation of Byproducts
122	Subjective Measure of Success or Failure
123	Basing of Research and Development Program
124	Type of Fixed Capital Employed
125	Length of Production Run
126	Extent of Plant Capacity Utilization
127	Number of Annual Production Runs Scheduled
128	Relative Success or Failure of New Industrial Chemical Products
129	Mode of Production
130	Type of Product
131	Types of Marketing Representatives Utilized
132	Source of Product Discovery
133	Standard Industrial Classification (SIC) Code
134	End-Use Patterns
135	Simulation Experiences
136	Analysis Procedure
137	Post Mortem Audit
138	Evaluation of Outcomes
139	Capital Budgeting Techniques
140	Types of Cut-Off Rates Used
141	Discount Factors Employed
142	Time Horizon
143	Length of Time Horizon
144	Policy for Time Horizon - Part 1
145	Policy for Time Horizon - Part 2
146	Minimum Discount Rate Used
147	Annualized Discounted Present Value Sum
148	Timing of Sales Cycle

Research Code Variable Number	Variable Title
149	Performance Index
150	Types of Sales Patterns
151	Shape and Timing of Sales Patterns
152	Annualized Net Sales
153	Annualized Net Profits (Losses) After Taxes
154	Critical Turning Point for Present Value Calculations

APPENDIX B

NONPARAMETRIC STATISTICAL TESTS OF GROUP VARIABLES AGAINST SELECTED PERFORMANCE CRITERIA

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
20	9	1	7.83	Kruskal-Wallis H	0.0809
		2	20.50	8.3101	
		3	12.50		
		4	18.30		
		5	13.33		
20	10	1	19.83	Kruskal-Wallis H	0.1779
		2	9.75	6.2994	
		3	11.00		
		4	10.00		
		5	15.22		
20	11	1	7.83	Bhapkar V	0.0714
		2	17.00	8.6189	
		3	18.33		
		4	20.00		
		5	12.00		
20	12	1	7.83	Bhapkar V	0.0598
		2	17.25	9.0528	
		3	18.67		
		4	19.80		
		5	11.89		
20	13	1	8.67	Kruskal-Wallis H	0.0676
		2	16.50	8.7531	
		3	21.33		
		4	19.00		
		5	11.22		
20	13	1	11.80	Kruskal-Wallis H	0.0439
		2	19.88	6.2535	
		3	11.22		
20	152	1	10.33	Kruskal-Wallis H	0.0685
		2	23.50	8.7192	
		3	12.33		
		4	9.80		
		5	15.11		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
20	153	1	7.50	Kruskal-Wallis H	0.0678
		2	22.25	8.7459	
		3	15.67		
		4	12.60		
		5	14.89		
20	154	1	20.92	Kruskal-Wallis H	0.0519
		2	10.50	9.3987	
		3	10.33		
		4	7.80		
		5	15.61		
21	1	1	14.00	Bhapkar V	0.0009
		2	16.20	18.6194	
		3	20.00		
		4	15.83		
		5	5.33		
21	2	1	10.60	Bhapkar V	0.0861
		2	18.00	8.1548	
		3	17.40		
		4	16.67		
		5	8.00		
21	3	1	6.60	Kruskal-Wallis H	0.0840
		2	16.60	8.2159	
		3	20.00		
		4	12.00		
		5	15.00		
21	4	1	6.60	Kruskal-Wallis H	0.0320
		2	18.40	10.5598	
		3	21.00		
		4	13.50		
		5	11.17		
21	6	1	20.33	Kruskal-Wallis H	0.0940
		2	8.60	7.9360	
		3	10.00		
		4	13.00		
		5	8.50		
21	9	1	7.40	Kruskal-Wallis H	0.0142
		2	20.70	12.4726	
		3	18.80		
		4	15.42		
		5	8.50		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
21	10	1	19.20	Kruskal-Wallis H	0.0432
		2	9.00	9.8386	
		3	10.40		
		4	10.67		
		5	20.17		
21	11	1	11.20	Bhapkar V	0.0152
		2	19.00	12.3025	
		3	17.60		
		4	17.00		
		5	6.17		
21	12	1	12.00	Bhapkar V	0.0263
		2	18.60	11.0247	
		3	17.60		
		4	16.50		
		5	6.33		
21	13	1	11.60	Bhapkar V	0.0807
		2	18.00	8.3142	
		3	17.40		
		4	15.50		
		5	8.33		
21	154	1	16.50	Kruskal-Wallis H	0.0357
		2	9.00	10.2967	
		3	9.20		
		4	12.33		
		5	21.75		
23	2	1	14.50	Bhapkar V	0.0879
		2	17.71	6.5452	
		3	4.33		
		4	9.00		
23	3	1	17.69	Kruskal-Wallis H	0.0351
		2	8.14	8.5985	
		3	9.00		
		4	11.00		
23	8	1	16.63	Kruskal-Wallis H	0.1362
		2	11.57	5.5406	
		3	9.33		
		4	3.00		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
23	9	1	15.47	Bhapkar V	0.0710
		2	14.29	7.0270	
		3	6.83		
		4	10.00		
23	11	1	14.50	Bhapkar V	0.0190
		2	17.43	9.9547	
		3	4.33		
		4	11.00		
23	12	1	14.56	Bhapkar V	0.0373
		2	17.14	8.4689	
		3	4.67		
		4	11.00		
23	13	1	14.81	Bhapkar V	0.0879
		2	17.00	6.5452	
		3	4.33		
		4	9.00		
23	147	1	14.25	Bhapkar V	0.0130
		2	18.29	10.7737	
		3	4.67		
		4	8.00		
24	6	1	9.00	Kruskal-Wallis H	0.1330
		2	13.23	2.2575	
24	9	1	11.38	Kruskal-Wallis H	0.1159
		2	16.10	2.4719	
24	11	1	11.00	Bhapkar V	0.0736
		2	16.40	3.2000	
24	12	1	11.17	Bhapkar V	0.0911
		2	16.27	2.8543	
24	13	1	11.25	Kruskal-Wallis H	0.1073
		2	16.20	2.5929	
24	147	1	11.67	Kruskal-Wallis H	0.1719
		2	15.87	1.8667	
24	152	1	16.33	Kruskal-Wallis H	0.1719
		2	12.13	1.8667	

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
27	8	1	12.75	Kruskal-Wallis H	0.2388
		2	22.67	5.5101	
		3	9.67		
		4	11.90		
		5	15.67		
27	152	1	15.90	Kruskal-Wallis H	0.0348
		2	10.00	10.3619	
		3	5.00		
		4	10.20		
		5	20.50		
28	9	1	10.66	Kruskal-Wallis H	0.0289
		2	17.17	4.7715	
28	153	1	11.71	Bhapkar V	0.0461
		2	17.90	3.9765	
30	147	1	10.50	Kruskal-Wallis H	0.1092
		2	15.22	4.4300	
		3	3.50		
30	152	1	5.50	Bhapkar V	0.1116
		2	14.22	4.3863	
		3	20.00		
31	9	1	12.50	Bhapkar V	0.3936
		2	12.95	1.8650	
		3	13.83		
31	11	1	12.60	Bhapkar V	0.5024
		2	15.60	1.3768	
		3	13.71		
31	152	1	12.70	Kruskal-Wallis H	0.5937
		2	13.50	1.0426	
		3	16.57		
32	6	1	14.70	Bhapkar V	0.0310
		2	8.83	4.6545	
32	147	1	11.17	Bhapkar V	0.0911
		2	16.27	2.8543	

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
34	1	1	16.50	Kruskal-Wallis H	0.0894
		2	11.31	2.8846	
34	2	1	16.07	Kolmogorov-	0.0855
		2	11.77	Smirnov D	
				0.4835	
34	6	1	15.25	Kruskal-Wallis H	0.0030
		2	7.00	8.8043	
34	8	1	11.11	Kruskal-Wallis H	0.0458
		2	17.12	3.9903	
34	10	1	12.00	Kruskal-Wallis H	0.1742
		2	16.15	1.8462	
34	11	1	16.14	Kruskal-Wallis H	0.1455
		2	11.69	2.1193	
39	8	1	26.50	Kruskal-Wallis H	0.1028
		2	13.52	2.6608	
39	9	1	24.50	Kruskal-Wallis H	0.1008
		2	12.52	2.6924	
41	10	1	7.00	Kruskal-Wallis H	0.2349
		2	14.04	2.8975	
		3	20.50		
41	147	1	16.00	Kruskal-Wallis H	0.2425
		2	14.61	2.8337	
		3	5.00		
45	1	1	5.50	Kruskal-Wallis H	0.1237
		2	14.17	2.3704	
45	9	1	6.75	Kruskal-Wallis H	0.1827
		2	14.06	1.7755	
51	5	1	20.80	Kruskal-Wallis H	0.0338
		2	12.45	4.5039	
51	6	1	17.00	Kruskal-Wallis H	0.1144
		2	10.63	2.4920	

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
53	152	1	6.33	Bhapkar V	0.0001
		2	13.80	19.2412	
		3	22.87		
53	153	1	8.67	Kruskal-Wallis H	0.0018
		2	12.40	12.5968	
		3	22.00		
54	1	1	16.55	Bhapkar V	0.0001
		2	18.33	18.2454	
		3	7.11		
54	3	1	7.33	Bhapkar V	0.0012
		2	16.22	13.5347	
		3	18.44		
54	4	1	9.78	Kruskal-Wallis H	0.1241
		2	17.22	4.1728	
		3	15.00		
54	8	1	8.89	Kruskal-Wallis H	0.0408
		2	15.11	6.3991	
		3	18.00		
54	11	1	15.22	Bhapkar V	0.0497
		2	17.67	6.0054	
		3	9.11		
54	149	1	15.44	Bhapkar V	0.0720
		2	17.22	5.2616	
		3	9.33		
54	154	1	15.11	Bhapkar V	0.0864
		2	9.83	4.8970	
		3	17.06		
55	11	1	10.00	Kruskal-Wallis H	0.1616
		2	15.14	1.9592	
55	12	1	9.67	Kruskal-Wallis H	0.1294
		2	15.24	2.2993	
55	147	1	7.67	Kruskal-Wallis H	0.0267
		2	15.81	4.9116	
55	152	1	17.67	Kruskal-Wallis H	0.1995
		2	12.95	1.6463	

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
63	1	1	10.22	Bhapkar V	0.0749
		2	15.89	3.1715	
63	6	1	7.00	Kruskal-Wallis H	0.0264
		2	13.60	4.9304	
63	8	1	18.00	Kruskal-Wallis H	0.0598
		2	12.00	3.5421	
63	9	1	9.67	Kruskal-Wallis H	0.0806
		2	14.88	3.0537	
63	10	1	17.78	Kruskal-Wallis H	0.0803
		2	12.11	3.0582	
63	11	1	10.00	Kruskal-Wallis H	0.0641
		2	16.00	3.4286	
63	149	1	9.67	Kruskal-Wallis H	0.0449
		2	16.17	4.0238	
63	154	1	18.11	Bhapkar V	0.0526
		2	11.94	3.7558	
65	2	1	16.00	Kruskal-Wallis H	0.1143
		2	11.09	2.4935	
65	9	1	16.89	Bhapkar V	0.0023
		2	8.05	9.2579	
65	10	1	11.69	Kruskal-Wallis H	0.0679
		2	17.36	3.3336	
65	11	1	15.81	Kruskal-Wallis H	0.1524
		2	11.36	2.0479	
65	149	1	15.63	Kruskal-Wallis H	0.1995
		2	11.64	1.6461	
65	154	1	12.34	Kruskal-Wallis H	0.1909
		2	16.41	1.7105	

