NEW PRODUCT STRATEGY IN THE TECHNOLOGY-BASED FIRM:
PRODUCT TECHNOLOGY, MARKET STRATEGY, AND PERFORMANCE

by

Marc H. Meyer

A.B., Harvard University
(1978)

S.M., Massachusetts Institute of Technology
(1980)

Submitted to the Sloan School Of Management
In Partial Fulfillment Of
The Requirement of the Degree of

DOCTOR OF PHILOSOPHY

at the

Massachusetts Institute of Technology
January 1986

© Marc H. Meyer, 1986

The author hereby grants to M.I.T permission to reproduce and to
distribute copies of this thesis document in whole or in part.

Signature of the Author .................................................. Sloan School of Management
..................................................................................

Edward S. Roberts
Thesis Supervisor

Accepted by ................................................................. Lotte Bailyn
Chairman
Doctoral Program Committee

 Archives FEB 03 1986

LIBRARIES
NEW PRODUCT STRATEGY IN THE TECHNOLOGY-BASED FIRM:
PRODUCT TECHNOLOGY, MARKET STRATEGY, AND PERFORMANCE

by

Marc H. Meyer

Submitted to the Department of Management of Technology and Innovation on January 17, 1986 in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

ABSTRACT

This research is an investigation of new product strategy in the technology-based firm. It examines the relationship between strategic focus in new product strategy and performance. A method is proposed to determine the strategic focus of new product strategy of the firm that evaluates the product sequences of sample firms as degrees of change along two dimensions, being the technology embodied in and the market applications of products.

The hypothesis that a high degree of strategic focus correlates favorably with high performance is tested with empirical data collected from a sample comprised of four clusters of technology-based companies. The hypothesis is confirmed by the data, and organizations which concentrate their development activities within a single, proprietary key technology area are found to perform better than firms which develop products spanning multiple key technologies.

Additionally, a high level of diversity in the technological dimension is contrasted with high diversity in the market applications dimension with respect to performance. It is found that high levels of change in market applications has a stronger negative correlation with performance than high diversity in product technologies. Technological product entry strategy is examined in the context of both long-term performance and its relationship with subsequent patterns of new product strategy. Lastly, the rate of new product introduction and technological change are investigated with respect to performance.

Thesis Supervisor:  
Professor Edward B. Roberts  
David Sarnoff Professor of Management of Technology
# Table Of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Literature Review</td>
<td>6</td>
</tr>
<tr>
<td>Conceptual Framework</td>
<td>34</td>
</tr>
<tr>
<td>Research Hypotheses</td>
<td>71</td>
</tr>
<tr>
<td>Research Methodologies</td>
<td>103</td>
</tr>
<tr>
<td>Research Results</td>
<td>155</td>
</tr>
<tr>
<td>Bibliography</td>
<td>212</td>
</tr>
<tr>
<td>Appendix A: Product Data</td>
<td>210</td>
</tr>
<tr>
<td>Appendix B: Sales Data</td>
<td>251</td>
</tr>
<tr>
<td>Appendix C: Equations Sets</td>
<td>278</td>
</tr>
<tr>
<td>Appendix D: Spearman Coefficient Values</td>
<td>283</td>
</tr>
<tr>
<td>Appendix E: Data Analysis Programs</td>
<td>285</td>
</tr>
</tbody>
</table>
Chapter 1

INTRODUCTION
Chapter 1

INTRODUCTION

Entrepreneurship research has examined many aspects of the technology-based firm. Among numerous findings are the observations that a diversity in the skills of the founding team, connections with sources of financial backing, appropriate organizational development, and well planned marketing programs can increase the firm's chances of success. What has not been studied rigorously is the products made by these firms, specifically the strategies adopted by management that determine the types of products made by the company. More generally, there is a lack of empirical research in the larger domain of strategy for the technology-based firm. This study examines the issue of new product strategy by first developing a conceptual framework for considering the key elements of new product strategy and then an empirical method for gathering data. The objective is to show that a focused strategy regarding new products made by the technology-based firm is more highly correlated with successful performance than strategies that span multiple technological fields and market applications.

What is the technology-based firm, and in consequence, to what industries does this research apply? The terms technology-based and high technology are used widely, and perhaps somewhat loosely, to refer to a type of company that engages in advanced technological fields. Davis and Smith (1984) recently offered a more specific
definition of the technology based firm: such firms include those industries — biomedical, micro-processors, optics, telecommunications, lasers — where operations are profoundly and continuously impacted by breakthroughs in product technology (p. 90). Computer manufacturers and software development companies fit this definition, for example. New component technologies, be it faster processors, new operating systems, or new programming tools, have facilitated a high rate of new product introduction in these industries. A chemical company or an oil refiner, however, while possessing highly complex process technology, does not exhibit this consistent and substantial alteration due to rapid technological change. Their research and development environment is far more stable than that of the technology-based firm. The frequency of competitive product introductions also requires that the technology-based firm quickly adapt its non-engineering activities, including marketing communications, sales and support, to the new products that are generated by the company’s technologists. And, the challenge to maintain product differentiation within established markets is also only part of the story, for it by the continued aggressive application of technology to new commercial applications, as in artificial intelligence or biotechnology, that the technology-based firm often achieves its greatest reward.

New product decision-making in the technology-based firm is inherently risky. Each investment in a new product may have substantial opportunity costs in terms of the time and resources that may have been channeled into alternative courses of action. Further, the investment in a new product only begins with prototype development. The prototype becomes a product only after the firm has developed the documentation and marketing communications materials, the sales programs, and the production and quality control mechanisms necessary to commercialize the technology. New product decisions may therefore have a broad impact on the policies and structure
of the organization as well as on its performance. Clearly, the risks and rewards evident in new product decision-making within the technology-based firm warrant the present investigation into elements of that process and the identification of factors that may lead to success.

The goal of this research has been to build and test a method for examining a set of hypotheses that center on the theme of strategic focus. Strategic focus is the degree to which a firm concentrates its resources on selected key technologies, product functionality, and market segments. The empirical method that has been developed has allowed the author to observe the product sequences in a sample of technology-based firms along several fundamental dimensions that represent the degree of focus in an organization's new product strategy. These data could then be quantified and correlated with performance measures.

From our perspective, a "focused" new product strategy is the result of a cumulative set of new product decisions made by the firm that produce a high degree of relatedness in the embodied technologies and market applications in the firm's products. This research examines new product strategy as the empirical outcome of new product decisions over time, and identifies the relationship between strategy patterns and performance. The direction of causality is therefore from new product decisions to a resulting strategy, as opposed to studying explicit "strategies" forwarded by management that in turn lead to particular types of technologies and market applications in new products. In a similar vein, this research does not investigate the process of new product decision-making or seek to explicitly answer the question of why one firm adopts a "focused" new product strategy, and another, an unfocused strategy. Just as many products in the new, technology-based firm environment may be
hypothesized to be the result of a "top-down", proactive new product decision process, we suggest that other products are also often the outcome of personal initiatives or "product championing". Thus, while this research focuses on the de facto new product strategy of the technology-based firm, which is the degree of relatedness between the successive products made by the firm, other issues for our consideration are the process of making formal new product strategy and the extent to which such strategy is tangibly implemented in the commercial products released by the firm.

The conceptual framework and empirical methods used in this study were primarily developed in earlier work by the author (Meyer 1982, Meyer and Roberts 1985). However, this research has benefited greatly from the application of its models and methods by the author's colleagues at the Sloan School to other research samples. In particular, the author wishes to acknowledge the participation of James Ishikawa (1985) and Charles Bow (1984), both of whom completed Master's theses on new product strategy and ventured into the field with the author to collect their data. Additionally, Professor Edward Roberts who, with an intuitive understanding of technological entrepreneurship and an extensive research background, has made a series of recommendations in both concepts and methods that have had a substantial impact on the final result. The author's appreciation is also extended to Professors James Utterback, who has assisted in the conceptual development of the research, and to Thomas Allen, who has been a model of how to conduct empirical research in the innovation field. The time spent with fellow graduate students Peter Vanderwerf and Kumar Nochur discussing this research was also of substantial value.