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
66	6	1	10.00	Bhapkar V	0.0311
		2	15.17	10.6269	
		3	7.00		
		4	13.00		
		5	10.83		
66	10	1	6.00	Kruskal-Wallis H	0.0625
		2	12.43	8.9458	
		3	16.60		
		4	9.00		
		5	19.25		
66	11	1	23.00	Kruskal-Wallis H	0.0330
		2	15.57	10.4859	
		3	11.80		
		4	19.00		
		5	8.13		
66	13	1	21.33	Kruskal-Wallis H	0.0883
		2	15.86	8.0921	
		3	12.80		
		4	18.00		
		5	8.38		
66	147	1	20.67	Bhapkar V	0.0006
		2	13.71	19.7136	
		3	14.40		
		4	21.50		
		5	7.75		
66	149	1	22.33	Kruskal-Wallis H	0.0457
		2	15.86	9.7052	
		3	11.80		
		4	18.75		
		5	8.25		
66	154	1	5.33	Kruskal-Wallis H	0.0418
		2	12.57	9.9223	
		3	19.80		
		4	8.63		
		5	17.56		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
72	5	1	13.40	Kruskal-Wallis H	0.1649
		2	21.50	1.9286	
72	6	1	11.90	Kruskal-Wallis H	0.1803
		2	3.00	1.7950	
73	152	1	13.13	Bhapkar V	0.0064
		2	5.25	14.3002	
		3	26.00		
		4	11.00		
		5	21.50		
73	153	1	12.07	Kiefer T	0.0344
		2	8.50	4.2519	
		3	26.00		
		4	9.00		
		5	23.25		
74	6	1	13.75	Kruskal-Wallis H	0.1239
		2	7.67	4.1762	
		3	9.00		
74	8	1	11.75	Kruskal-Wallis H	0.1917
		2	11.28	3.3042	
		3	17.67		
75	5	1	16.10	Bhapkar V	0.0305
		2	9.00	4.6784	
75	6	1	13.56	Bhapkar V	0.0129
		2	6.00	6.1875	
75	154	1	12.18	Bhapkar V	0.0621
		2	18.31	3.4803	
76	6	1	12.40	Kruskal-Wallis H	0.1717
		2	13.57	3.5238	
		3	6.80		
76	10	1	11.18	Kruskal-Wallis H	0.1632
		2	17.45	3.6260	
		3	12.60		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
76	13	1	17.09	Kruskal-Wallis H	0.1886
		2	10.91	3.3362	
		3	14.00		
76	152	1	11.27	Kruskal-Wallis H	0.0332
		2	13.00	6.8098	
		3	22.20		
77	5	1	13.50	Kruskal-Wallis H	0.2168
		2	15.36	4.4503	
		3	6.75		
		4	16.83		
77	149	1	16.00	Bhapkar V	0.1307
		2	14.64	5.6365	
		3	6.75		
		4	15.67		
78	2	1	1.50	Bhapkar V	0.0022
		2	19.43	16.6667	
		3	15.50		
		4	13.57		
		5	10.20		
78	9	1	1.50	Kruskal-Wallis H	0.1768
		2	15.93	6.3160	
		3	13.33		
		4	16.36		
		5	13.80		
78	10	1	25.50	Kruskal-Wallis H	0.0948
		2	9.29	7.9129	
		3	12.50		
		4	14.14		
		5	17.60		
78	11	1	2.00	Bhapkar V	0.0084
		2	17.71	13.6852	
		3	15.17		
		4	15.71		
		5	9.80		
78	12	1	2.50	Bhapkar V	0.0203
		2	17.86	11.6296	
		3	14.33		
		4	16.14		
		5	9.80		

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
78	13	1	1.50	Bhapkar V	0.0022
		2	19.43	16.6667	
		3	14.33		
		4	14.57		
		5	10.20		
78	152	1	4.00	Kruskal-Wallis H	0.0444
		2	17.43	9.7723	
		3	8.00		
		4	15.29		
		5	18.60		
78	153	1	1.50	Bhapkar V	0.0022
		2	19.29	16.6667	
		3	10.50		
		4	16.00		
		5	13.00		
79	147	1	13.54	Kruskal-Wallis H	0.1234
		2	26.00	2.3736	
79	152	1	13.54	Kruskal-Wallis H	0.1234
		2	26.00	2.3736	
81	8	1	18.00	Kruskal-Wallis H	0.0842
		2	12.32	2.9828	
81	9	1	15.00	Kruskal-Wallis H	0.3833
		2	12.22	0.7600	
81	154	1	12.00	Kruskal-Wallis H	0.3955
		2	14.84	0.7220	
82	1	1	9.00	Bhapkar V	0.0893
		2	17.00	8.0625	
		3	11.00		
		4	16.60		
		5	7.83		
82	3	1	20.50	Bhapkar V	0.0807
		2	12.10	8.3148	
		3	6.33		
		4	12.00		
		5	18.33		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
82	6	1	14.00	Kruskal-Wallis H	0.0653
		2	11.75	8.8377	
		3	3.00		
		4	16.75		
		5	6.50		
82	11	1	11.50	Bhapkar V	0.0753
		2	15.90	8.4860	
		3	6.67		
		4	15.60		
		5	11.83		
82	12	1	10.50	Bhapkar V	0.0741
		2	15.70	8.5253	
		3	6.67		
		4	16.20		
		5	12.00		
83	5	1	16.25	Kruskal-Wallis H	0.1877
		2	12.20	1.7357	
83	9	1	9.88	Kruskal-Wallis H	0.0358
		2	15.88	4.4044	
83	10	1	16.75	Kruskal-Wallis H	0.1073
		2	11.80	2.5929	
83	11	1	11.50	Kruskal-Wallis H	0.1432
		2	16.00	2.1429	
84	1	1	14.18	Kruskal-Wallis H	0.2581
		2	17.57	2.7087	
		3	11.00		
84	2	1	14.73	Kruskal-Wallis H	0.2494
		2	17.14	2.7772	
		3	10.67		
85	1	1	12.07	Kruskal-Wallis H	0.1571
		2	16.42	2.0024	
85	11	1	12.67	Kruskal-Wallis H	0.3291
		2	16.50	0.9524	

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
86	3	1	17.25	Bhapkar V	0.0236
		2	12.00	7.4953	
		3	6.00		
86	4	1	16.19	Kruskal-Wallis H	0.1160
		2	13.33	4.3084	
		3	7.80		
86	8	1	17.25	Kruskal-Wallis H	0.0396
		2	10.33	6.4564	
		3	8.40		
87	10	1	14.57	Bhapkar V	0.0939
		2	15.67	4.7318	
		3	8.25		
87	147	1	13.00	Kruskal-Wallis H	0.1383
		2	12.33	3.9563	
		3	21.25		
87	154	1	15.54	Bhapkar V	0.0616
		2	14.72	5.5744	
		3	7.00		
88	6	1	12.00	Bhapkar V	0.0065
		2	1.12	12.2744	
		3	16.00		
		4	5.20		
88	9	1	18.75	Bhapkar V	0.0755
		2	16.43	6.8884	
		3	14.67		
		4	8.00		
88	10	1	7.75	Kruskal-Wallis H	0.1955
		2	17.00	4.6956	
		3	12.33		
		4	16.71		
88	11	1	20.50	Kruskal-Wallis H	0.0536
		2	11.29	7.6616	
		3	17.11		
		4	9.00		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
88	12	1	20.50	Kruskal-Wallis H	0.0386
		2	11.14	8.3888	
		3	17.44		
		4	8.71		
88	13	1	19.50	Kruskal-Wallis H	0.0919
		2	11.00	6.4447	
		3	17.22		
		4	9.71		
88	147	1	24.25	Kruskal-Wallis H	0.0023
		2	9.14	14.5469	
		3	17.56		
		4	8.43		
88	149	1	20.25	Kruskal-Wallis H	0.0322
		2	11.00	8.7933	
		3	17.78		
		4	8.57		
88	152	1	22.50	Kruskal-Wallis H	0.0203
		2	17.71	9.8027	
		3	9.67		
		4	11.00		
88	153	1	24.00	Kruskal-Wallis H	0.0149
		2	16.29	10.4853	
		3	11.67		
		4	9.00		
88	154	1	6.50	Kruskal-Wallis H	0.0212
		2	15.93	9.7115	
		3	10.94		
		4	20.29		
89	1	1	16.83	Kruskal-Wallis H	0.0373
		2	8.90	6.5751	
		3	17.40		
89	10	1	10.75	Kruskal-Wallis H	0.0822
		2	18.30	4.9976	
		3	13.20		
89	11	1	16.50	Bhapkar V	0.0150
		2	9.10	8.4008	
		3	17.80		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
89	12	1	16.58	Kruskal-Wallis H	0.0356
		2	8.90	6.6696	
		3	18.00		
89	13	1	17.08	Kruskal-Wallis H	0.0290
		2	8.70	7.0823	
		3	17.20		
89	149	1	16.67	Kruskal-Wallis H	0.0364
		2	8.90	6.6291	
		3	17.80		
89	153	1	18.58	Kruskal-Wallis H	0.0201
		2	9.20	7.8140	
		3	12.60		
89	154	1	11.67	Kruskal-Wallis H	0.0853
		2	18.40	4.9243	
		3	10.80		
90	9	1	18.50	Bhapkar V	0.0225
		2	17.44	7.5905	
		3	10.43		
90	10	1	8.00	Kruskal-Wallis H	0.1336
		2	13.75	4.0261	
		3	16.29		
90	11	1	19.60	Bhapkar V	0.0196
		2	15.88	7.8688	
		3	10.93		
90	12	1	19.20	Bhapkar V	0.0203
		2	16.13	7.7958	
		3	10.93		
90	147	1	22.00	Kruskal-Wallis H	0.0187
		2	15.13	7.9623	
		3	10.50		
90	152	1	23.00	Kruskal-Wallis H	0.0193
		2	11.75	7.8980	
		3	12.07		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
90	153	1	24.20	Kruskal-Wallis H	0.0055
		2	12.88	10.4179	
		3	11.00		
90	154	1	7.00	Kruskal-Wallis H	0.0714
		2	14.00	5.2794	
		3	16.50		
91	1	1	11.73	Bhapkar V	0.0911
		2	16.83	2.8543	
91	8	1	16.20	Kruskal-Wallis H	0.1017
		2	11.25	2.6787	
92	147	1	15.38	Bhapkar V	0.0850
		2	9.17	2.9665	
92	152	1	12.62	Kruskal-Wallis H	0.0908
		2	18.83	2.8605	
94	10	1	12.50	Bhapkar V	0.0626
		2	4.00	5.5429	
		3	11.18		
94	13	1	8.00	Bhapkar V	0.1405
		2	16.00	3.9256	
		3	10.36		
94	147	1	11.00	Kruskal-Wallis H	0.0378
		2	18.00	6.5532	
		3	8.18		
94	153	1	7.83	Kruskal-Wallis H	0.1992
		2	15.33	3.2273	
		3	10.64		
94	154	1	12.83	Bhapkar V	0.0626
		2	4.00	5.5429	
		3	11.00		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
95	8	1	12.71	Kruskal-Wallis H	0.1762
		2	16.50	3.4722	
		3	9.67		
95	152	1	16.29	Kruskal-Wallis H	0.0370
		2	16.00	6.5911	
		3	6.67		
95	153	1	15.14	Kruskal-Wallis H	0.1732
		2	15.71	3.5072	
		3	8.67		
97	1	1	7.71	Bhapkar V	0.0048
		2	15.80	12.9374	
		3	16.00		
		4	17.20		
97	3	1	17.86	Bhapkar V	0.0015
		2	15.50	15.4085	
		3	5.00		
		4	14.60		
97	8	1	20.14	Kruskal-Wallis H	0.0232
		2	15.10	9.5103	
		3	7.50		
		4	9.70		
97	152	1	16.86	Bhapkar V	0.0027
		2	15.50	14.1611	
		3	5.20		
		4	15.80		
98	152	1	14.46	Kruskal-Wallis H	0.3961
		2	10.33	0.7202	
98	154	1	13.27	Kruskal-Wallis H	0.1769
		2	19.83	1.8235	
99	147	1	17.00	Bhapkar V	0.0211
		2	13.38	9.7254	
		3	14.50		
		4*	6.83		

*Group 4 created for those products not applicable.

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
99	152	1	16.86	Kruskal-Wallis H	0.0474
		2	15.63	7.9326	
		3	5.75		
		4*	9.83		
99	153	1	18.00	Kruskal-Wallis H	0.0265
		2	15.25	9.2246	
		3	7.00		
		4*	8.17		
100	3	1	12.79	Kruskal-Wallis H	0.4094
		2	15.31	0.6805	
100	10	1	12.71	Kruskal-Wallis H	0.3824
		2	15.38	0.7630	
101	5	1	7.80	Bhapkar V	0.0135
		2	16.20	12.5826	
		3	16.25		
		4	9.67		
		5	16.50		
101	8	1	4.70	Kruskal-Wallis H	0.0129
		2	10.90	12.6918	
		3	15.63		
		4	18.33		
		5	20.00		
101	9	1	7.40	Kruskal-Wallis H	0.1751
		2	17.50	6.3410	
		3	12.75		
		4	14.83		
		5	17.83		
101	152	1	7.40	Bhapkar V	0.0233
		2	19.60	11.3047	
		3	10.88		
		4	20.33		
		5	15.83		

*Group 4 created for those products not applicable.

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
101	153	1	8.60	Kruskal-Wallis H	0.0448
		2	22.20	9.7540	
		3	10.75		
		4	18.00		
		5	14.00		
101	154	1	20.60	Kruskal-Wallis H	0.1353
		2	7.60	7.0117	
		3	13.00		
		4	13.67		
		5	15.33		
102	9	1	15.95	Kruskal-Wallis H	0.1854
		2	11.97	1.7537	
102	154	1	11.90	Kruskal-Wallis H	0.3990
		2	14.50	0.7114	
103	3	1	15.57	Bhapkar V	0.0400
		2	9.60	4.2195	
103	8	1	14.21	Kruskal-Wallis H	0.1744
		2	10.23	1.8448	
103	152	1	16.00	Kruskal-Wallis H	0.0264
		2	9.40	4.9304	
104	6	1	12.27	Bhapkar V	0.0108
		2	15.00	11.1708	
		3	12.60		
		4	3.33		
104	8	1	12.73	Kruskal-Wallis H	0.0502
		2	7.38	7.8070	
		3	16.29		
		4	23.00		
107	1	1	18.42	Kruskal-Wallis H	0.0349
		2	10.22	6.7094	
		3	10.83		
107	2	1	18.67	Kruskal-Wallis H	0.0236
		2	10.56	7.4965	
		3	9.83		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
107	6	1	14.55	Bhapkar V	0.0158
		2	10.71	8.2921	
		3	4.50		
107	9	1	17.32	Kruskal-Wallis H	0.0121
		2	11.75	8.8337	
		3	6.75		
107	10	1	10.08	Bhapkar V	0.0147
		2	17.33	8.4376	
		3	16.83		
107	11	1	18.33	Kruskal-Wallis H	0.0400
		2	10.56	6.4383	
		3	10.50		
107	12	1	18.58	Kruskal-Wallis H	0.0272
		2	10.44	7.2068	
		3	10.17		
107	13	1	18.50	Kruskal-Wallis H	0.0298
		2	10.89	7.0282	
		3	9.67		
107	149	1	18.83	Kruskal-Wallis H	0.0181
		2	10.33	8.0238	
		3	9.83		
107	153	1	17.00	Kruskal-Wallis H	0.1882
		2	12.44	3.3404	
		3	10.33		
107	154	1	8.54	Kruskal-Wallis H	0.0034
		2	16.56	11.3898	
		3	21.08		
108	3	1	14.20	Kruskal-Wallis H	0.4422
		2	11.00	1.6320	
		3	15.71		
108	5	1	15.80	Kruskal-Wallis H	0.2090
		2	9.89	3.1308	
		3	14.86		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
109	10	1	14.83	Kruskal-Wallis H	0.1228
		2	7.33	2.3810	
109	11	1	13.04	Bhapkar V	0.0708
		2	21.67	3.2654	
109	12	1	12.92	Bhapkar V	0.0411
		2	22.67	4.1728	
109	13	1	12.88	Kruskal-Wallis H	0.0372
		2	23.00	4.3393	
109	147	1	13.00	Bhapkar V	0.0593
		2	22.00	3.5556	
109	149	1	12.83	Bhapkar V	0.0278
		2	23.33	4.8395	
109	154	1	15.08	Bhapkar V	0.0411
		2	5.33	4.1728	
110	152	1	16.00	Kruskal-Wallis H	0.5084
		2	13.89	1.3530	
		3	11.63		
110	153	1	17.00	Kruskal-Wallis H	0.2943
		2	13.00	2.4464	
		3	11.38		
110	154	1	12.40	Kruskal-Wallis H	0.3820
		2	12.89	1.9246	
		3	17.25		
111	6	1	13.67	Bhapkar V	0.0796
		2	8.90	3.0727	
111	9	1	16.08	Kruskal-Wallis H	0.0252
		2	9.67	5.0113	
111	153	1	16.50	Bhapkar V	0.0837
		2	11.31	2.9915	
111	154	1	11.04	Bhapkar V	0.0403
		2	17.19	4.2057	

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
112	10	1	14.25	Bhapkar V	0.2094
		2	10.20	4.5329	
		3	16.60		
		4	17.33		
112	147	1	12.50	Bhapkar V	0.2358
		2	16.00	4.2490	
		3	13.80		
		4	7.33		
113	2	1	17.88	Kruskal-Wallis H	0.1853
		2	10.43	3.3716	
		3	13.50		
113	10	1	9.75	Kruskal-Wallis H	0.1610
		2	17.29	3.6533	
		3	14.92		
114	10	1	16.20	Kruskal-Wallis H	0.1062
		2	9.75	6.1137	
		3	18.50		
		4	9.25		
114	11	1	10.50	Kruskal-Wallis H	0.0495
		2	17.63	7.8355	
		3	7.75		
		4	18.50		
114	12	1	10.70	Kruskal-Wallis H	0.0383
		2	17.75	8.4085	
		3	6.25		
		4	18.50		
114	13	1	10.50	Kruskal-Wallis H	0.0767
		2	18.00	6.8547	
		3	8.50		
		4	17.00		
114	147	1	10.40	Kruskal-Wallis H	0.1156
		2	17.13	5.9184	
		3	9.50		
		4	18.00		
114	154	1	17.00	Kruskal-Wallis H	0.0550
		2	9.63	7.6030	
		3	18.00		
		4	8.00		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
115	1	1	17.00	Kruskal-Wallis H	0.3534
		2	10.00	2.0802	
		3	14.95		
115	10	1	13.00	Kruskal-Wallis H	0.5065
		2	17.33	1.3606	
		3	13.05		
116	8	1	15.97	Kruskal-Wallis H	0.0074
		2	20.38	9.8179	
		3	7.13		
116	9	1	14.83	Kruskal-Wallis H	0.0140
		2	22.00	8.5357	
		3	8.44		
116	10	1	15.13	Kruskal-Wallis H	0.1829
		2	7.25	3.3971	
		3	15.25		
116	11	1	12.80	Kruskal-Wallis H	0.1408
		2	21.25	3.9202	
		3	12.63		
116	147	1	11.73	Kruskal-Wallis H	0.0355
		2	23.25	6.6737	
		3	13.63		
116	149	1	12.67	Kruskal-Wallis H	0.1603
		2	21.00	3.6614	
		3	13.00		
116	152	1	16.27	Bhapkar V	0.0012
		2	19.50	13.4473	
		3	7.00		
116	153	1	14.53	Bhapkar V	0.0240
		2	22.00	7.4593	
		3	9.00		
116	154	1	13.73	Kruskal-Wallis H	0.0757
		2	7.00	5.1614	
		3	18.00		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
119	1	1	13.74	Bhapkar V	0.0533
		2	18.17	5.8621	
		3	4.00		
119	8	1	13.71	Kruskal-Wallis H	0.1046
		2	11.33	4.5159	
		3	24.75		
120	9	1	14.80	Bhapkar V	0.0928
		2	11.80	4.7548	
		3	18.14		
120	10	1	15.00	Bhapkar V	0.0775
		2	16.13	5.1162	
		3	8.71		
120	13	1	15.00	Bhapkar V	0.0935
		2	11.80	4.7392	
		3	18.00		
120	152	1	12.20	Kruskal-Wallis H	0.0078
		2	10.87	9.7058	
		3	22.00		
120	153	1	12.60	Kruskal-Wallis H	0.0035
		2	10.47	11.2913	
		3	22.57		
120	154	1	12.20	Kruskal-Wallis H	0.1005
		2	16.80	4.5946	
		3	9.29		
121	1	1	1.00	Kruskal-Wallis H	0.0951
		2	14.50	2.7857	
121	3	1	26.00	Kruskal-Wallis H	0.1234
		2	13.54	2.3736	

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
122	2	1	19.60	Bhapkar V	0.0422
		2	13.07	8.1945	
		3	17.75		
		4	6.50		
122	5	1	13.80	Kruskal-Wallis H	0.8358
		2	14.36	0.8569	
		3	16.00		
		4	11.00		
122	6	1	14.25	Kruskal-Wallis H	0.1858
		2	9.85	4.8156	
		3	16.00		
		4	4.00		
122	7	1	1.00	Kruskal-Wallis H	0.8333
		2	3.00	1.8000	
		3	0.00		
		4	3.00		
122	8	1	19.00	Kruskal-Wallis H	0.0253
		2	16.14	9.3232	
		3	6.75		
		4	7.50		
122	9	1	19.70	Kruskal-Wallis H	0.0267
		2	15.25	9.2001	
		3	11.88		
		4	4.63		
122	10	1	8.40	Bhapkar V	0.0578
		2	14.71	7.4922	
		3	11.75		
		4	20.75		
122	11	1	19.60	Bhapkar V	0.0873
		2	13.21	6.5610	
		3	16.75		
		4	7.00		
122	12	1	19.60	Bhapkar V	0.0562
		2	13.36	7.5543	
		3	17.00		
		4	6.25		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
122	13	1	19.20	Kruskal-Wallis H	0.0434
		2	13.29	8.1324	
		3	18.50		
		4	5.50		
122	147	1	21.80	Kruskal-Wallis H	0.1148
		2	12.36	5.9363	
		3	12.00		
		4	12.00		
122	149	1	19.60	Bhapkar V	0.0561
		2	13.29	7.5573	
		3	17.25		
		4	6.25		
122	152	1	18.60	Kruskal-Wallis H	0.0205
		2	16.07	9.7837	
		3	11.25		
		4	3.75		
122	153	1	19.40	Kruskal-Wallis H	0.0391
		2	15.07	8.3630	
		3	13.00		
		4	4.50		
122	154	1	7.60	Kruskal-Wallis H	0.0143
		2	14.11	10.5711	
		3	11.25		
		4	24.38		
123	6	1	5.83	Bhapkar V	0.0104
		2	13.63	6.5682	
123	9	1	9.69	Kruskal-Wallis H	0.0610
		2	15.82	3.5114	
123	11	1	10.00	Bhapkar V	0.0836
		2	15.68	2.9942	
123	12	1	9.88	Bhapkar V	0.0744
		2	15.74	3.1842	
123	13	1	10.25	Kruskal-Wallis H	0.1112
		2	15.58	2.5376	

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
123	147	1	10.50	Kruskal-Wallis H	0.1371
		2	15.47	2.2105	
123	154	1	18.38	Bhapkar V	0.0584
		2	12.16	3.5819	
124	1	1	19.60	Kruskal-Wallis H	0.1932
		2	11.91	3.2883	
		3	13.55		
124	3	1	22.60	Kruskal-Wallis H	0.0239
		2	12.91	7.4644	
		3	11.18		
124	4	1	23.40	Kiefer T	0.0475
		2	12.09	3.0842	
		3	11.64		
124	9	1	17.90	Kruskal-Wallis H	0.1651
		2	13.22	3.6026	
		3	10.59		
124	153	1	24.00	Kruskal-Wallis H	0.0077
		2	11.64	9.7431	
		3	11.82		
124	154	1	7.60	Kruskal-Wallis H	0.0918
		2	16.95	4.7768	
		3	13.95		
125	8	1	11.50	Kruskal-Wallis H	0.1089
		2	16.32	2.5696	
125	11	1	16.31	Kruskal-Wallis H	0.1455
		2	11.86	2.1193	
125	147	1	16.69	Bhapkar V	0.0837
		2	11.50	2.9915	
125	149	1	16.46	Kruskal-Wallis H	0.1205
		2	11.71	2.4113	
125	152	1	8.77	Kolmogorov-Smirnov D	0.0005
		2	18.86	0.7802	

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
125	153	1	11.15	Bhapkar V	0.0675
		2	16.64	3.3431	
126	1	1	15.88	Bhapkar V	0.0338
		2	16.80	10.4261	
		3	20.60		
		4	8.50		
		5	4.33		
126	2	1	14.50	Kruskal-Wallis H	0.0459
		2	13.80	9.6931	
		3	22.60		
		4	9.33		
		5	8.00		
126	9	1	15.69	Kruskal-Wallis H	0.0826
		2	14.30	8.2586	
		3	20.20		
		4	10.50		
		5	5.67		
126	10	1	13.25	Bhapkar V	0.0030
		2	12.60	15.9995	
		3	5.40		
		4	19.33		
		5	22.00		
126	11	1	15.25	Kruskal-Wallis H	0.0099
		2	14.60	13.3095	
		3	23.20		
		4	8.33		
		5	5.67		
126	12	1	14.88	Kruskal-Wallis H	0.0145
		2	14.40	12.4173	
		3	23.20		
		4	8.83		
		5	6.00		
126	113	1	14.00	Kruskal-Wallis H	0.0543
		2	13.40	9.2884	
		3	22.80		
		4	10.17		
		5	8.00		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
126	147	1	15.63	Kruskal-Wallis H	0.0384
		2	15.80	10.1263	
		3	20.60		
		4	9.50		
		5	4.67		
126	149	1	14.88	Kruskal-Wallis H	0.0128
		2	14.20	12.7030	
		3	23.40		
		4	8.83		
		5	6.00		
126	154	1	14.38	Bhapkar V	0.0015
		2	13.80	17.5961	
		3	5.00		
		4	19.50		
		5	17.33		
127	1	1	11.31	Bhapkar V	0.0190
		2	14.75	7.9251	
		3	18.83		
127	3	1	19.23	Kruskal-Wallis H	0.0011
		2	6.13	13.5870	
		3	13.17		
127	4	1	16.92	Bhapkar V	0.0123
		2	7.88	8.7892	
		3	15.83		
127	8	1	16.54	Bhapkar V	0.0211
		2	7.69	7.7209	
		3	16.92		
127	9	1	14.04	Kruskal-Wallis H	0.0447
		2	7.64	6.2166	
		3	17.17		
127	12	1	11.85	Kruskal-Wallis H	0.1296
		2	13.25	4.0869	
		3	19.67		
127	154	1	14.19	Kruskal-Wallis H	0.1084
		2	17.69	4.4447	
		3	8.67		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
129	152	1	17.31	Kolmogorov-	0.0315
		2	10.93	Smirnov D	
				0.5549	
129	153	1	16.46	Kruskal-Wallis H	0.1205
		2	11.71	2.4113	
130	6	1	12.13	Kruskal-Wallis H	0.5031
		2	10.14	0.4484	
130	153	1	14.53	Kruskal-Wallis H	0.5954
		2	12.75	0.2820	
131	3	1	15.06	Kruskal-Wallis H	0.5066
		2	13.13	1.3601	
		3	8.50		
131	8	1	15.38	Kruskal-Wallis H	0.1586
		2	13.50	3.6833	
		3	4.25		
132	5	1	12.17	Bhapkar V	0.0839
		2	17.67	2.9877	
132	10	1	12.61	Kruskal-Wallis H	0.1985
		2	16.78	1.6534	
133	152	1	14.50	Bhapkar V	0.0003
		2	21.00	23.1325	
		3	22.00		
		4	14.67		
		5	11.29		
		6	4.60		
133	153	1	14.17	Bhapkar V	0.0334
		2	21.00	12.0999	
		3	22.00		
		4	11.67		
		5	12.14		
		6	5.60		