In the next section, Chapter 2, the relevant literature is reviewed with the purpose of establishing a context within which the reader may place and consider the
present research on new product strategy. The literature review covers by necessity a broad range of topics in the fields of strategy and innovation. Chapter 3 builds a conceptual framework of new product strategy in technology-based firm that is the basis of the research. A set of hypotheses is then generated from this framework in the following chapter, Chapter 4. Additionally, the strategic focus hypothesis is contrasted to several major concepts that have dominated the strategy and product innovation fields. Chapter 5 the describes the research methodologies, including the research sample and the methods employed for gathering and analyzing the data. The results of the research analyses and their implications are presented in Chapter 6.
Chapter 2

LITERATURE REVIEW
Chapter 2

LITERATURE REVIEW

While the research in the fields of strategy and innovation is extensive, the particular study of the strategy for developing new products in technology-based firms is comparatively unexplored. Nonetheless, the existing strategy and innovation research points to a number of important variables that, together with new product strategy, affect the firm's performance. Thus, the existing research literature provides both the perspective and the qualifications for considering the hypotheses that will be developed and validated in the present research regarding the relationship between product strategies and firm performance.

New product strategy, as a research topic, has two foundations in the literature. The first foundation is the study of corporate strategy. Within the field of corporate strategy are two basic subsets: the first being conceptual models of the strategic decision-making process, and the second, empirical studies of patterns of diversification and their organizational outcomes. The first group of research has concentrated on methods of business definition, the formulation of functional strategies, and the processes of resource allocation. The main themes that have emerged are that businesses may define the scope of their activities, position their products, and evaluate the attractiveness of new market opportunities through a process of competitive and
market need analysis. The substantiating evidence of these works tends to be case studies.

The second subset of strategy research, which looks at the relationship between business strategy and organization structure, is empirical in nature (Chandler 1968, Rumelt 1973). This research has generally shown that the activities of a firm over time may be monitored by the researcher and that relationships between events may be modeled and used as the basis for hypothesis generation and testing.

In addition to the strategy research, another foundation for the present work is the study of innovation and entrepreneurship. This set of research is both diverse and rich in content. Specific fields include the generation of innovative ideas, the process of developing products, communications within development laboratories, the characteristics of entrepreneurs, and general success factors for innovation.

While many studies exist in both areas of corporate strategy and innovation, not all employ an empirical research method. Those that do are of the greatest interest to the author, primarily because field research in the social sciences is a difficult matter, is prone to inconsistencies, and is best entered by first having observed the strengths and weaknesses of earlier works. Therefore, the review below will focus on empirical research if it has been performed within the particular topic being discussed. It should also be noted that while some subjects covered below may are only tangentially to the field of product innovation in technology-based firms, they serve as a research foundation and describe important factors that coexist with new product strategy in the domain of technological entrepreneurship.
1. Corporate Strategy

1.1. Perspectives on Corporate Strategy

Corporate strategy has evolved along several distinct conceptual paths. Encompassing all these perspectives however, is the the end result of corporate strategy which as Ansoff (1965) notes, "is deceptively simple; a combination of product and markets is selected, arrived at by the addition of new product-markets, divestment from some old ones, and expansion of the present position (into new product-markets" (p. 14). Corporate strategy is a specific type of decision-making. Simon (1960) established the groundwork for assessing decision-making in an organizational context. He constructed a model of the decision process consisting of four components. The first phase of this model is the perception of a decision-making need or opportunity. This is then followed by the formulation of alternative courses of action. These action alternatives must then be evaluated, followed by a choice of one or more actions made for implementation.

Taking a different tack from that of Simon, Cyert and March (1963) set aside the monolithic view of the organization and suggested that strategic policy is the result of a negotiated consensus among individual power brokers within the firm. Another approach to strategy was adopted by Lorange and Vancil (1977), who examined strategy-making as a formal system and identified three stages in the process of strategic planning: a) business planning (objective setting at the corporate level); b) functional planning (product-marketing and production planning at the divisional level); and c) sales forecasting combined with budgeting (within divisions). Thompson (1967) developed yet another perspective on strategy by focusing on the interrelationships between the firm and its external competitive and social environments. The firm's
"domain" or business territory continually evolves through specific interdependencies. These include the relationships between the firm and the technology affecting its products, the firm and its customer population, and the firm's competition, all of which comprise its "domain". Thompson approached strategy as a social scientist, and his interest was primarily in the area of the interactions between the different players existing in a business organization and elements of its competitive environment.

Other strategy research has a more direct bearing on the study of new product strategy. These include the work of Ansoff (1965), Abell and Hammond (1979), Abell (1980), and Porter (1980). Their collective theme is that business opportunities may be assessed through a process of market segmentation and analysis, and that the firm differentiates its products and services in response to competitive environments. Ansoff argued that strategic decision-making is unique and that that traditional capital investment theory is inadequate for determining growth policies. Similar to Simon, Ansoff proposed a method for planning that views strategy as the result of: a) setting corporate objectives, both economic and social; b) estimating the "gap" between the firm's current position and objectives; c) identifying possible alternative actions and 4) selecting a course of action based on its "gap-reducing" potential. Additionally, he identified key elements of strategy. One component is the firm's "product-market scope", being the markets in which its products and services will compete. A second component is the firm's "growth vector", which consists of the technical and marketing domains in which the firm wishes to expand. Competitive advantage, achieved through technical superiority, marketing, or patent protection, is a third component. Lastly, Ansoff proposed that the mutually reinforcing aspects of different functional areas of the firm are an important element in strategic decision-making. This was termed "synergy". Using these concepts, Ansoff sought to explain why firms might diversify into new
product markets as opposed to expanding activities in existing ones.

Methods for strategic market planning have also been extensively developed. Abell and Hammond (1979) define three dimensions to defining business activities, being a) the types of customers served by the firm’s products and services, b) the functional needs of these customers, and c) the technologies embodied in products and services. Abell (1980) extended the application of these three dimensions of strategy by offering more specific guidelines for market boundary definition and developing typologies of strategy. A firm may differentiate its products in two ways, being first to modify its product offerings for its current customer base (adding new functionality), and second, to bring its technologies (same functionality) to new sets of customers. He called the first type of differentiation a strategy of "extension". "Systemization" was used to refer to the second type of differentiation, where new user functions are addressed within existing customer groups. Lastly, Abell called substantial change in the technology vector (with little change in customer groups or functions) "technological substitution". This is delivery of similar functional capability to existing customers through a new base of technology.

Porter (1980) has more fully explored strategy in the context of product differentiation in response to competition. He has developed methods for segmenting markets and performing analysis of those segments to assess the attractiveness of potential business opportunities. Five key factors that affect the attractiveness of a new business opportunity were identified as:

1. the existence and strength of present competitors,
2. the probability of new competitors,
3. the probability that new substitute technologies will emerge for products in the market,

4. the overall demand and the degree of pressure for product change by buyers, and

5. pressure of various forms from suppliers.

Davis and Smith (1984) extended Porter's competitive analysis to the application of market strategy and communications programs to the new, technological enterprise. Most recently, Roberts and Berry (1985) presented a framework for selecting new business opportunities that uses matrix of degrees of the firm's "familiarity" along two dimensions, being technology and markets relevant to the venture, and associate less familiarity with higher degrees of risk.

1.2. Strategy and Structure

The research into the organizational aspects of strategy is significant to the present research primarily for methodological reasons. It provides a method for observing a class of activities taken by the firm over extended of periods of time and for using these observations to confirm research hypotheses. Chandler's *Strategy and Structure*, is the most important work in this area (1962). Our method for measuring the new product strategy of technology-based firms, which essentially tracks product flows within companies along specific criteria, originated from the reading of Chandler's research. By studying the development of seventy large American companies over a period of their growth of approximately twenty years, he supported the hypothesis that organizational structure follows strategy. Chandler showed that as organizations change their strategy to both better utilize resources and to respond to changing competitive
environments, organizational structures evolve in a concurrent fashion. Thus, the optimal design for any given company at a particular point in time is contingent upon the tasks that it must achieve and the external environment in which the firm competes. This finding was extended by Galbraith (1973).

Chandler’s method was to trace the evolution of businesses along the two dimensions of strategy and organizational structure, for which he developed two simple taxonomies. His classification of strategy had four elements:

1. "volume expansion", for a single main product line;
2. "geographic expansion", of a single product line;
3. "vertical integration", where components and processes formerly acquired from external organization are brought inside the firm; and
4. "product diversification", which is the extension of current business activities into new technologies and markets.

Chandler viewed these four strategies groups as related to one another over time, where each leads to the next in a sequential fashion. This strategy taxonomy continues to be a foundation for considering corporate development, and has been refined and extended in subsequent research (Salter 1970, Scott 1971, Stopford 1968, Rumelt 1973, Galbraith and Nathanson 1978).

The next step in Chandler’s method was to correlate patterns of organization design with the four stages of growth. He found that single product line companies tend to pursue a functional organization where product development, sales, and services activities are maintained as separate entities within the organization. As corporate strategy evolves towards greater diversity in products and markets, organization design
also shifts to a "product" or "business" structure. In contrast to the functional design, various disciplines are grouped together into divisional business units. Chandler's explanation for this shift in organization structure is that new mechanisms are required to handle the increased complexity involved in diversification. It has also been observed that while the primary focus of functional organization is the improvement of the technology in existing products, the multi-divisional structure provides the institutionalization of a generic "search" process (Galbraith and Nathanson 1978). This search process is the identification and development of new product-market areas, a process that is essential for a company that chooses to diversify extensively.

Following Chandler's lead, Rumelt (1972) provided another important empirical study of corporate strategy. Rumelt proposed a strategy taxonomy that included a single product line company, a "dominant" product line strategy, a "related" diversified strategy, and lastly, a "unrelated" or highly diversified strategy. Within these groups are a variety of subsets that depend upon degrees of familiarity in product technologies and markets, a concept that is extensively utilized in our research framework. Using another sample of 100 large corporations, Rumelt basically confirmed Chandler's finding that large corporations have evolved from single-product line strategies into higher levels of product diversification and that organization design shifts with these new strategies.

The leading research in the area of organization design and task integration is that of Lawrence and Lorsch (1969) who developed the concept of "contingency". They suggest that both strategy and organization structure are widely influenced by the industrial environment facing the firm. Additionally, just as the "fit" between strategy and structure was asserted by Chandler, Lawrence and Lorsch
proposed a similar pairing between organization design and the competitive environment. Their data showed that high performing companies in stable industries have centralized structures and control mechanisms. In contrast to the stable environment, the high performers in unstable environments, typified by rapidly changing product technologies and strong competition, chose management and departmental structures that were decentralized. Task management has been studied further by Galbraith (1973, 1977), who explored alternative management processes in the context of the tradeoffs between centralized control structures and decentralized organization. He has also proposed integration mechanisms such as the "matrix" reporting structure, that may accommodate localized decision-making while maintaining the necessary information flows required by corporate headquarters.

In summary, the empirical strategy research, while focusing primarily on the linkage between strategy and organization design, provides several relevant lessons. The first is that effective research models may be developed to track the historical activities of a firm. Secondly, strategy is closely related to other key elements within the corporate body, and cannot be viewed in isolation from them. Any hypothesized "best" strategy cannot, by itself, directly lead to economic success. A policy of business diversification, and the new products or services that emerge from it, may result in a wide range of outcomes due to the variation in the ways that a firm organizes itself, manages tasks, and positions its technology against competitors.
1.3. The Role of Technology in Strategy

Technology has been more recently perceived as a key element of strategy. Nonetheless, as stated by Madique and Patch (1978), "Technology is a vital force in the competitive environment of the modern firm. This is especially true in technology intensive industries ... yet, even in these industries, technology is rarely an explicit element of corporate strategy. It is ... a missing link." (p.273)

One aspect of technology that has received considerable attention is technological forecasting. Martino (1969) describes the most common forecasting methods which include intuitive forecasting from technology experts, consensus or "Delphi" methods that were originally developed by the Rand Corporation, and trend extrapolation. Fusfeld (1970) created the concept of the "technological progress function" by employing case studies from the airplane, automotive and computer software industries. In addition to different forms of curve-fitting and projection forecasts, there are also qualitative methods of forecasting, two of which are described by Wheelwright and Makridakis (1980): "S-curves", which are projections of the longevity of particular technologies, and morphological research, which attempts to predict events in one technology by examining historical events that have occurred in other, similar technologies. A qualitative method that monitors technological opportunities by looking for "signals" or key events that may affect materials supply or announce the emergence of substitute technologies was presented by Utterback and Brown (1972). In all these works, the relationship between technological forecasting and the strategic decision-making processes has been implicitly assumed and not directly linked with diversification and new product actions taken by the firm.
Technology development has been directly related to strategy in several research models. The most interesting of these is that of Utterback and Abernathy (1975), who distinguished product innovation from process innovation and posit that each type of innovation assumes different rates of change over the life cycle of a product. In earlier phases of a product life cycle, product innovation is high. Similarly, process innovation is relatively low because the product's design is not yet fully stabilized. As the life cycle matures, product design does become stable and this allows large improvements in production methods that achieve cost reductions. The Utterback and Abernathy model is shown in Figure 2.1. Their characterization of innovation as a dynamic, changing process was tested with data collected from another study (Myers and Marquis 1967). A primary strategic implication of the model is that a firm should guard against investing too heavily in process innovation when a product is relatively young.
"Technology profiling" is a more recent concept for evaluating the firm's technological position. It is adopted from profiling of business portfolios developed by Henderson (1973) and his colleagues at the Boston Consulting Group. Technology profiling was first used by Fusfeld (1979), and later by Petrov (1983). Petrov argued that a firm can assess the viability of its total technological effort by first identifying the distinct "technology units" underlying its products. Then, the firm can determine both the relative competitive position and the attractiveness of each technology unit. His measure for relative technological position is the cumulative R&D and capital
expenditure. Regarding attractiveness, Petrov proposed two related measures: the growth of applications based on the technology, and the rate of change in the technology itself. While there is no indication of how to operationalize either of these measurements, the concept of the technology portfolio suggests several important issues in technology strategy. These include the determination of distinct technologies embodied in a company's products and the source of technology, being either internal or external to the firm. It also suggests that the evolution of technologies be tracked over time along key dimensions.

Typologies of technology strategy have also been developed in the literature. Maidique and Patch (1978), for example, posit a set of factors within technology planning. These include alternative technologies, levels of competence within particular technologies, sources of technology, competitive timing, and organizational research and development policies. These key factors are then illustrated by Maidique and Patch in the context of four basic strategies that are 1) a first to market strategy, 2) second to market or the "fast follower" strategy, 3) cost minimization or late to market, and 4) market segmentation or a niche player strategy. Martin (1978) also described alternative "technology strategies". However, these works emphasize their own "checklists" of possible strategies patterns, based on case studies, and generally fail to make solid conceptual links between dimensions of technology strategy and the strategy patterns that are then proposed.

Technology strategy is also a matter of resource allocation in the firm. In this light, Ketteringham and White (1982) examined the issue of technology investment by first positing three types of generic product technology: "key" technology (the firm's proprietary, competitive technology), "base" technology (widely available product
components), and "pacing" technology (immature technologies that are potential substitutes for existing key technology. They suggest that research and development funding should be balanced among these three types of technology projects, and specifically, that management must actively investigate emerging, pacing technologies that may substantially alter the firm's competitive environment. Roberts and Frohman (1978) also stated that the total R&D investment may be viewed as a balanced portfolio of alternative projects that includes long-term projects for basic research, middle-term projects that are major product enhancements, and short-term projects representing product customizations.

Most recently, Porter (1985) extended his competitive analysis of business environments in an interesting discussion of the implications of technology for the firm's competitive advantage. First making the general criticism that companies often innovate for scientific interest rather than for direct business advantage, Porter argues that investment decisions should be based on the contributions of the technology to the organization's "value chain". A value chain of a technology may extend well beyond specific commercial products; it can include, for example, production methods for a range of products, internal systems of management, and the overall synergy between a series of products. A technology can have a beneficial impact on the firm's competitive advantage by either changing the firm's cost position for a set of products or differentiating products from those of competitors. New technology can also offer "first to market" benefits, although Cooper (1979) and Abell and Hammond (1979) have showed that pioneering new markets does not always lead to success. In a field lacking conceptual models for evaluating technology strategy, Porter's perspective of technology and competitive advantage is refreshing and may have substantial influence in the future.