(Continued)

Group Code Variable Number	Against Performance Code Variable Number	Group	Mean Rank	Test Statistic	Significance
134	13	1	15.25	Bhapkar V	0.3614
		2	11.00	10.9500	
		3	16.00		
		4	9.00		
		5	13.00		
		6	11.50		
		7	7.00		
		8	23.00		
		10	16.00		
		11	11.00		
		12	15.00		
134	152	1	21.50	Kruskal-Wallis H	0.1080
		2	8.67	15.7169	
		3	16.67		
		4	13.00		
		5	3.00		
		6	6.00		
		7	16.00		
		8	5.00		
		10	12.00		
		11	15.00		
		12	7.50		

APPENDIX C

LISTING OF CALCULATING FORMULAS FOR SELECTED STATISTICAL TESTS

Kolmogorov-Smirnov Two Sample Test

When both sample sizes are large, the D statistic sampling distribution is approximated by the chi-square distribution with df = 2. That is,

$$X^2 = 4D^2 \frac{n_1 \cdot n_2}{n_1 + n_2}, \text{ for a one-tailed test}$$

where $d = \text{maximum} \left[CP_{kn_1} - CP_{kn_2} \right] k_m$

CP_k = cumulative proportion in sample k

k_m = interval scale m

n_i = sample size

Kruskal-Wallis One-Way Analysis of Variance

Including a correction term for possible ties, the calculating formula for H as defined below is distributed as a chi-square distribution with df = k - 1, as long as each n_j is sufficiently large. If any $n_j \leq 5$ and k = 3, the chi-square approximation is not satisfactory and reference is made to tabled probabilities associated with values as large as the observed H.[1]

$$H = \frac{\dfrac{12}{N(N+1)} \displaystyle\sum_{j=1}^{k} \frac{R_j^2}{n_j} - 3(N+1)}{1 - \dfrac{\sum T_i}{N^3 - N}}$$

where H = test statistic

k = number of samples

n_j = number of observations in jth sample

R_j = sum of ranks in jth sample

T_i = $t^3 - t$, where t is the number of tied observations in the ith tied group of values

N = $\sum n_j$, the number of observations in all samples

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[1] One such source is William Beyer (ed.), Handbook of Tables for Probability and Statistics, (Cleveland, Ohio: The Chemical Rubber Company, 1966), pp. 327-8.

Kiefer K-Sample Analogue Test

In the k-sample case, Kiefer developed the statistic

$$T = \mathrm{SUP}_x \sum_{i=1}^{k} n_i \left[S_{in_i}(x) - \bar{S}_N(x) \right]$$

where $S_{in_i} = \frac{1}{n_i}$ (number of $x_{ij} \leq x,\ 1 \leq j \leq n_i$)

$$\bar{S}_N(x) = \frac{\sum_{i=i}^{k} n_i S_{in_i}(x)}{\sum_{i=1}^{k} n_i},$$

the cumulative distribution function for the pooled observations

Bhapkar K-Sample Analogue Test

The proposed Bhapkar test statistic is

$$V = N(2k - 1)\left[\sum_{i=1}^{k} P_i\left(u^{(i)} - \frac{1}{k}\right)^2 - \left\{\sum_{i=1}^{k} P_i\left(u^{(i)} - \frac{1}{k}\right)\right\}^2\right]$$

where $$N = \sum {}_i n_i$$

$$P_i = \frac{n_i}{N}$$

$$u^{(i)} = \frac{\sum_{j=1}^{n_i} \prod_{r \neq i} \left[\text{number of } x_{rs} > x_{ij}\right]}{n_1 n_2 . \ldots n_k}$$

with $s = 1,2, \ldots n_r$

It is based on the summation of the products of the number of observations in the ith sample which is greater than the value assigned to n_{ij}, where $i = 1,2, \ldots k$ and $j = 1,2, \ldots n$.

Spearman Rank Correlation Coefficient

The calculating formula for the Spearman rank correlation coefficient is:

$$r = 1 - \frac{6 \sum_{i=1}^{N} D_i^2}{N^3 - N}$$

where D^2 = sum of the squared differences in ranks

N = number of paired ranks

The mean of the tied ranks is assigned in the case of tied observations. However, if the proportion of tied scores is large, a different computing formula is suggested which includes a correlation factor for this bias.

$$r = \frac{\sum x^2 + \sum y^2 - \sum D^2}{2\sqrt{\sum x^2 \quad \sum y^2}}$$

where $\sum x^2 = \frac{N^3 - N}{12} - \sum T_i(x)$

$$\sum y^2 = \frac{N^3 - N}{12} - \sum T_i(y)$$

$$T_i = \frac{t_i^3 - t_i}{12}$$

t_i = number of observations tied at a given rank i

<u>Multiple Regression</u>

Estimation by simple least squares consists of evaluating Y_t such that the sum of the squared residuals is a minimum, i.e.,

$$\sum_{t=i}^{N} (Y_t - \hat{Y}_t)^2 \text{ is a minimum}$$

APPENDIX D

QUESTIONNAIRE

GRADUATE SCHOOL OF BUSINESS ADMINISTRATION
DEPARTMENT OF MARKETING AND TRANSPORTATION ADMINISTRATION
MICHIGAN STATE UNIVERSITY
East Lansing, Michigan 48823

As a basis for documenting patterns associated with new industrial chemical products marketed by leading chemical manufacturers, an exhaustive research design has been formulated to provide the necessary framework in organizing the collection effort. Each participating firm is asked to contribute a number of product histories which would be randomly selected. The gathered information will be treated in the strictest confidence. The inputs are to be used in a supportive capacity for testing hypothesized relationships between performance and those factors thought to be important in explaining product behavior.

Corporation ______________________________

Location ______________________________

____

Respondent ______________________________

Title ______________________________

Date ______________________________

Product Number ______________________________

SECTION 1

1. Product life span data

Year of Market Introduction		1
Year of Product Withdrawal		2

(NOTE: IF THE PRODUCT HAS NOT BEEN WITHDRAWN FROM THE MARKETPLACE TO DATE, RECORD NA AS RESPONSE 2)

2. Sales Information

Year	(thousands of dollars)	
1954		1
1955		2
1956		3
1957		4
1958		5
1959		6
1960		7
1961		8
1962		9
1963		10
1964		11

(NOTE: RECORD GROSS SALES, NOT ADJUSTING FOR FREIGHT OR OTHER ALLOWED DEDUCTIONS)

3. Profit Information

Year	(thousands of dollars)	
1954		1
1955		2
1956		3
1957		4
1958		5
1959		6
1960		7
1961		8
1962		9
1963		10
1964		11

(NOTE: RECORD NET PROFITS AFTER TAXES, MAKING ALLOWANCES FOR THE DEDUCTION OF MANUFACTURING, MARKETING AND GENERAL ADMINISTRATIVE COSTS AS WELL AS PRODUCT DEVELOPMENT AND PRODUCTION START-UP EXPENSES. ALL DEDUCTIONS MAY BE CALCULATED ON A DIRECT OR ALLOCATED BASIS)

4. Standard Industrial Classification (SIC) Number

SIC Code		1

(NOTE: USE THE FIVE DIGIT REPORTING LEVEL FOR THE PRODUCT CLASSIFICATION)

5. Research and Development Data

Year	(thousands of dollars)	
1950		1
1951		2
1952		3
1953		4
1954		5
1955		6
1956		7
1957		8
1958		9
1959		10
1960		11
1961		12
1962		13
1963		14
1964		15

(NOTE: RECORD ALL RESEARCH AND DEVELOPMENT COSTS ASSIGNED OR ALLOCATED TO THE PROJECT LEADING TO THE DEVELOPMENT AND SUPPORT OF THE PRODUCT)

6. Investment Requirements

Year	(thousands of dollars)	
1954		1
1955		2
1956		3
1957		4
1958		5
1959		6
1960		7
1961		8
1962		9
1963		10
1964		11

(NOTE: DEFINED TO INCLUDE EXPENDITURES FOR NEW FIXED ASSETS, TRANSFERRED FIXED ASSETS, CARRY-FORWARD ASSETS, AND WORKING CAPITAL ON A DIRECT OR ALLOCATED BASIS)

7. Marketing Cost Data

Year	(as a percentage of gross sales)	
1954		1
1955		2
1956		3
1957		4
1958		5
1959		6
1960		7
1961		8
1962		9
1963		10
1964		11

(NOTE: INCLUDE ALL DIRECT AND ALLOCATED COSTS INCURRED IN THE MARKETING EFFORTS TO PROMOTE THE SALE OF THE NEW PRODUCT, AS FIXED SELLING, ADVERTISING, PURCHASED MARKETING RESEARCH AND DISTRIBUTION COSTS)

8. Price Data

INSTRUCTIONS: Whenever a question requires a response in each year of the product life cycle, BEGIN the analysis in the first year when revenues totalled at least $50,000 in volume. This year will be DESIGNATED as year 1. Other years will follow in sequential order.

	Year	1	2	3	4	5	6	7	8	9	10	
SKIP TO QUESTION NO. 10	Severe price increases, i.e., greater than 20%											1
SKIP TO QUESTION NO. 10	Moderate price increases, i.e., 10-20%											2
SKIP TO QUESTION NO. 10	Relatively stable price increases, i.e., 5-10%											3
SKIP TO QUESTION NO. 10	Stable price movements, i.e., less than 5%											4
SKIP TO QUESTION NO. 10	Relatively stable price decreases, i.e., 5-10%											5
	Moderate price decreases, i.e., 10-20%											6
	Severe price decreases, i.e., greater than 20%											7
	Unknown											8
	Not applicable											9

(NOTE: RECORD THE AVERAGE PRICE DATA AS A PERCENTAGE CHANGE OVER THE PREVIOUS YEAR)

9. Cause of Marked Price Decline

	Year	1	2	3	4	5	6	7	8	9	10	
Severe competition, i.e., external attrition by competitors												1
Internal market strategy to improve market position, i.e., internal attrition												2
Unknown												3
Not applicable												4

(NOTE: LIST THE REASON BEHIND THE PRICE CHANGE)

10. Number of Significant Direct Competitors

Year	Number	
1		1
2		2
3		3
4		4
5		5
6		6
7		7
8		8
9		9
10		10

(NOTE: LIST THE NUMBER OF COMPETING FIRMS OFFERING THE IDENTICAL PRODUCT, BOTH IN FORM AND COMPOSITION)

11. Number of Significant Indirect Competitors

Year	Number	
1		1
2		2
3		3
4		4
5		5
6		6
7		7
8		8
9		9
10		10

(NOTE: LIST THE NUMBER OF COMPETING FIRMS OFFERING SUBSTITUTE PRODUCTS IN THE SAME APPLICATION AREAS, EVEN THOUGH THEIR FORM AND/OR COMPOSITION DIFFERED)

12. End-Use Determination. What were the end-uses for the new chemical product?

	1
	2
	3
	4
	5
	6

(NOTE: SPECIFY THE END-USE APPLICATIONS AND THE INCLUSIVE YEARS OF SALE FOR THE LISTED END-USES)

13. Specificity of Use

Highly specific		1
Moderately specific		2
Slightly specific		3
Indifferent or so-so		4
Slightly general		5
Moderately general		6
Highly general		7
Unknown		8
Not applicable		9

(NOTE: LIST THE MOST REPRESENTATIVE DESCRIPTION)

14. Number of Major Consuming Industries

Year	Number	
1		1
2		2
3		3
4		4
5		5
6		6
7		7
8		8
9		9
10		10

(NOTE: LIST THE NUMBER OF INDUSTRIES CONSUMING MAJOR AMOUNTS OF PRODUCT SOLD ON A YEARLY BASIS)

15. Number of Minor Consuming Industries

Year	Number	
1		1
2		2
3		3
4		4
5		5
6		6
7		7
8		8
9		9
10		10

(NOTE: LIST THE NUMBER OF INDUSTRIES CONSUMING SMALL AMOUNTS OF PRODUCT USED ON A YEARLY BASIS)

16. Market Share Data

Year	Number	
1		1
2		2
3		3
4		4
5		5
6		6
7		7
8		8
9		9
10		10

(NOTE: LIST EXISTING MARKET PENETRATION AS A PERCENTAGE OF REALIZED SALES TO THE RELEVANT EXISTING MARKET VALUATION ON A YEARLY BASIS)

17. Success or Failure Determination

Highly successful		1
Moderately successful		2
Slightly successful		3
Indifferent or so-so		4
Slight failure		5
Moderate failure		6
High failure		7
Unknown		8
Not applicable		9

(NOTE: EVALUATE THE OUTCOME OF PRODUCT BEHAVIOR AGAINST EXPECTED OBJECTIVES SET FOR THE PRODUCT BY MANAGEMENT)

18. Byproduct Listings

Year	Percentage	
1		1
2		2
3		3
4		4
5		5
6		6
7		7
8		8
9		9
10		10

(NOTE: LIST ALL YEARLY BYPRODUCT SALES AS A PERCENTAGE OF GROSS SALES FOR THE NEW PRODUCT)