New Product Strategy
Concluding this review of technology strategy research is the empirical work of Old (1982) and his colleagues at Arthur D. Little. Old investigated the benefits of investment in technology. His data, which was gathered for a twenty year period for major firms in the chemicals and pharmaceutical industries, showed that investments in technology correlated favorably with gains in operating income, with a the correlation coefficient of 85%. Old’s definition of technology investment includes both product R&D and investments in plant and equipment. It is unfortunate that the same tests were not performed for each area separately so as to differentiate product from process innovation. Figure 2.2 presents data collected a portion of Old’s results. Old also suggested that corporate planning should be augmented with regular "technology audits" that monitor technology investments and performance outcomes.
Figure 2.2
The Economic Return Of Investment In Technology
Old's Research

Exhibit II Total investment in pharmaceutical technology, 1959-1972 vs. increase in operating income, 1959-1960 minus 1977-1978

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Merck</td>
<td></td>
<td>600 $ mllns</td>
</tr>
<tr>
<td>Eli Lilly</td>
<td></td>
<td>500 $ mllns</td>
</tr>
<tr>
<td>Smith Kline</td>
<td></td>
<td>400 $ mllns</td>
</tr>
<tr>
<td>Upjohn</td>
<td></td>
<td>300 $ mllns</td>
</tr>
<tr>
<td>Richardson-Merrell</td>
<td></td>
<td>200 $ mllns</td>
</tr>
<tr>
<td>Rohm &amp; Haas</td>
<td></td>
<td>100 $ mllns</td>
</tr>
<tr>
<td>Syntex</td>
<td></td>
<td>0 $ mllns</td>
</tr>
</tbody>
</table>

Investment in R&D, plus capital expenditures, 1959-1968 in $ mllns

Exhibit III Total investment in chemical technology, 1959-1972 vs. increase in operating income, 1959-1960 vs. 1977-1978

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Du Pont</td>
<td></td>
<td>1200 $ mllns</td>
</tr>
<tr>
<td>Monsanto</td>
<td></td>
<td>1000 $ mllns</td>
</tr>
<tr>
<td>Union Carbide</td>
<td></td>
<td>800 $ mllns</td>
</tr>
<tr>
<td>Grace</td>
<td></td>
<td>600 $ mllns</td>
</tr>
<tr>
<td>Celanese</td>
<td></td>
<td>400 $ mllns</td>
</tr>
<tr>
<td>American Cyanamid</td>
<td></td>
<td>200 $ mllns</td>
</tr>
<tr>
<td>Hercules</td>
<td></td>
<td>0 $ mllns</td>
</tr>
</tbody>
</table>

Investment in R&D, plus capital expenditures, 1959-1968 in $ mllns
2. Innovation Research

2.1. Innovation Factors

The empirical research on innovation has concentrated on factors relating to successful innovation and the innovation process itself.\(^1\) A widely cited work in this area is Myers and Marquis' (1969) study of the origination of the designs for industrial products and the sources of information for research and development. Examining 567 successful innovations in five industry clusters, Myers and Marquis gathered data from 121 companies. They divided the innovation process into two stages, the first being idea generation and the second, problem solving or idea implementation. Their main finding for the first area was that three quarters of the innovations originated from a specific market demand, as opposed to the recognition of a technological opportunity. In the domain of problem-solving, they observed the importance of technical and scientific information for successful product development. Thus, while technical information was deemed relatively unimportant for idea conception, Myers and Marquis found it crucial for effective idea implementation. Clearly, the validity of this result relies heavily on a determination of when idea "conception" stops and "implementation" begins for a given product.

Langrish et al. (1972) subsequently conducted research that did not support the primacy of "demand-pull" versus "technology-push" in product innovation. In a study of 84 highly successful British innovations, they found that a synthesis between

---

\(^1\) For an excellent analysis and criticism of the findings and research methodologies of numerous empirical studies on innovation see D. Mowery and N. Rosenberg (1979).
the recognition of a market opportunity and technological ability was necessary for effective industrial innovation. Carter and Williams (1957) also studied a sample of 152 British companies in their search for the motivation behind product innovations. They were able to identify a broad range of motivational factors that include market potential, improving the quality of existing product lines, cost reduction and, interestingly, to be recognized as an innovator by peers and customers.

The SAPPHO project (Rothwell et al. 1974) added an important aspect to innovation research: the comparison of successful innovations with unsuccessful ones. The sample was comprised of 43 pairs of innovations in the scientific instruments and chemicals industries, and the commercial success of these projects was analyzed along 24 variables. Their analysis revealed five factors that most significantly distinguished successes from failures. Successful innovations showed a better understanding of user's needs and allocated more resources to marketing activities than failures. In the area of communications, the role of obtaining targeted technical information from external sources was also associated with successful product development. Lastly, the data indicated the importance of "sponsors" that promote innovations as well as efficient project management.

The literature has also separated basic from applied research and development (Allen 1977). Most notable among these studies is Project HINDSIGHT (Sherwin and Isenson 1967). Hindsight investigated the long term effects of Defense Department funding of basic research for twenty weapons systems that were eventually developed and were viewed as "applied" research and development. By tracking the subsequent application of 710 "research events" from funded university research to these weapons, it was concluded that relatively untargeted scientific research had important
contributions to applied work occurring later in time. In a similar vein, the Traces (1968) study observed the contributions of basic research to the product development activities the five major commercial innovations.

2.2. Information Sources for Effective Innovation

Several of the studies described above employed the sources of information for idea generation and problem solving as a research variable. The effectiveness of different types of information sources for research and development has been the primary focus of the work of Utterback (1974), Allen (1978), Allen, Tushman and Lee (1979), and Allen, Lee and Tushman (1980). Utterback gathered data for a sample of 32 scientific instruments innovations, and used the moment of the funding of the project as the delimiter between idea generation and problem-solving. He found that external inputs of information were the dominant source of communication prior to the funding point, e.g. for idea generation. Product originators frequently collected both market and technical information from colleagues and other sources outside their companies. After the point of funding, internal communications assumed a primary role in problem solving. As with many of the studies described above, Utterback’s sample was comprised of only successful innovations.

In research generally noted for its methodological discipline, Allen (1977) observed information flows in thirty-three pairs of aerospace development projects, a sample design that permitted performance comparisons between members of the pairs. Allen measured the usage by project members of different types of communication channels and sources of information. These included face-to-face communications both
internal and external to the organization, technical literature, and information obtained from vendors and suppliers. He proved the importance of external communications for particular types of engineering activity, and called those individuals who serve as conduits for external information "gatekeepers". For short-term problem solving, face-to-face communications inside the laboratory was found to be the most effective and most widely used information source. Subsequent research also confirmed Utterback's observation that external communications was suited only to particular types of work, being "research" activity, and that it could be detrimental in more targeted development type activities (Allen et al. 1979). In further research, Allen investigated the design of R&D laboratories, quantifying the probability of two individuals speaking with one another, in the event that one needed to solve a specific problem and the other could provide assistance, with the physical distance separating the two persons. His conclusion is sobering: after approximately ten meters, the probability of such communications occurring plummets.

2.3. Organizing Product Development

The work of Lawrence and Lorsch (1967), Lorsch and Allen (1973), and Galbraith (1973, 1977) have all addressed organization design. A more specific discussion of organization design in the context of research and development management may be found in Pelz and Andrews (1966), Andrews and Farris (1967), and Allen (1977). There are two basic requirements in development environments: first, efficient technical implementation, and second, multi-disciplinary integration, including the combination of marketing information with technical development. Allen, for example, in finding that the first requirement of technical task completion is best
attained through face-to-face communications between engineers who work in similar disciplines, supports a functional organization design. On the other hand, integration may be best achieved through "project" organization where individuals from different disciplines are grouped together so as to more effectively exchange information. In noting this, Allen offered the insight that the best design depends on the duration of the development effort and the degree of change occurring in the basic technological area. Product development in unstable, difficult technological areas, where the engineering staff focuses on a problem for more than several years, should probably be functionally organized to assure the face-to-face communications necessary for technical excellence. Shorter term, minor improvement projects, where customizations are dictated by new user requirements or competitive actions, are candidates for project organization.

These observations are also supported by Katz's (1980) research on project longevity and the effectiveness of work groups. Galbraith (1973) discusses a hybrid organization structure, long used in the aerospace industry, called "matrix organization" which integrates both technical and multidisciplinary requirements but at the same time maintains functional integrity. An applied perspective on the organization of large technical projects is provided by Brooks (1975), who managed several monolithic IBM mainframe operating systems projects. Brooks highlights the problems associated with of adding additional manpower in the effort to quicken development time and cites the difficulty of maintaining communications in large projects.
2.4. The Locus of Innovation

Another important aspect of innovation research are studies determining the locus or originating point of innovations. These include studies of chemical industries (Meadows 1969, Berger 1975, Boyden 1976), scientific instrumentation (Utterback 1974, Von Hippel 1976), and process innovations as used in production facilities (Von Hippel 1977, Lionetta 1977). The objective of these studies has generally been to categorize instances where innovations are originated by "users", as opposed to the final "manufacturer" or vendor of innovations. This research shows that user innovation is a significant phenomenon. In a theory called "the appropriability of benefit", Von Hippel (1979) hypothesized that users will innovate when the economic benefit of the resulting innovation is greater for them than for the ultimate sellers of the innovation. Process innovations have been good candidates for this theory since it clear that incremental process improvements can reduce the costs of each item made by a manufacturing "user".

2.5. Entrepreneurship

The entrepreneurship research is diverse. Roberts (1989), in a study of approximately two hundred technology-based firms that were "spin-offs" from M.I.T, found a number of general characteristics of entrepreneurs. He found a strong entrepreneurial heritage, where over half of the founders came from families where the father was self-employed. Roberts also observed high levels of education among entrepreneurs, with an average being a graduate degree in engineering. The founders in the Roberts sample were also relatively young, the average age being 32. Following
McClelland's (1961) research on entrepreneurial motivation, Roberts examined both positive and negative motivations for starting companies, and found that the entrepreneurs have a high need to achieve. Lastly, the entrepreneurs tended to have technical backgrounds that stressed applied engineering rather than basic research.

Factors of success in technological entrepreneurship were also found by Roberts. These factors, which focus on a well-balanced, organized management team, are:

1. Successful firms were founded by a team of individuals rather than a single person.
2. A formal marketing program was correlated with success in contrast to opportunistic marketing where founders handle sales in a random fashion.
3. A broad range of skills in the founding group, particularly management skills, is important for successful venturing.
4. There is a significant degree of technology transfer from the founders' former places of employment to the new company.
5. Successful entrepreneurs view personnel issues high on their management agenda.

The issues raised by Roberts have been the subject of other research. Wainer and Rubin (1969) found that a high need for achievement and a moderate need for power were positively correlated with performance in entrepreneurial ventures. In the area of educational background, Litvak and Maule (1971) and Cooper (1973) supported Roberts' observation of high levels of education among technological entrepreneurs. The role of prior business experience has been shown to be important for successful start-ups by Mayer and Goldstein (1961), Cole (1965), Cooper (1970) and Lamont (1972), and Cooper and Bruno (1977).
The theory that small firms are more productive innovators than larger organizations has also been investigated. For example, the relationship between the size of the firm and its innovative capability was the subject of study by Sherer (1970) and Boswell (1973). Birch (1969) provided a statistical portrait of small business activity. In addition to the Roberts (1969) study described above, which looked at Boston area companies, the geographic clustering aspect of entrepreneurship has been discussed by Cooper (1971) whose sample was comprised of Silicon Valley firms. Utterback et al. (1982) examined a broad range of innovation factors for two localized samples, the first being technology-based companies in Sweden, and the second, firms in the Route 128 Boston area. Following the issue of the linkages between entrepreneurs and universities that was raised by Roberts' (1968) sample, Shapero (1972) noted the importance of proximity to major research universities for the start up of new technology-based firms.

2.6. New Product Success Factors

There has been little research that specifically targets new product strategy. A noteworthy exception is a series of studies of Canadian firms by Cooper (1975, 1979, 1984a, 1984b). Cooper (1975) employed factor analysis on data gathered for 102 "successes" and 93 "failures" from 103 Canadian industrial firms to identify key factors for successful new product development. While there was no hard definition of the criteria for a "success" or "failure", interviewees were asked to include only "clear-cut" instances of one of each case in their responses. Data were collected for 77 variables, and factor analysis was employed to consolidate these variables into 18 dimensions. Using the simple "success" and "failure" rankings for each product case, Cooper then identified those factors that were most highly correlated with successful
new product introduction. The results of the discriminant analysis are shown in Figure 2.4. The three factors that were most strongly associated with successful products were:

1. Product Uniqueness and Superiority

2. Market Knowledge and Marketing Proficiency

3. Technical and Production Synergy

Figure 2.4
Significant Product Innovation Factors
Discriminant Analysis Results From Cooper

<table>
<thead>
<tr>
<th>Factor</th>
<th>Factor Name*</th>
<th>Standardized Function Coefficients</th>
<th>Wilks' Lambda</th>
<th>F To Enter or Remove</th>
</tr>
</thead>
<tbody>
<tr>
<td>F4</td>
<td>Product Uniqueness/Superiority</td>
<td>0.527</td>
<td>0.859</td>
<td>31.66</td>
</tr>
<tr>
<td>F2</td>
<td>Market Knowledge and Marketing Proficiency</td>
<td>0.465</td>
<td>0.730</td>
<td>33.95</td>
</tr>
<tr>
<td>F1</td>
<td>Technical/Production Synergy and Proficiency</td>
<td>0.325</td>
<td>0.680</td>
<td>14.13</td>
</tr>
<tr>
<td>F14</td>
<td>Market Dynamism (Frequency of New Product Introductions)</td>
<td>-0.264</td>
<td>0.644</td>
<td>10.65</td>
</tr>
<tr>
<td>F8</td>
<td>Market Need, Growth, and Size</td>
<td>0.271</td>
<td>0.610</td>
<td>10.49</td>
</tr>
<tr>
<td>F15</td>
<td>Relative Price of Product</td>
<td>-0.252</td>
<td>0.576</td>
<td>10.62</td>
</tr>
<tr>
<td>F6</td>
<td>Marketing and Managerial Synergy</td>
<td>0.193</td>
<td>0.557</td>
<td>6.49</td>
</tr>
<tr>
<td>F5</td>
<td>Marketing Competitiveness and Customer Satisfaction</td>
<td>-0.186</td>
<td>0.540</td>
<td>5.88</td>
</tr>
<tr>
<td>F3</td>
<td>Newness to the Firm</td>
<td>-0.170</td>
<td>0.526</td>
<td>4.93</td>
</tr>
<tr>
<td>F9</td>
<td>Strength of Marketing Communications and Launch Effort</td>
<td>0.137</td>
<td>0.517</td>
<td>3.24</td>
</tr>
<tr>
<td>F18</td>
<td>Source of Idea/Investment Magnitude</td>
<td>0.114</td>
<td>0.510</td>
<td>2.27</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group Centroids:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successes: 0.666 (N = 102)</td>
</tr>
<tr>
<td>Failures: -0.731 (N = 93)</td>
</tr>
</tbody>
</table>

*In order of inclusion in the discriminant solution.
*Significant at the 0.001 level.

Cooper's definition what constitutes Product Uniqueness and Superiority is broad: it includes a high degree of technological innovativeness, providing new functionality to users, and exhibiting a degree of reliability and longevity not found in competitive
products. Included in the second factor are the incorporation of market research into product development, effective communications programs to reach potential users, and strong distribution programs. The third success factor concerns the efficiency of the firm's technical and production departments. Gerlach and Wainwright (1968) also described two success factors similar to Cooper, and additionally, found that internal product championing and adequate funding were important to new product success. Factors significantly associated with failure concerned market conditions. The data showed that highly-priced products (relative to the competition) were prone to failure. Similarly, products competing in markets noted for a rapid degree of change and new product introductions also were common failures. Lastly, products introduced into market where customers were already "satisfied" by existing products were highly correlated with failure.