19. Action Taken Regarding Sales Force Size

	Year	1	2	3	4	5	6	7	8	9	10	
	Increased											1
	Decreased											2
	Not changed											3
SKIP TO QUESTION NO. 21	Unknown											4
	Not applicable											5

(NOTE: LIST THE STRATEGY OPERATIONALIZED BY YOUR FIRM IN REGARD TO THIS SPECIFIC PRODUCT; THESE ARE CHANGES IN ANY GIVEN YEAR OVER THE LAST PERIOD IN THE ANALYSIS)

20. Evaluation of Action Taken Regarding Sales Force Size

Year	1	2	3	4	5	6	7	8	9	10	
Highly beneficial											1
Moderately beneficial											2
Slightly beneficial											3
Indifferent or so-so											4
Slightly detrimental											5
Moderately detrimental											6
Highly detrimental											7
Unknown											8
Not applicable											9

(NOTE: EVALUATE THE STRATEGY OPERATIONALIZED BY YOUR FIRM IN REGARD TO THE SPECIFIC PRODUCT FOR EACH YEAR OF ITS LIFE UNDER STUDY)

21. Action Taken Regarding Number of Sales Calls Per Unit of Time

	Year	1	2	3	4	5	6	7	8	9	10	
	Increased											1
	Decreased											2
	Not changed											3
SKIP TO QUESTION NO. 23	Unknown											4
	Not applicable											5

(NOTE: LIST THE STRATEGY OPERATIONALIZED BY YOUR FIRM IN REGARD TO THIS SPECIFIC PRODUCT; THESE ARE CHANGES IN ANY GIVEN YEAR OVER THE LAST PERIOD IN THE ANALYSIS)

22. Evaluation of Action Taken Regarding Number of Sales Calls Per Unit of Time

Year	1	2	3	4	5	6	7	8	9	10	
Highly beneficial											1
Moderately beneficial											2
Slightly beneficial											3
Indifferent or so-so											4
Slightly detrimental											5
Moderately detrimental											6
Highly detrimental											7
Unknown											8
Not applicable											9

(NOTE: EVALUATE THE STRATEGY OPERATIONALIZED BY YOUR FIRM IN REGARD TO THE SPECIFIC PRODUCT FOR EACH YEAR OF ITS LIFE UNDER STUDY)

23. Action Taken Regarding Number of Distribution Outlets

	Year	1	2	3	4	5	6	7	8	9	10	
	Increased											1
	Decreased											2
	Not changed											3
SKIP TO QUESTION NO. 25	Unknown											4
	Not applicable											5

(NOTE: LIST THE STRATEGY OPERATIONALIZED BY YOUR FIRM IN REGARD TO THIS SPECIFIC PRODUCT; THESE ARE CHANGES IN ANY GIVEN YEAR OVER THE LAST PERIOD IN THE ANALYSIS)

24. Evaluation of Action Taken Regarding Number of Distribution Outlets

Year	1	2	3	4	5	6	7	8	9	10	
Highly beneficial											1
Moderately beneficial											2
Slightly beneficial											3
Indifferent or so-so											4
Slightly detrimental											5
Moderately detrimental											6
Highly detrimental											7
Unknown											8
Not applicable											9

(NOTE: EVALUATE THE STRATEGY OPERATIONALIZED BY YOUR FIRM IN REGARD TO THE SPECIFIC PRODUCT FOR EACH YEAR OF ITS LIFE UNDER STUDY)

25. Action Taken Regarding Number of Product Offerings for Same Use

	Year	1	2	3	4	5	6	7	8	9	10	
	Increased											1
	Decreased											2
	Not changed											3
SKIP TO QUESTION NO. 27	Unknown											4
	Not applicable											

(NOTE: LIST THE STRATEGY OPERATIONALIZED BY YOUR FIRM IN REGARD TO THIS SPECIFIC PRODUCT; THESE ARE CHANGES IN ANY GIVEN YEAR OVER THE LAST PERIOD IN THE ANALYSIS)

26. Evaluation of Action Taken Regarding Number of Product Offerings for Same Use

	Year 1	2	3	4	5	6	7	8	9	10	
Highly beneficial											1
Moderately beneficial											2
Slightly beneficial											3
Indifferent or so-so											4
Slightly detrimental											5
Moderately detrimental											6
Highly detrimental											7
Unknown											8
Not applicable											9

(NOTE: EVALUATE THE STRATEGY OPERATIONALIZED BY YOUR FIRM IN REGARD TO THE SPECIFIC PRODUCT FOR EACH YEAR OF ITS LIFE UNDER STUDY)

27. Action Taken Regarding Product Promotion

		Year 1	2	3	4	5	6	7	8	9	10	
	Increased											1
	Decreased											2
	Not changed											3
SKIP TO QUESTION NO. 29	Unknown											4
	Not applicable											5

(NOTE: LIST THE STRATEGY OPERATIONALIZED BY YOUR FIRM IN REGARD TO THIS SPECIFIC PRODUCT; THESE ARE CHANGES IN ANY GIVEN YEAR OVER THE LAST PERIOD IN THE ANALYSIS)

28. Evaluation of Action Taken Regarding Product Promotion

Year	1	2	3	4	5	6	7	8	9	10	
Highly beneficial											1
Moderately beneficial											2
Slightly beneficial											3
Indifferent or so-so											4
Slightly detrimental											5
Moderately detrimental											6
Highly detrimental											7
Unknown											8
Not applicable											9

(NOTE: EVALUATE THE STRATEGY OPERATIONALIZED BY YOUR FIRM IN REGARD TO THE SPECIFIC PRODUCT FOR EACH YEAR OF ITS LIFE UNDER STUDY)

29. Action Taken Regarding Capacity Requirements

	Year	1	2	3	4	5	6	7	8	9	10	
	Increased											1
	Decreased											2
	Not changed											3
SKIP TO QUESTION NO. 31	Unknown											4
	Not applicable											5

(NOTE: LIST THE STRATEGY OPERATIONALIZED BY YOUR FIRM IN REGARD TO THIS SPECIFIC PRODUCT; THESE ARE CHANGES IN ANY GIVEN YEAR OVER THE LAST PERIOD IN THE ANALYSIS)

30. Evaluation of Action Taken Regarding Capacity Requirements

Year	1	2	3	4	5	6	7	8	9	10	
Highly beneficial											1
Moderately beneficial											2
Slightly beneficial											3
Indifferent or so-so											4
Slightly detrimental											5
Moderately detrimental											6
Highly detrimental											7
Unknown											8
Not applicable											9

(NOTE: EVALUATE THE STRATEGY OPERATIONALIZED BY YOUR FIRM IN REGARD TO THE SPECIFIC PRODUCT FOR EACH YEAR OF ITS LIFE UNDER STUDY)

31. Action Taken Regarding R&D Expenditures in Related Areas

	Year	1	2	3	4	5	6	7	8	9	10	
	Increased											1
	Decreased											2
	Not changed											3
SKIP TO QUESTION NO. 33	Unknown											4
	Not applicable											5

(NOTE: LIST THE STRATEGY OPERATIONALIZED BY YOUR FIRM IN REGARD TO THIS SPECIFIC PRODUCT; THESE ARE CHANGES IN ANY GIVEN YEAR OVER THE LAST PERIOD IN THE ANALYSIS)

32. Evaluation of Action Taken Regarding Research and Development Expenditures in Related Areas

Year	1	2	3	4	5	6	7	8	9	10	
Highly beneficial											1
Moderately beneficial											2
Slightly beneficial											3
Indifferent or so-so											4
Slightly detrimental											5
Moderately detrimental											6
Highly detrimental											7
Unknown											8
Not applicable											9

(NOTE: EVALUATE THE STRATEGY OPERATIONALIZED BY YOUR FIRM IN REGARD TO THE SPECIFIC PRODUCT FOR EACH YEAR OF ITS LIFE UNDER STUDY)

33. Action Taken Regarding Trends of Wholesale Margins

	Year	1	2	3	4	5	6	7	8	9	10	
	Increased											1
	Decreased											2
	Not changed											3
SKIP TO QUESTION NO. 35	Unknown											4
	Not applicable											5

(NOTE: LIST KNOWN TRENDS IN WHOLESALE MARGINS EXPERIENCED BY DISTRIBUTORS)

34. Evaluation of Action Taken Regarding Trends of Wholesale Margins

Year	1	2	3	4	5	6	7	8	9	10	
Highly beneficial											1
Moderately beneficial											2
Slightly beneficial											3
Indifferent or so-so											4
Slightly detrimental											5
Moderately detrimental											6
Highly detrimental											7
Unknown											8
Not applicable											9

(NOTE: EVALUATE THE EFFECTS OF NOTED WHOLESALE MARGIN TRENDS IN TERMS OF PRODUCT MOVEMENT ON A YEARLY BASIS)

35. Action Concerning Product Improvements

	Year	1	2	3	4	5	6	7	8	9	10	
	Yes											
	No											
SKIP TO QUESTION NO. 37	Unknown											
	Not applicable											

(NOTE: RECORD THE ACTION TAKEN BY YOUR FIRM; THIS IS AN ANALYSIS OF AN ACTION TAKEN IN A GIVEN TIME PERIOD WHEN COMPARED WITH THE PREVIOUS YEAR IN THE ANALYSIS)

36. Evaluation of Action Concerning Product Improvements

Year	1	2	3	4	5	6	7	8	9	10	
Highly beneficial											1
Moderately beneficial											2
Slightly beneficial											3
Indifferent or so-so											4
Slightly detrimental											5
Moderately detrimental											6
Highly detrimental											7
Unknown											8
Not applicable											9

(NOTE: EVALUATE THE EFFECTS OF THE ACTION TAKEN REGARDING PRODUCT IMPROVEMENT ON A YEARLY BASIS)

37. Action Taken Regarding Distribution Channel Changes

	Year	1	2	3	4	5	6	7	8	9	10	
	Yes											1
	No											2
SKIP TO QUESTION NO. 39	Unknown											3
	Not applicable											4

(NOTE: RECORD THE ACTION TAKEN BY YOUR FIRM: THIS IS AN ANALYSIS OF AN ACTION TAKEN IN A GIVEN TIME PERIOD WHEN COMPARED WITH THE PREVIOUS YEAR IN THE ANALYSIS)

38. Evaluation of Action Taken Regarding Distribution Channel Changes

Year	1	2	3	4	5	6	7	8	9	10	
Highly beneficial											1
Moderately beneficial											2
Slightly beneficial											3
Indifferent or so-so											4
Slightly detrimental											5
Moderately detrimental											6
Highly detrimental											7
Unknown											8
Not applicable											9

(NOTE: EVALUATE THE EFFECTS OF THE ACTION TAKEN REGARDING DISTRIBUTION CHANNEL CHANGES ON A YEARLY BASIS)

39. Action Taken Regarding Cessation of Production

	Year	1	2	3	4	5	6	7	8	9	10	
	Yes											1
	No											2
SKIP TO QUESTION NO. 41	Unknown											3
	Not applicable											4

(NOTE: RECORD THE ACTION TAKEN BY YOUR FIRM: THIS IS AN ANALYSIS OF AN ACTION TAKEN IN A GIVEN TIME PERIOD WHEN COMPARED WITH THE PREVIOUS YEAR IN THE ANALYSIS)

40. Evaluation of Action Taken Regarding Cessation of Production

Year	1	2	3	4	5	6	7	8	9	10	
Highly beneficial											1
Moderately beneficial											2
Slightly beneficial											3
Indifferent or so-so											4
Slightly detrimental											5
Moderately detrimental											6
Highly detrimental											7
Unknown											8
Not applicable											9

(NOTE: EVALUATE THE EFFECTS OF THE ACTION TAKEN REGARDING CESSATION OF PRODUCTION ON A YEARLY BASIS)

41. Action Taken Regarding Promotional Media Changes

	Year	1	2	3	4	5	6	7	8	9	10	
	Yes											1
	No											2
SKIP TO QUESTION NO. 43	Unknown											3
	Not applicable											4

(NOTE: RECORD THE ACTION TAKEN BY YOUR FIRM: THIS IS AN ANALYSIS OF AN ACTION TAKEN IN A GIVEN TIME PERIOD WHEN COMPARED WITH THE PREVIOUS YEAR IN THE ANALYSIS)

42. Evaluation of Action Taken Regarding Promotional Media Changes

Year	1	2	3	4	5	6	7	8	9	10	
Highly beneficial											1
Moderately beneficial											2
Slightly beneficial											3
Indifferent or so-so											4
Slightly detrimental											5
Moderately detrimental											6
Highly detrimental											7
Unknown											8
Not applicable											9

(NOTE: EVALUATE THE EFFECTS OF THE ACTION TAKEN REGARDING PROMOTIONAL MEDIA CHANGES ON A YEARLY BASIS)

43. Action Taken Regarding Price Changes

	Year	1	2	3	4	5	6	7	8	9	10	
	Yes											1
	No											2
SKIP TO QUESTION NO. 45	Unknown											3
	Not applicable											4

(NOTE: RECORD THE ACTION TAKEN BY YOUR FIRM: THIS IS AN ANALYSIS OF AN ACTION TAKEN IN A GIVEN TIME PERIOD WHEN COMPARED WITH THE PREVIOUS YEAR IN THE ANALYSIS)

44. Evaluation of Action Taken Regarding Price Changes

Year	1	2	3	4	5	6	7	8	9	10	
Highly beneficial											1
Moderately beneficial											2
Slightly beneficial											3
Indifferent or so-so											4
Slightly detrimental											5
Moderately detrimental											6
Highly detrimental											7
Unknown											8
Not applicable											9

(NOTE: EVALUATE THE EFFECTS OF THE ACTION TAKEN REGARDING PRICE CHANGES ON A YEARLY BASIS)

45. Distribution Channels Used

Distribution Channels Used	Years in Effect	
		1
		2
		3

(NOTE: LIST THE TYPES OF DISTRIBUTION CHANNELS USED AS DIRECT SALE TO USERS, THROUGH DISTRIBUTORS WHO SOLD TO USERS, ETC., INDICATING THE YEARS WHEN THE VARIOUS TYPES OF CHANNELS WERE IN EFFECT AS WELL AS NOTING ANY CHANGES AND YEARS OF THOSE CHANGES)

46. In regard to overall industry and its plant facilities to supply this product, there was on the average:

INSTRUCTIONS: If this product is a member of a family of related products on the basis of similarity of molecular structure, chemical process, etc., and these products are produced in common plant production facilities, proceed to Question 47. If this product has separate production facilities, SKIP Question 47 and PROCEED to Question 48.