A fact that cannot be overlooked in Cooper's work is that the research was entered without a conceptual framework to guide the data collection. Lacking a new product strategy "model", Cooper collected data for a vast number of variables and relied on a statistical technique to consolidate the data to obtain more concise results. This approach differs from that taken by Chandler (1962) or Allen (1977), for example, who developed models to attack their research topics and then gathered a specific set of data to test their hypotheses. Another element of Cooper work is that it looks at single product cases rather than all products made by the firm. This seems an insufficient basis for evaluating "new product strategy", which is the accumulation of all the products made by the firm, and not the result of specific instances of success or failure. In more recent work, Cooper (1984a, 1984b) asked company managers through an extensive questionnaire to define their companies' overall product strategy and then correlated strategy groupings with various measures of company performance.
Another element of product strategy research is the process of new product planning. Urban and Hauser (1982) and Greenley (1984) proposed planning methods, where the introduction of a new product is the culmination of a sequential process of need identification, product prototyping and development, market communications, test marketing, and distribution planning. Similarly, Wind (1973) and Donath (1984) presented tools for screening new product ideas, known as "concept test models". However, the variables employed in these screening methods, and the relative weighting of the variables, are subjective in nature and have no empirical backing. This was noted by Shocker et al. (1969) in their critique of industrial product concept tests. Detailed market structure analysis has also been used by Urban, Johnson and Brudnick (1979), and Pessemier and Root (1979) as a basis for new product planning. The latter, for example, described a method whereby market segments were specified on the basis of consumer brand preferences. Pessemier and Root then tested the attractiveness of product attributes and produced perceptual maps by multi-dimensional scaling. The results of this technique were then used to position new products in the marketplace. While a combination of screening and market structure analysis tools may be generally useful for new product planning, empirical studies supporting their utility in technology intensive industries are not available.
3. A Summary of the Innovation Research

The innovation literature offers a number of examples of well-conducted field research, and has addressed a host of specific issues that are relevant to technological entrepreneurship. These perspectives include the sources of idea generation, the information best employed to solve technical problems, and entrepreneurship itself. However, it can be noted that many of the studies treat innovations in isolation from other product events that have historically occurred in the respondent organization.

New product strategy is the relationship between product innovations in the firm. A number of examples in the literature reviewed above have taken the approach of building a conceptual model that examines research variables in a historical context of some time deemed appropriate for the research. In turn, this modeling of the research topic has allowed the gathering of data to focus on a specific set of issues, the result being that the research results assume a clarity and strength not found in "shotgun" methodologies. The work of Chandler and Rumelt in the strategy and structure field, of Allen in communications, and of Roberts in entrepreneurship are all examples of targeted research. These and similar works provide the agenda for the remainder of this document. In the next chapter, we will build a framework that views new product events in the context of past products, a model that will serve as the basis for hypothesis generation and will dictate the specific types of data required to validate those hypotheses.
Chapter 3

THE CONCEPTUAL FRAMEWORK
Chapter 3

THE CONCEPTUAL FRAMEWORK

1. Introduction

New product decision-making in the technology-based enterprise addresses four basic issues:

1. what are the basic needs or user functions that the firm will satisfy with its products and services,

2. what are the groups of customers that share these needs or functional requirements and to whom products and services will be sold,

3. what technology will be used to build the products or deliver the services, and what is the source of that technology,

4. and, what distribution mechanisms will be employed to bring successfully developed products to the marketplace.

The answers to these issues are time specific and take greater meaning when compared to the actions previously taken by the firm relative to these issues. Further, these questions may be modeled as a composite of two key dimensions which in turn yield a framework for hypothesis generation.
The first key dimension of new product strategy is the technology embodied in products. Embodied technology is itself a combination of distinct sets of skills and techniques that achieve a physical manifestation in any given product. Behind a technology are two types of complementary skills. The first group of skills are those of product design, the architecture and specifications that deliver a defined functionality. The second group are implementation skills which translate product designs into working products. Both types of skills are highly interrelated. Functional specifications and designs, for example, may often be modified to facilitate the physical implementation of technology, to incorporate particular component technologies, or to facilitate certain production efficiencies.

The second key dimension of new product strategy is the market application of the product. The market application is comprised of two basic factors: first, the intended functionality of a product from the user’s perspective, and second, the customer groups to which the product is marketed. Product functionality is the basic use, or set of uses for a given product. Similarly, customer groups may be distinguished as customer "niches" or "segments" within a given market.

While new product strategy always involves new "products", it does not necessarily entail new technology or new market applications between successive products. Many product innovations in technology intensive industries are incremental in nature, consisting of minor improvements to technologies that already exist within the firm. These improvements are often upgrades of current products and add new members to an established product line. In such cases, the consequences in economic, resource allocation, and business development parameters may be estimated with a high level of confidence by management. Development personnel, already skilled in the basic
technology of the product line, can predict the time and resources required to meet the new specifications. However, when the proposed new product requires the development of new technologies that have not been employed in earlier products made by the firm, the implications of the innovation decision are not as clear. The greater the degree of newness entailed in the development of technologies for the new product, the greater the uncertainty.

Actions emerging from strategic decisions regarding for what purpose, to whom, and methods for selling new products have a similar range in the degree of change and risk. New products sold to existing customer sets are familiar territory for decision-making. Existing sales programs can be extended and the service requirements for the product are generally known from prior experience. The specification of product features to meet user needs can also be generated with a high level of confidence. However, as soon as the firm extends its product strategy to new groups of customers or to cover new basic functionality, decision-making assumes a level of uncertainty, commensurate with the degree of difference between the new market applications and those of earlier products.

A product represents a particular level of change or "newness" along both dimensions of new product strategy. Each dimension, technology and market applications respectively, may be viewed as a vector containing distinct levels of change based on the comparison of successive products. This approach to new product strategy in technology-based firms therefore employs a historical basis for assessment. The challenge is to build a framework that provides this historical context in specific terms. These terms are the technological content of the current product versus the technology in past products, and the market applications of current products versus past products.
In the discussion below, the units of analysis for identifying newness in each key dimension of new product strategy will be defined and illustrated with examples, the result being that we will be equipped with a framework to evaluate the new product efforts of the firms in the research sample and compare their strategies.

2. Technology Strategy

The basis of determining newness in technology dimension is the technology "content" of the respective products of a firm, evaluated in the context of its earlier product developments. The degree of similarity between the technological content of different products spans a continuum; some products may be outgrowths of existing technological capabilities, while others represent major departures from previous technical accomplishments. It is important to note that even when a product is the beginning of a new product line, it may not exhibit greater technological change than other products that are extensions of existing product lines. In other words, formal product line demarcations can potentially be misleading and do not always indicate substantial comparative technological newness. Technology-based companies often enhance existing product designs with new technology that may equal or surpass technology development for new product lines. Fusfeld (1978) has also observed the problem of products, and by extension product lines, as the basic unit of analysis for evaluating technology strategy because technological functions or skills may cross formal product line boundaries. Similarly, Ansoff (1980) states that "the danger is that business definition may be perceived as a choice of products on one hand and of markets on the other. In reality the product should be considered simply as a physical
manifestation of the application of a technology for a specific customer group. The choice is one of technologies, functions, and customers to serve, not of products to offer. The product is the result of such choices, not an independent decision that results in such choices”.

The research literature provides models that have attempted to define orthogonal measures for technological change or newness. Johnson and Jones (1957), for example, developed a framework that is shown in Figure 3.1 and which contains levels of technological newness to evaluate a company’s products.
As seen in that Figure, imposed on top of their model is a series of generic strategy patterns that are based on the underlying dimensions of technological and market newness, where combinations of degrees of change in each respective dimension yield particular strategies. In the technological dimension, Johnson and Jones identify three levels of change: "existing technology", "improved technology", and "new technology". The first level of technological newness comprises the absence of or marginal improvement to a technology already developed by the firm. The second level is a
substantial improvement to an existing technology. Presumably the third level, "new" technology, encompasses higher degrees of technical change.

A problem with the Johnson and Jones model is that it makes no distinction between the development of technologies for products that are essentially "related" to past research and development in the firm and those that are largely widely unrelated. Rumelt (1973) found that this distinction was important and used the terms "linked" and "unlinked" within his typology of strategy to embrace it. Clearly, undertaking a new product effort that entails engineering in technological areas outside the company's know-how may be far more difficult and risky than efforts where engineers already possess a base of skills and techniques. Day's (1975) strategy model, shown in Figure 3.2, also distinguishes related new product technologies from those that are unrelated.
Ketteringham and White (1982) provide a more precise unit of analysis that can be used to more identify levels of technological change. As mentioned in the previous chapter, Ketteringham and White posited several generic types of technology embodied in products: technology that contributes to the firm’s competitive advantage, and technology which is not proprietary and which is also available to competitors. The first type of technology is called a key core technology. It is defined as the firm’s proprietary set of skills and techniques embodied in its products and which give
products some level of distinctive functionality in the marketplace. The latter type of technology is a *base technology*. Base technologies are the auxiliary components integrated into the firm's products, and are commonly available to the firm from widely known external sources. The products of technology-based organizations typically consist of multiple base technologies that are integrated within the firm's proprietary product design and supplement specific parts of the product that stem from the key technologies developed internally by the company.

An example of the distinction between key and base technology in the technology-based firm may be found in the products of computer manufacturers. Among such companies, the key technology is often embodied in the the specific design or architecture of their computers. This design dictates the distinctive functionality that the product will offer. The key technology is manifest in the "layout" of the internal boards, the accommodation of processing units and communication ports, and the low-level systems programming for interfacing to peripheral devices. Many of the parts used to build computers are components purchased from chip and peripheral manufacturers, and these are the base technologies of the final product. Others are proprietary key technology, an example of which might be a proprietary operating system sold with the computer, that are engineered internally.

Using Ketteringham and White's concepts, the primary unit of analysis for the technology dimension for this research framework is *core technology*. It is defined as the unique set of skills and implementation techniques developed by the firm that are translated into operational products. Levels of change in the technological dimension can now be proposed under the premise that each assessment of a new product is dynamic, based on all the past technology development by the firm in its earlier
products. The first level of change occurs when the technology embodied in a new product is the result of a minor improvement to an existing core technology. The second level of technological change is major enhancement to an existing core technology. The difference between these first two levels is a matter of degree, where the latter is often (but not always) distinguished by a comparatively substantial commitment of resources by the organization. Major enhancements often have a major impact on the evolution of the firm’s product portfolio.

While a major enhancement effort may result in the initiation of a new product line, it also may be used to extend existing ones with a new "generation" of products. In technology-based firms, a major enhancement often occurs when engineers propose and then implement a redesign of an existing product. Typically this redesign takes advantage of new component or base technologies that can be integrated with the firm’s proprietary technology. A product redesign may also lead to new production processes. Substantial product redesign may also lead to improved production processes. Minor improvements, on the other hand, can be efforts as marginal as repackaging existing technology. Alternatively, a minor improvement can be a comparatively simple customization of an existing product to address requests received from customers for additional features, the result of which is released as a "new" product. Minor improvements can also include the correction of known problems. Software companies, for example, commonly release upgraded versions of their software that are a combination of "bug fixes" and new incremental functionality.

The third level of technological change is when a product requires the implementation of a new core technology that is "related" to existing core technologies in the firm. Among the research described above, Rumelt, Johnson and Jones, and Day
all conceived "relatedness" in the sense that distinct technologies are "closer" to each other in content than others. Our usage of the term is specific: a new core technology is related to an existing core technology if it is mechanically combined with the existing technology in an operational, commercially released product. However, if the product contains core technology that is novel to the firm and is not combined with core technology used in earlier products, then the core technology of the new product is "unrelated" and the product represents the fourth and highest level of technological change.

To accurately measure which of the four levels of technological change a new product contains, clearly those aspects of a product that are engineered internally must be distinguished from those that are acquired or licensed from other vendors. This and other issues regarding the collection and evaluation of product data are discussed in Chapter 5. Figure 3.3 illustrates the four levels of newness in the technological dimension with several brief examples.1

1. These examples are abstracted from data gathered in the course of this research.
## Figure 3.3
Levels of Technological Change
Illustrated With Examples

<table>
<thead>
<tr>
<th>Level of Change</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Improvement</td>
<td>Having made a 80 column dot-matrix, a firm develops a 132 column printer.</td>
</tr>
<tr>
<td>Major Enhancement</td>
<td>A firm that has made alpha-numeric terminals makes a high resolution graphics terminal.</td>
</tr>
<tr>
<td>Related New Core Technology</td>
<td>A firm that makes operating systems software develops a database system for use with its operating system.</td>
</tr>
<tr>
<td>Unrelated New Core Technology</td>
<td>Having made a high resolution graphics terminal for scientific use, a firm develops a graphics tablet tailored for CAD systems</td>
</tr>
</tbody>
</table>

A firm that shows low or moderate levels of technological newness across its products obviously concentrates on a single internal core technology. Low levels of change in this dimension however, do not necessarily equate with overall technological stagnation. In fact, to remain competitive in a single technological field may require equal if not greater amounts of research and development than venturing into new and different core technologies, particularly in product markets noted for complex, rapidly changing technologies. Therefore, technological focus may indicate considerable aggressiveness in engineering efforts, wherein management chooses to push its chosen key technology into new application frontiers.
The author conducted a pilot study, gathering data from a sample of convenience of ten firms engaged in computer-related businesses to test elements of the framework presented in this chapter. (Meyer 1982, Meyer and Roberts 1985) The frequencies of technological change observed in that study show that the levels of newness significantly captured new product events. The third level of change applied in a number of cases where a new core technology was developed internally and integrated with the firm’s existing technology. In even fewer cases, products represented the highest level of newness where the firm ventured into technological areas that did not employ or leverage upon its earlier technology. In many instances of major enhancement efforts new varieties of components were bought from other companies and were integrated into “a next generation” design of an existing product. Lastly, as might be expected, minor improvements had the greatest frequency, exhibiting a combination of problem fixing and incremental new functionality.

Upon a review of the data, three generic technology strategy patterns emerged. The description and illustration of these strategies with cases extracted from the pilot study show how the four levels of technological change become manifest in real product development histories.

The first technology strategy pattern, the focused technology strategy, is a continuous concentration by the firm on a single key core technology. The firm’s historical product flow is highlighted by several milestone technical developments that are major enhancements. Each milestone is consolidated and augmented by a series of minor improvements that result in new products. Restating the observation made above, a focused technology strategy does not necessarily mean that the firm shies away from an aggressive research and development program. Rather, it opts to forgo product
opportunities that require the development of new core technology.

The technology strategy pattern is illustrated in the sample by a manufacturer of high-speed line printers. Its products are distributed by a number of large computer companies for use in large volume data processing facilities. Starting in the late 1960s, the firm used a "drum" printing head in its first printer. This printing head technology had already been developed by other companies. In the mid-1970s, however, the firm was among the first printer manufacturers to develop a "linked-chain" printing head. This new implementation, which constituted a major enhancement in the firm's core technology area, offered greater reliability and speed to end-users. This enhancement was followed by a number of minor improvements to the technology which generated several new versions of the printer that had different speeds and costs. Then, in the early 1980s, management undertook a second major project to implement "band" printing heads. This technology reduces the mechanical complexity and size of line printers, but the firm has had to work hard to overcome the inherently weaker construction of a welded band, as opposed to a string of "linked chains". The first model of the band printer was again followed by a many minor improvements, generating a range of price-performance alternatives in the new product family. The affable president of this company summarized his research and development policy in this way: "I tell my guys that if they want to make anything else other than the world's fastest, most reliable chain and band printers, this just isn't the place for them." At the time of this writing, the firm has undertaken the development of a new, related core technology, being the development of a nonimpact laser printer. Most of the component technology for the laser printer, including the laser engine, is purchased from Japanese vendors and has been integrated within the firm's proprietary printer design.
An *evolving* technology strategy is the second pattern indicated by the pilot study data. This strategy is highlighted by instances of the third level of technological change, which is the implementation of new, related key technologies. A product that embodies this degree of technological change often provides the opportunity to leverage existing technological know-how into promising market areas by combining it with a newly developed technology. The result is a new product line. In other situations, the third level of technological change represents a strategy of backward integration, where critical components previously purchased from vendors are replaced by those of the firm's own creation.

A case that illustrates an evolving technology strategy is a company that has specialized in portable terminals. These terminals have been used by organizations that have large field salesforces where individuals must enter customer information and orders remotely from a customer's site. The firm steadily improved its terminal line by incorporating new communications protocols and user interfaces, which were major enhancements and refinements as described above. At one point, however, management chose to diversify by building a portable microcomputer with its own operating system and software development tools. This project required the design of complete computer architecture which included a built-in printer. While the systems and applications software were licensed from external software vendors, the design of the computer and the peripheral interfacing technology developed internally.