Year	1	2	3	4	5	6	7	8	9	10	
Marked overcapacity, i.e., greater than 20% idle capacity present											1
Moderate overcapacity, i.e., between 5% and 20% idle capacity present											2
Slight overcapacity, i.e., less than 5% idle capacity present											3
No undercapacity or overcapacity present											4
Slight undercapacity, i.e., less than 5% expansion required to meet market demands											5
Moderate undercapacity, i.e., between 5% and 20% expansion required to meet market demands											6
Marked undercapacity, i.e., over 20% expansion required to meet market demands											7
Unknown											8
Not applicable since this product constituted the industry											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

47. In regard to your firm and its plant facilities to supply this product and yet remain to supply the needed demands for the related products, there was on the average:

Year	1	2	3	4	5	6	7	8	9	10	
Marked overcapacity, i.e., greater than 20% idle capacity present											1
Moderate overcapacity, i.e., between 5% and 20% idle capacity present											2
Slight overcapacity, i.e., less than 5% idle capacity present											3
No undercapacity or overcapacity present											4
Slight undercapacity, i.e., less than 5% expansion required to meet market demands											5
Moderate undercapacity, i.e., between 5% and 20% expansion required to meet market demands											6
Marked undercapacity, i.e., over 20% expansion required to meet market demands											7
Unknown											8
Not applicable since this product constituted the industry											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

48. In regard to your firm and its plant facilities to supply the product, there was on the average:

	Year 1	2	3	4	5	6	7	8	9	10	
Marked overcapacity, i.e., greater than 20% idle capacity present											1
Moderate overcapacity, i.e., between 5% and 20% idle capacity present											2
Slight overcapacity, i.e., less than 5% idle capacity present											3
No undercapacity or overcapacity present											4
Slight undercapacity, i.e., less than 5% expansion required to meet market demands											5
Moderate undercapacity, i.e., between 5% and 20% expansion required to meet market demands											6
Marked undercapacity, i.e., over 20% expansion required to meet market demands											7
Unknown											8
Not applicable since this product constituted the industry											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

49. In terms of protecting the product from external competition, the patent rights for the product, i.e., a product patent, had a:

Strong beneficial effect		1
Moderate beneficial effect		2
Slight beneficial effect		3
Indifferent or so-so		4
Slight detrimental or limiting effect		5
Moderate detrimental or limiting effect		6
Strong detrimental or limiting effect		7
Unknown		8
No product patent		9

(NOTE: SELECT ONE ANSWER ONLY)

50. In terms of protecting the product from external competition, the process patent had a:

Strong beneficial effect		1
Moderate beneficial effect		2
Slight beneficial effect		3
Indifferent or so-so		4
Slight detrimental or limiting effect		5
Moderate detrimental or limiting effect		6
Strong detrimental or limiting effect		7
Unknown		8
No process patent		9

(NOTE: SELECT ONE ANSWER ONLY)

51. In terms of protecting the product from external competition, the use patent had a:

Strong beneficial effect		1
Moderate beneficial effect		2
Slight beneficial effect		3
Indifferent or so-so		4
Slight detrimental or limiting effect		5
Moderate detrimental or limiting effect		6
Strong detrimental or limiting effect		7
Unknown		8
No use patent		9

(NOTE: SELECT ONE ANSWER ONLY)

52. In regard to raw materials used in the manufacture of this product, there was on the average:

Year	1	2	3	4	5	6	7	8	9	10	
Heavy shortages with difficult access to existing supplies											1
Moderate shortages with difficult access to existing supplies											2
Moderate shortages with moderate difficulty in getting access to existing supplies											3
Moderate shortages with slight difficulty in getting access to existing supplies											4
Slight shortages with moderate difficulty in getting access to existing supplies											5
Slight shortages with slight difficulty in getting access to existing supplies											6
No shortage or access difficulties											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

53. The technological specialties (i.e., various professionally trained individuals) critical to the success of overcoming any technological barriers existing in the research and development program for this product were:

INSTRUCTIONS: If the product and/or process originated out of your research laboratories, PROCEED to both Questions 53 and 54. If the product and/or process are mere duplications of chemical products existing on the market, SKIP Questions 53 and 54 and PROCEED to Question 55.

Present in the firm		1
Absent from the firm, but considered a nominal factor, i.e., unimportant to the success or failure of the product development program		2
Absent from the firm, but obtained without difficulty		3
Absent from the firm and considered a slight limiting factor		4
Absent from the firm and considered a moderate limiting factor		5
Absent from the firm and considered between a moderate and a serious limiting factor		6
Absent from the firm and considered a serious limiting factor		7
Unknown		8
Not applicable		9

(NOTE: SELECT ONE ANSWER ONLY)

54. The degree of difficulty in harnessing the research and development program in order to commercialize this product as:

Highly difficult		1
Moderately difficult		2
Slightly difficult		3
Indifferent or so-so		4
Slightly easy		5
Moderately easy		6
Very easy		7
Unknown		8
Not applicable		9

(NOTE: SELECT ONE ANSWER ONLY)

55. In regard to the fruits of the research activities related to the new product, the results were:

Development of the new product and/or related product only		1
Development of the new product and discovery of its potential uses		2
Development of the new product and related products with the discovery of the potential uses of the new product only		3
Development of the new product and discovery of its potential uses in addition to uncovering important technical knowledge in the area		4
Development of a family of related products and discovery of their potential uses in addition to uncovering important technical knowledge in the area		5
Development of the new product, discovery of its potential uses, discovery of important technical knowledge, and the uncovering of new leads for furthering important research in the area		6
Development of a family of new products, discovery of its potential uses, discovery of important technical knowledge, and the uncovering of new leads for furthering important research in the area		7
Unknown		8
Not applicable		9

(NOTE: SELECT ONE ANSWER ONLY)

56. If the uses for the new product were such that developmental samples were distributed to potential industrial users for evaluation, what effect did the supply capabilities on a commercial basis of your firm have on the user's decision to attempt to evaluate its potential uses in his laboratories:

Year	1	2	3	4	5	6	7	8	9	10	
Marked beneficial effect, since firm able to supply all user requirements											1
Moderately beneficial effect, since firm able to supply most user requirements											2
Slight beneficial effect, since firm able to supply good portion of user requirements											3
No noticeable effect											4
Slight detrimental effect, since firm unable to supply a good portion of user requirements											5
Moderate detrimental effect, since firm unable to supply user requirements											6
Marked detrimental effect, since firm unable to supply any user requirements											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH OF THE THE PRODUCT LIFE CYCLE UNDER STUDY)

57. The percentage of potential users that evaluated the new product in their own laboratories on an experimental quantity basis once approached by your firm was:

Year	1	2	3	4	5	6	7	8	9	10	
100%											1
80-99%											2
60-79%											3
40-59%											4
20-39%											5
1-19%											6
0%											7
Unknown											8
Not applicable since no sample distribution was attempted											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

58. From the industrial user's viewpoint, of what importance did the reputation and image of the manufacturer and its established rapport in cooperative development programs to meet specific user requirements have on the selection of the manufacturer for supply of this product as well as others:

Highly important		1
Moderately important		2
Slightly important		3
Indifferent or so-so		4
Slightly unimportant		5
Moderately unimportant		6
Highly unimportant		7
Unknown		8
Not applicable since no cooperative programs established		9

(NOTE: SELECT ONE ANSWER ONLY)

59. The degree of difficulty for competitors to duplicate the important characteristics of the new product when evaluated over the dimensions of existing patent rights and technological obstacles was:

Extremely difficult		1
Moderately difficult		2
Slightly difficult		3
Indifferent or so-so		4
Slightly easy		5
Moderately easy		6
Very easy		7
Unknown		8
Not applicable		9

(NOTE: SELECT ONE ANSWER ONLY)

60. In regard to possible licensing arrangements, they were:

	Year	1	2	3	4	5	6	7	8	9	10	
	Were acquired											1
SKIP TO QUESTION NO. 62	Investigated possibilities											2
	Not considered											3
	Unknown											4
	Not applicable											5

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

61. In regard to licensing acquisitions made by other firms, they had a:

Year	1	2	3	4	5	6	7	8	9	10	
Strong beneficial effect											1
Moderate beneficial effect											2
Slight beneficial effect											3
Indifferent or so-so											4
Slight limiting effect											5
Moderate limiting effect											6
Strong limiting effect											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE

62. The new product may have had advantages that were recognizable by industrial users, that is, those responsible for the buying decision, at varying degrees. Indicate which was typical for this product.

Year	1	2	3	4	5	6	7	8	9	10	
Extremely difficult to recognize											1
Moderately difficult to recognize											2
Slightly difficult to recognize											3
Indifferent or so-so											4
Slightly easy to recognize											5
Moderately easy to recognize											6
Extremely easy to recognize											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

63. The number of purchases on the average made by an industrial buyer each year was:

Year	1	2	3	4	5	6	7	8	9	10	
One											1
Two to three											2
Four to six											3
Seven to eight											4
Nine to ten											5
Eleven to twelve											6
Over twelve											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

64. In regard to the matching of technological characteristics of the product with the market requirements as perceived by the typical industrial user, they were:

Extremely well matched		1
Moderately well matched		2
Slightly well matched		3
Indifferent or so-so		4
Slightly not well matched		5
Moderately not well matched		6
Extremely not well matched		7
Unknown		8
Not applicable		9

(NOTE: SELECT ONE ANSWER ONLY)

65. From a marketing standpoint, the new product was:

Highly innovative		1
Moderately innovative		2
Slightly innovative		3
Indifferent or so-so		4
Slightly duplicative		5
Moderately duplicative		6
Highly duplicative		7
Unknown		8
Not applicable		9

(NOTE: SELECT ONE ANSWER ONLY)

66. In regard to a technological standpoint, the new product was:

Highly innovative		1
Moderately innovative		2
Slightly innovative		3
Indifferent or so-so		4
Slightly duplicative		5
Moderately duplicative		6
Highly duplicative		7
Unknown		8
Not applicable		9

(NOTE: SELECT ONE ANSWER ONLY)

67. From an industrial user's viewpoint, to what extent was the quality of the product an important consideration:

Highly important		1
Moderately important		2
Slightly important		3
Indifferent or so-so		4
Slightly unimportant		5
Moderately unimportant		6
Highly unimportant		7
Unknown		8
Not applicable		9

(NOTE: SELECT ONE ANSWER ONLY)

68. The effect of the new product on the sales of other products in your product line was:

Year	1	2	3	4	5	6	7	8	9	10	
Strong detrimental effect, since essentially replaced an existing product or products with no increase in net sales											1
Moderate detrimental effect, since moderate decreases in sales of related products were experienced											2
Slight detrimental effect, since slight decreases in sales of related products were experienced											3
No effect, since not related to other products											4
Slight beneficial effect, since slight increases in sales of related products were experienced											5
Moderate beneficial effect, since moderate increases in sales of related products were experienced											6
Strong beneficial effect, since significantly large increases in sales of related products were experienced											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

69. The general trend of promotional outlays for the new product was:

Year	1	2	3	4	5	6	7	8	9	10	
Marked rise, since growth rates for promotional outlays significantly greater than that of sales											1
Marked to moderate rise, since growth rates for promotional outlays slightly greater than that of sales											2
Concomitant rise, since growth rates for promotional outlays equal to that of sales											3
Moderate rise, since growth rates of promotional outlays less than that of sales but remaining positive in increments											4
No change in absolute amounts for promotional outlays											5
Actual decline in absolute amounts for promotional outlays											6
No promotional outlays for this product											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

70. What was the general dependence of the final sale on personal contacts by company representatives?

Strongly dependent		1
Moderately dependent		2
Slightly dependent		3
Indifferent or so-so		4
Slightly not dependent		5
Moderately not dependent		6
Strongly not dependent		7
Unknown		8
Not applicable		9

(NOTE: SELECT ONE ANSWER ONLY)

71. What was the general effect of industrial advertising in selecting a manufacturer of the new product?

Year	1	2	3	4	5	6	7	8	9	10	
Strong positive effect											1
Moderate positive effect											2
Slight positive effect											3
Indifferent or so-so											4
Slight negative effect											5
Moderate negative effect											6
Strong negative effect											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF PRODUCT LIFE CYCLE UNDER STUDY)

72. The suitability of existing marketing personnel to promote the new product was:

Strongly unsuitable, with requirement of adding all new personnel		1
Moderately unsuitable, with requirement of adding a significant number of new personnel		2
Slightly unsuitable, with requirement of adding a large number of new personnel		3
Indifferent or so-so, with requirement of adding a number of new personnel		4
Slightly suitable, with requirement of adding a small number of new personnel		5
Moderately suitable, with requirement of adding a nominal number of new personnel		6
Highly suitable, with requirement of adding no additional new personnel		7
Unknown		8
Not applicable		9

(NOTE: SELECT ONE ANSWER ONLY)

73. Mergers, combinations, or the like may directly assist the various functional areas of the business to exploit more completely the market opportunity of this product. Which tactic was used by your firm?

		Year 1	2	3	4	5	6	7	8	9	10	
	Formal completion of one or more											1
SKIP TO QUESTION NO. 75	Possibilities explored											2
	Not considered											3
	Unknown											4
	Not applicable											5

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

74. Formal completion of one or more merger, combination, or the like had a:

	Year 1	2	3	4	5	6	7	8	9	10	
Strong beneficial effect											1
Moderate beneficial effect											2
Slight beneficial effect											3
Indifferent or so-so											4
Slight detrimental effect											5
Moderate detrimental effect											6
Strong detrimental effect											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

75. The apparent corporate asset size that effectively competed in the production and marketing of this product was:

No limitation on asset size		1
Minimum of $1 million		2
Minimum of $10 million		3
Minimum of $20 million		4
Minimum of $30 million		5
Minimum of $40 million		6
Only major firms, i.e., those in the top 500 industrial firms class		7
Unknown		8
Not applicable since no competing firms		9

(NOTE: SELECT ONE ANSWER ONLY)

76. The trends in the specific markets for the new product were:

Year	1	2	3	4	5	6	7	8	9	10	
Strongly increasing, i.e., annual growth rate exceeding 10%											1
Moderately increasing, i.e., annual growth rate exceeding 3% but less than 10%											2
Slightly increasing, i.e., annual growth rate of 3% or less											3
No change in market demands											4
Slightly decreasing, i.e., annual decay rate of 3% or less											5
Moderately decreasing, i.e., annual decay rate exceeding 3% but less than 10%											6
Strongly decreasing, i.e., annual decay rate exceeding 10%											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

77. The demand for the new product rested on a:

Strong necessity		1
Moderate necessity		2
Slight necessity		3
Indifferent or so-so		4
Slight desire		5
Moderate desire		6
Very weak desire		7
Unknown		8
Not applicable		9

(NOTE: SELECT ONE ANSWER ONLY)

78. The demand for the new product was:

Year	1	2	3	4	5	6	7	8	9	10	
Clearly understood											1
Moderately understood											2
Slightly understood											3
Indifferent or so-so											4
Slightly misunderstood											5
Moderately misunderstood											6
Clearly misunderstood											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

79. If the new product was an intermediary, the demand for the other product(s) from which the derived demand situation existed had:

	Year 1	2	3	4	5	6	7	8	9	10	
Strongly increased, i.e., annual growth rate exceeding 10%											1
Moderately increased, i.e., annual growth rate between 3% and 10%											2
Slightly increased, i.e., annual growth rate of 3% or less											3
No change in market demands											4
Slightly decreased, i.e., annual decay rate of 3% or less											5
Moderately decreased, i.e., annual decay rate between 3% and 10%											6
Strongly decreased, i.e., annual decay rate exceeding 10%											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

80. The average industrial buyer purchased the new product from:

	Year 1	2	3	4	5	6	7	8	9	10	
One producer											1
Two producers											2
Three producers											3
Four producers											4
Five producers											5
Six producers											6
More than six producers											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

81. The number of customers for the new product was:

	Year	1	2	3	4	5	6	7	8	9	10	
One												1
Two to five												2
Six to ten												3
Eleven to twenty												4
Twenty-one to forty												5
Forty-one to one hundred												6
Over one hundred												7
Unknown												8
Not applicable												9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

82. The seasonal patterns for the new product were:

Highly seasonal		1
Seasonal		2
Moderately seasonal		3
Moderately to slightly seasonal		4
Slightly seasonal		5
Very slightly seasonal		6
Nonseasonal		7
Unknown		8
Not applicable		9

(NOTE: SELECT ONE ANSWER ONLY)

83. The cyclical patterns for the new product were:

Highly cyclical		1
Cyclical		2
Moderately cyclical		3
Moderately to slightly cyclical		4
Slightly cyclical		5
Very slightly cyclical		6
Noncyclical		7
Unknown		8
Not applicable		9

(NOTE: SELECT ONE ANSWER ONLY)

84. Trade relations with users were best described as:

Year	1	2	3	4	5	6	7	8	9	10	
Extremely good											1
Moderately good											2
Slightly good											3
Indifferent or so-so											4
Slightly weak											5
Moderately weak											6
Extremely weak											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

85. Product loyalty on the average was:

	Year 1	2	3	4	5	6	7	8	9	10	
Very strong											1
Strong											2
Moderately strong											3
Moderately weak											4
Weak											5
Very weak											6
No loyalty existing											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

86. The initial purchase of the new product required:

Detailed deliberation		1
Detailed to moderate deliberation		2
Moderate deliberation		3
Moderate to slight deliberation		4
Slight deliberation		5
Very slight deliberation		6
No deliberation		7
Unknown		8
Not applicable		9

(NOTE: SELECT ONE ANSWER ONLY)

87. To what extent did customers integrate backward?

Year	1	2	3	4	5	6	7	8	9	10	
Very slight move, i.e., less than 5% of customers											1
Slight move, i.e., between 5% and 10% of customers											2
Moderate move, i.e., between 10% and 20% of customers											3
Moderate to strong move, i.e., between 20% and 40% of customers											4
Strong move, i.e., between 40% and 60% of customers											5
Very strong move, i.e., between 60% and 80% of customers											6
Highly marked move, i.e., greater than 80% of customers											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

88. Rate the distribution channel effectiveness in terms of product flows:

Year	1	2	3	4	5	6	7	8	9	10	
Highly effective											1
Moderately effective											2
Slightly effective											3
Indifferent or so-so											4
Slightly ineffective											5
Moderately ineffective											6
Highly ineffective											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

89. Rate the general ability of the manufacturer's representative to get across the product concept associated with the new product and its promotion:

Year	1	2	3	4	5	6	7	8	9	10	
Highly effective											1
Moderately effective											2
Slightly effective											3
Indifferent or so-so											4
Slightly ineffective											5
Moderately ineffective											6
Highly ineffective											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

INSTRUCTIONS: It is necessary at times to "educate" the industrial user on the product characteristics, advantages, and uses. Evaluate the education process along the dimensions defined in the following three questions.

90. The typical time to educate the user was:

Three or more years		1
Two but less than 3 years		2
One but less than 2 years		3
Six months but less than 1 year		4
Three months but less than 6 months		5
One month but less than 3 months		6
Less than one month		7
Unknown		8
Not applicable if no education process needed		9

(NOTE: SELECT ONE ANSWER ONLY)

91. The number of contacts on the average required by marketing and technical development people before the sale was concluded:

One		1
Two		2
Three		3
Four		4
Five		5
Six		6
Over six		7
Unknown		8
Not applicable		9

(NOTE: SELECT ONE ANSWER ONLY)

92. The service requirement of technical personnel required to assure user satisfaction (measured as man-hours of technical personnel/man-hours of marketing personnel):

Fraction value between 0 and 0.5		1
Fraction value between 0.5 and 1.0		2
Fraction value between 1.0 and 1.5		3
Fraction value between 1.5 and 2.5		4
Fraction value between 2.5 and 3.0		5
Fraction value greater than 3.0		6
Unknown		7
Not applicable if no service requirement needed		8

(NOTE: SELECT ONE ANSWER ONLY)

93. The approximate percentage of imports to domestic sales for the new product was:

Year	1	2	3	4	5	6	7	8	9	10	
Over 50%											1
40-50%											2
30-40%											3
20-30%											4
10-20%											5
1-10%											6
Unknown											7
Not applicable since no importing was experienced											8

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

94. The approximate percentage of exports to domestic sales for the new product was:

Year	1	2	3	4	5	6	7	8	9	10	
Over 50%											1
40-50%											2
30-40%											3
20-30%											4
10-20%											5
1-10%											6
Unknown											7
Not applicable since no exporting took place											8

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

95. What were the trends in gross margin for this product?

Year	1	2	3	4	5	6	7	8	9	10	
Strongly increased, i.e., annual growth rate exceeding 10%											1
Moderately increased, i.e., annual growth rate between 3% and 10%											2
Slightly increased, i.e., annual growth rate of 3% or less											3
No change in market demands											4
Slightly decreased, i.e., annual decay rate of 3% or less											5
Moderately decreased, i.e., annual decay rate between 3% and 10%											6
Strongly decreased, i.e., annual decay rate exceeding 10%											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

96. The new product research and development program can best be described as:

Research-based: the product was developed as a result of pure scientific investigation		1
Marketing-based: the product was developed through applied scientific investigation only after the user's requirements became known		2
Unknown		3
Not applicable		4

(NOTE: SELECT ONE ANSWER ONLY)

97. The type of fixed capital equipment used in the production of this new product was typically:

Single-purpose equipment		1
Combination of single-purpose and multipurpose equipment with majorly being single-purpose equipment		2
Combination of single-purpose and multipurpose equipment with majorly being multipurpose equipment		3
Multipurpose equipment		6
Unknown		5
Not applicable		6

(NOTE: SELECT ONE ANSWER ONLY)

98. The length of the product run for the new product on the average was:

Year	1	2	3	4	5	6	7	8	9	10	
Less than one week											1
Between one and two weeks											2
Greater than two weeks but less than one month											3
Between one and two months											4
Greater than two months but less than four months											5
Four months or longer but not on a continuous basis											6
On a continuous basis											7
Unknown											8
Not applicable											9

(NOTE: EVALUATE EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

99. The percentage of actual operating to existing capacity was on the average:

Year	1	2	3	4	5	6	7	8	9	10	
Less than 50%											1
50-59%											2
60-69%											3
70-79%											4
80-89%											5
90-99%											6
100%											7
Unknown											8
Not applicable											9

(NOTE: EVALUATE EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

100. The number of production runs experienced in the production of this new product was:

Year	1	2	3	4	5	6	7	8	9	10	
One, with the production being on a continuous basis											1
One, with the production not being on a continuous basis											2
Two											3
Three											4
Four to five											5
Six to seven											6
Greater than seven											7
Unknown											8
Not applicable											9

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

101. Indicate which one of the listed responses below was representative of the type of production facilities:

Product produced in separate production facilities		1
Product produced in common production facilities		2
Unknown		3
Not applicable		4

(NOTE: SELECT ONE ANSWER ONLY)

102. The product is best described as:

A chemical product unrelated by process to other products		1
A chemical product related by process to other products, i.e., coproducts or byproducts		2
Unknown		3
Not applicable		4

(NOTE: SELECT ONE ANSWER ONLY)

103. Many types of marketing representatives may be used to gain and maintain product acceptance. Which of the following strategies were used?

Year	1	2	3	4	5	6	7	8	9	10	
Regular sales force											1
Combination of regular sales force and special market development groups											2
Marketing development groups											3
Unknown											4
Not applicable											5

(NOTE: SELECT ONE ANSWER FOR EACH YEAR OF THE PRODUCT LIFE CYCLE UNDER STUDY)

104. What was the source(s) of the original discovery of the product?

Research conducted by "in-house" personnel		1
Research conducted by private individuals		2
Research conducted by nonprofit institutions		3
Research conducted by educational institutions		4
Research conducted by governmental agencies		5
Research conducted by other industrial firms		6
Unknown		7
Not applicable		8

(NOTE: SELECT ONE ANSWER ONLY)

APPENDIX E

PROGRAM ANALYSIS

```
      PROGRAM ANALYSIS
      DIMENSION TITLE(9),DS(17),DEMAND(17),TOTSALES(17),PARD(6,17),
     1PARUMC(6),UMC(17),PARUSE(6),USE(17),PARUAE(6),UAE(17),PARNRE(6),
     2TNNRE(17),DEPR(17),CIR(18),COST(17),GP(17),BTP(17),TPTP(17),
     3ATP(17),OCF(17),NCF(17),PRWORD(25),PRES(25),PV(17)
      COMMON TABLE(200,20),INTEREST(200)
      COMMON XINV(50),EARN(50)
      DATA (PRWORD = 8HDEMAND  ,8HUMC     ,8HUSE     ,8HUAE     ,      1-4
     1               8HT. SALES,8HT. COSTS,8HG PROFIT,8HBTP     ,      5-8
     2               8H= TSALES,8HTNNRE   ,8H= TSALES,8HTPTP    ,      9-12
     3               8H= TSALES,8HATP     ,8H= TSALES,8HDEPR    ,      13-16
     4               8HOCF     ,8HCIR     ,8HNCF     ,8HDISCOUNT,      17-20
     5               8HP. VALUE,8HSUM PV  ,8H        ,8H        ,      21-24
     6               8H        )                                       25
      TYPE REAL MEAN
      TYPE DOUBLE PV,SUM,SUMPV
      DF(X,A,B,C,D,E,F) = A+B*X+C*X*X+D*X*X*X+E*X**4+F*X**5
C         READ IN TITLE CARD-NUMBER PRODUCTS TO FOLLOW
  105 READ 110,NPROD,TITLE
  110 FORMAT (2X,I4,9A8)
      IF (EOF,60) 815,120
  120 PRINT 125,TITLE
  125 FORMAT (1H1,9A8/)
C         ZERO SUMS
C         THE FOLLOWING PROCESS WILL BE PERFORMED FOR EACH PRODUCT
      SUMOCF=0.
      SUMCIR=0.
      SUMPV=0.
      MAXLI=0
      MAXLE=0
      SUMATP=0.
      SDISOCF=0.
      TPROFIT=0.
      TSALES=0.
      DO 800 MC=1,NPROD
C     READ PARAMETER CARD TO GET MEANS AND STD. DEV. FOR ECONOMIC
C         LIFE AND SELLING PRICE AND ALSO A SUBTITLE
      READ 165,MAXYEARS,EMEAN,ESD,SPMEAN,SPSD,(TITLE(I),I=1,5)
  165     FORMAT (2X,I2,2(F7.2,F5.2),12X,5A8)
      GO TO 1000
C         READ PARAMETER CARDS FOR DEMAND FUNCTION
      DO 220 M=1,MAXYEARS
  220 READ 225,DS(M),(PARD(J,M),J=1,6)
  225 FORMAT (2X,F5.2,6F9.3)
C         READ PARAMETER CARD FOR UNIT MANUFACTURING COST
      READ 225,SDUMC,PARUMC
C         READ PARAMETER CARD FOR UNIT SELLING EXPENSES
      READ 225,SDUSE,PARUSE
C     READ PARAMETER CARD FOR UNIT ADMINISTRATION EXPENSE
      READ 225,SDUAE,PARUAE
C         READ PARAMETER CARD FOR TOTAL NET NON-RECURRING EXPENSES
      READ 225,SDNRE,PARNRE
 1000 CONTINUE
C         READ TAX RATE CONSTANT
      READ 268,TX
  268 FORMAT (2X, F3.2)
C         READ PARAMETER CARD FOR PRESENT DEPRECIATION
      MAX = MAXYEARS + 1
      READ 280,(DEPR(K),K=1,MAX)
  280 FORMAT (2X,6F12.3)
C         READ PARAMETER CARD FOR CAPITAL INVESTMENT REQUIREMENTS
```

```
      READ 280,(CIR(K),K=1,MAX)
C          READ PARAMETER CARD FOR COST OF CAPITAL
      READ 305,CCMEAN,CCSD
  305 FORMAT (2X,F5.3,F7.3)
C          FIGURE ECONOMIC LIFE
  175 ECONLIFE = EMEAN + ESD * RSNDF(DUMMY)
      LIFE = ECONLIFE
      IF (LIFE.LT.0.OR.LIFE.GT.MAXYEARS) GO TO 175
C          FIGURE SELLING PRICE
      SELLINGP = SPMEAN + SPSD * RSNDF(DUMMY)
      PRINT 205,(TITLE(I),I=1,5),LIFE,SELLINGP
  205 FORMAT (1H0,5A8/*0ECONOMIC LIFE = *,I2,5X,*SELLING PRICE = *,F7.2)
      CC = CCMEAN + CCSD * RSNDF(DUMMY)
      CCPER=CC*100.
      PRINT 309,CCPER
  309 FORMAT (*0COST OF CAPITAL = *,F6.2,1H=)
      SUM = -CIR(1)+ DEPR(1)
      SUMPV=SUMPV-CIR(1) + DEPR(1)
      SUMCIR    =SUMCIR    +CIR(1)
      ACCMAX=SUMCIR
      SDISINV= CIR(1)
      PRINT 315,SUM,SUM
  315 FORMAT (1H0,3X,*TIME  0*/1H0,6X,*NCF       = *,F14.3/7X,*P. VALUE =
     1 *,D17.5)
      READ 280,(TOTSALES(K),K=1,MAXYEARS)
      READ 280,(TPTP(K),K=1,MAXYEARS)
      IF (LIFE.EQ.0) GO TO 740
C     GO THROUGH FOLLOWING PROCESS FOR EACH YEAR OF ECONOMIC LIFE
      DO 730 L=1,LIFE
      GO TO 1001
C          DEMAND
      MEAN = DF(SELLINGP,PARD(1,L),PARD(2,L),PARD(3,L),PARD(4,L),
     1PARD(5,L),PARD(6,L))
      DEMAND(L) = MEAN + DS(L) *RSNDF(DUMMY)
C          TOTAL SALES
      TOTSALES(L) = SELLINGP * DEMAND(L)
C          UNIT MANUFACTURING COST
      MEAN = DF(DEMAND(L),PARUMC(1),PARUMC(2),PARUMC(3),PARUMC(4),
     1PARUMC(5),PARUMC(6))
      UMC(L) = MEAN + SDUMC * RSNDF(DUMMY)
C          UNIT SELLING EXPENSES
      MEAN = DF(DEMAND(L),PARUSE(1),PARUSE(2),PARUSE(3),PARUSE(4),
     1PARUSE(5),PARUSE(6))
      USE(L) = MEAN + SDUSE * RSNDF(DUMMY)
C          UNIT ADM. EXP.
      MEAN = DF(DEMAND(L), PARUAE(1),PARUAE(2),PARUAE(3),PARUAE(4),
     1PARUAE(5),PARUAE(6))
      UAE(L) = MEAN + SDUAE * RSNDF(DUMMY)
C          COSTS OF GOODS SOLD
      COST(L) = DEMAND(L) * UMC(L)
C          GROSS PROFIT
      GP(L) = TOTSALES(L) - COST(L)
C          BEFORE TAX PROFIT
      BTP(L) = GP(L) - (USE(L) + UAE(L))
C          TOTAL NET NON-RECURRING EXPENSE
      MEAN = DF(DEMAND(L),PARNRE(1),PARNRE(2),PARNRE(3),PARNRE(4),
     1PARNRE(5),PARNRE(6))
      TNNRE(L) = MEAN + SDNRE * RSNDF(DUMMY)
C          TOTAL PRE-TAX PROFIT
```

```
      TPTP(L) = BTP(L) - TNMRE(L)
 1001 CONTINUE
C          AFTER-TAX PROFIT
      ATP(L) = (1-TX    ) * TPTP(L)
      SUMATP=SUMATP + ATP(L)
C     OPERATING CASH FLOWS
      OCF(L) = ATP(L) + DEPR(L+1)
      SUMOCF    =SUMOCF    +OCF(L)
      SUMCIR       =SUMCIR       +CIR(L+1)
      IF (SUMCIR       .GT.ACCMAX) ACCMAX=SUMCIR
C          NET CASH FLOWS
      NCF(L) = OCF(L) - CIR(L+1        )
C          CALCULATE DISCOUNT FACTOR
      EXP=CC*L
      DISCOUNT = 1. / 2.71828 **EXP
      SDISOCF = SDISOCF + OCF(L) * DISCOUNT
      SDISINV = SDISINV + CIR(L+1) * DISCOUNT
C          CALCULATE PRESENT VALUE
      PV(L)=DISCOUNT*NCF(L)
      SUM = SUM + PV(L)
      SUMPV=SUMPV+PV(L)
      TSALES=TSALES+TOTSALES(L)
      TPROFIT=TPROFIT+TPTP(L)
C          PRINT ALL RESULTS
      PRINT 580,L
  580 FORMAT (1H0,3X,*TIME *,I2/)
      PRES(1) = DEMAND(L)
      PRES(2) = UMC(L)
      PRES(3) = USE(L)
      PRES(4) = UAF(L)
      PRES(5) = TOTSALES(L)
      PRES(6) = COST(L)
      PRES(7) = GP(L)
      PRES(8) = BTP(L)
      PRES(10)= TNMRE(L)
      PRES(12)= TPTP(L)
      PRES(14) = ATP(L)
      PRES(16) = DEPR(L+1)
      PRES(17) = OCF(L)
      PRES(18) = CIR(L+1)
      PRES(19) = NCF(L)
      PRES(20) = DISCOUNT
      PRES(21) = PV(L)
      PRES(9)=PRES(11)=PRES(13)=PRES(15)=0.
      IF (TOTSALES(L).LT..01) GO TO 670
      PRES(9) = BTP(L) / TOTSALES(L)*100.
      PRES(11) = TNMRE(L) / TOTSALES(L)*100.
      PRES(13) = TPTP(L) / TOTSALES(L)*100.
      PRES(15) = ATP(L) / TOTSALES(L)*100.
  670 CONTINUE
      PRINT 705,(PRWORD(K),PRES(K),K=1,20)
      PRINT 705,8HSUMCIR   ,SUMCIR
      PRINT 705,8HSUMOCF   ,SUMOCF
      PRINT 705,8HACCMAX   ,ACCMAX
      PRINT 705,8HSUMATP   ,SUMATP
      PRINT 705,8HSDISOCF  ,SDISOCF
      PRINT 705,8HSDISINV  ,SDISINV
C          CALCULATE RETURN ON INVESTMENT
      PRES(22)=ATP(L)*100./SUMCIR
```

```
      PRINT 705,8HRTN INVT,PRES(22)
  705 FORMAT (7X,A8,* = *,F14.3)
      PRINT 715,PRWORD(21),PRES(21)
  715 FORMAT (7X,A8,* = *,D17.8)
C         PRINT SUM PRESENT VALUES
      PRINT 715,PRWORD(22),SUM
  730 CONTINUE
  740 CONTINUE
C         LI - NUMBER YEARS INVESTMENT CASH FLOW
      LI=LIFE+1
C         GET MAXIMUM NUMBER OF YEARS
      IF (LI.GT.MAXLI) MAXLI=LI
C         LE - ECONOMIC LIFE - NUMBER YEARS EARNINGS CASH FLOW
      IF (LIFE.GT.MAXLE) MAXLE=LIFE
  800 CONTINUE
      PRINT 705,8HTSALES   ,TSALES,8HTPROFITS,TPROFIT
      PRINT 715,8HFINAL PV,SUMPV
      KCYCLEP=0
      KCYCLES=0
      PRINT 950
  950 FORMAT (*0GROWTH RATE  SALES       PROFITS *)
      DO 980 IG1=1,LIFE
      IG2=IG1+1
      PRINT 955,IG1,IG2
  955 FORMAT (* YEAR *,I2,* TO YEAR *,I2)
      GRATES=GROWTHF(TOTSALES(IG1),TOTSALES(IG2),1)
      GRATEP=GROWTHF(TPTP(IG1),TPTP(IG2),2)
      PRINT 965,GRATES,GRATEP
  965 FORMAT (12X,2(2X,F8.2,1H=))
      IF (TOTSALES(IG1).GT.0.) KCYCLES=KCYCLES+1
      IF(TPTP(IG1).GT.0.) KCYCLEP=KCYCLEP+1
  980 CONTINUE
      PRINT 985,KCYCLES,KCYCLEP
  985 FORMAT (*0TIMING CYCLE FOR SALES=*,I2/*0TIMING CYCLE FOR PROFITS =
     1 *,I2)
C         CALCULATE PAYBACK PERIOD
      PAYBACK = ACCMAX /(SUMOCF        / LIFE)
      PRINT 705,8HPAY BACK,PAYBACK
C         CALCULATE ACCOUNTING RATE OF RETURN
      ACCRATE =(SUMATP / LIFE / (.5 * ACCMAX)) * 100.
      PRINT 705,8HACCTRATE,ACCRATE
C         CALCULATE EQUIVALENT RATE OF RETURN
      EQUIVRT = (SUMPV/SDISINV) * 100.
      PRINT 705,8HEQUIVRTE,EQUIVRT
  804 FORMAT (* *,A8,F10.4  )
      GO TO 105
C         END OF JOB
  815 CONTINUE
      END
```

```
      FUNCTION GROWTHF(TIME0,TIME1,KIND)
      IF (TIME0.GT.-.001.AND.TIME0.LT..001) GO TO 60
      IF (KIND.EQ.1) GO TO 45
   10 IF (TIME0.LT.0.) 15,35
   15 IF (TIME1.LT.0.) 20,55
   20 PRINT 25,8HLOSS
   25 FORMAT(26X,A8)
      GO TO 45
   35 IF (TIME1.LT.0.) 55,40
   40 PRINT 25,8HPROFIT
   45 GROWTHF=(TIME1-TIME0)/TIME0*100.
      RETURN
   55 PRINT 25,8HMISSING
   60 GROWTHF=0.
      RETURN
      END
```

```
      FUNCTION RSNDF (DUMMY)
    1 RANN=SQRTF(-2.*LOGF(RANF(-1,0)))*SINF(6.283185307*RANF(-2.0))
      IF (RANN.GT.3.0) GO TO 1
      RSNDF=RANN
      END
```

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