The third technology strategy pattern in the pilot study data is an *unfocused* technology strategy. This occurs when a firm embarks on one or more new product efforts where new *core* technologies are developed that are not combined with previous company technology. There may be several motivations for an unfocused technology
strategy. One is that of corporate survival. A company may see a technological area as its first product effort that fails, for a large number of potential reasons, and rather than cease business activities, management tries a radically different product market. An example is provided by a firm that initially implemented a cable television network for a particular municipality. The failure of this effort forced the company into temporary bankruptcy. Today, the same company has achieved financial stability as a leading supplier of plastic card scanners that are used by systems integrators to control access to bank Automated Teller facilities, data processing shops, and residential complexes.

An unfocused technology strategy may also be the result of an engineering-oriented management that seeks new "hills to climb" and has the resources from earlier successes to fund the endeavor. For example, a pilot study firm, founded by MIT professors known for their research in image scanning technologies, has consistently shown a high level of technical diversity. Its first major product line was optical character recognition machines, based on laser scanning techniques developed by the professors in their university laboratories. These OCR products are still used in the newspaper industry to digitize text that is received on paper media. The firm's second product line represented new, related core technology development. The founders had experimented in the area of manipulating graphics images read into computers through laser scanning. This research was the basis for the development of a computer-based camera and composition system designed for the newspaper industry. The new core technology of the product, embodied in the image processing algorithms, was combined with the firm's previous laser-scanning technology. However, a third product line contained unrelated, new core technology. This was a multi-user text composition system used for editing and formatting of text in newspaper companies. The new core
technology of this product was the applications software, developed by recently hired software engineers, and was not combined with either the laser scanning or image processing technologies.

It was also found in the pilot study that the interviewees, who were either presidents of relatively small technology-based firms or engineering directors, quickly understood the concepts of core and base technologies and were able to effectively participate in determining the levels of change for their respective products.

3. The Market Applications Dimension

As noted in the last chapter, a theme that spans much of corporate strategy literature is that new business opportunities may be identified and evaluated through a process of market segmentation and analysis of user requirements and competition within segments. In the pilot study, this approach served as the basis for determining the levels of market applications change. A method for segmenting the sample firms' markets was extracted from the consumer products oriented research of Urban, Johnson, and Brudnick (1979), who modeled markets as hierarchical trees containing multiple level branches. The levels of the tree are defined by analysis of the type and effects of product usage and the general characteristics of users. The significance of each branch of the market tree was established by Urban et al. by measuring the probability of purchase under "forced choice" polling of consumers.

As applied to the research, the market tree was limited to three levels: the lowest level being the market niche; the next level, market segments; and the highest
level, the general market. Accordingly, four levels of market newness were proposed. The first level is a new product that is sold to existing customers; the second, when the market application for a product is a new niche; the third, the market application is a new segment; and the fourth, when a product takes the firm into a new general market. Thus, when a new product is marketed to a new element of the firm’s market tree(s), or creates a new general market for the firm, commensurate levels of change in the market applications dimension are indicated.

It was found however that this model for market applications newness had several basic limitations when applied to field research. Two limitations were pragmatic in nature. First, experience showed that it can be difficult to differentiate a new segment from a new niche, particularly in relatively immature, rapidly growing markets. A second limitation is that unlike the levels of change in the technological dimension, this framework for market applications presented a level of abstraction and lack of specificity that, upon occasion, was elusive to interviewees.

A third limitation of the market applications model is conceptual. In the definition of market tree segmentation, two distinct aspects of the market applications for new products, being the customer groups and basic functionality or use of the product, are grouped together. It is a nonorthogonal grouping because different customer groups may share identical functionalities. The bills we receive from both our lawyers and accountants, for example, can be generated on computer products that have equivalent functionality but are marketed to different customer groups. It seemed more appropriate to treat these two factors as different parameters and gather data for them separately. Additionally, the importance to new product strategy of the firm’s selection of distribution channels for its respective products, a factor also ignored by the model,
was also highly apparent in the pilot study interviewing. Instances of this occurred when a new product contained the same user functionality and targeted the same customer groups as in earlier products, but was channeled through entirely new distribution mechanisms. In turn, the new channels can significantly changed the nature of the firm’s market applications strategy. A simple hypothetical example is a minicomputer product targeted for scientific applications. This laboratory tool is first sold to technically experienced systems integrators who supply the system to end-users. The minicomputer product might then be upgraded for sale directly to end-user laboratories. In all likelihood, this will substantially change the firm’s marketing programs, the nature of its product documentation, and its support programs.

In short, the initial market applications framework was revised for this research because experience showed that entrepreneurs tend to view the market applications of their products in terms of specific end-user customer groups, basic product functionality, and methods for selling and servicing the product, rather than as a set of branches within a market tree. This redefinition of the market applications dimension is also supported by the marketing strategy literature. As described in the previous chapter, Abell (1980) used customer groups and product usage as two vectors for evaluating business opportunities. Our market applications framework thus has three parameters. The first of these, *product functionality*, is defined as the general set of customer needs that a product, or class of products, satisfy. It can be clearly distinguished from the technology embodied in products: functionality is the goal of a product whereas technology is the tool for delivering that functionality. The same functionality may be delivered by different technologies, perhaps by a process of technological substitution. Conversely, a single technology or group of technologies may be extended to different sets of functionality. A product will address a new user
functionality when the basic needs that it satisfies are different than needs addressed by earlier products in the firm.

In the second parameter, *end-user customer groups*, identification of the customers of successive products is the criterion for measuring change. Unlike the initial framework for market applications described above, all new customer groups are treated equally and there is no differentiation for relatedness as in niches versus market segments. The benefit of the present approach is that it removes the ambiguity of trying to pinpoint different levels of market boundaries in rapidly changing markets. However, a number of factors are considered in the process of differentiating customer groups. Industrial classification codes, common organizational environments, and levels of user experience level are criteria employed by firms to segment markets into customer groups. Abell and Hammond (1979) suggest additional factors: "Customers may differ also in their needs for information, reassurance, technical support, service ... and a host of other "non-product" benefits that are part of their purchase" (p.48)

The distinction between user functionality and customer groups can be illustrated further with a hypothetical example of a software company. The company makes a database package. The defined purpose or user functionality of the database system is software development, e.g. the building of end-user applications programs using the database as a tool. Management targets two types of software developers: those who work in large corporations, and make applications for other employees in their organizations, and software developers who make an applications package and sell it to other companies. An example of the first customer group is a computer department in bank that makes a portfolio management system for use by investment account managers who work for the bank. An example of the second customer group is
a software company that makes a project management system and sells the package to users who require that software. While the database system is used to facilitate software development in both cases, the two customer groups are substantially different, and will probably expect different pricing programs and support services. Further, each customer group may have to be reached through different distribution channels and advertising programs.

The third parameter of the market applications dimension is change in distribution channels. Debord (1984) investigated strategies for establishing distribution networks, and specifically, the development and maintenance of dealer channels. The selection of channel mechanism by the technology-based firm encompasses a number of decision criteria. These include the appropriateness of the product for a given channel (e.g. in the case of sales intermediaries, has the reseller shown success selling similar types of products), cost structures or margins that are sacrificed to resellers, support requirements for end-users or resellers, and the lead times required to effectively implement sales through a channel. A taxonomy of distribution channels for technology-based firms is as follows:

A. Direct Sales

B. Original Equipment Manufacturer Reselling

C. Non-Manufacturing Value Added Resellers

D. Non-Manufacturing, Non-Value Added Resellers

E. Mail order

_in the first category, direct sales, a product is sold by the firm's own sales force directly to product end-users. The company typically assumes responsibility for
customer support which may include training, and equipment maintenance, and
sometimes the integration of the product with other vendors' products that are required
by the end-user. The second channel, known as the "OEM" channel, is frequently
employed by technology-based firms. Micro-processors, software packages, terminals,
printers, peripheral storage devices, and even entire computer systems are commonly
distributed through large manufacturers for integration within the manufacturer's own
product line. Convergent Technologies, a California company that makes Motorola
68000-based computers, distributes its products exclusively through OEMs. Burroughs
and AT&T, for example, private label two of Convergent's products, "the Tower" and
the "7300" respectively. In the third channel of non-manufacturing, value-added
resellers (VAR), the firm distributes its products through systems integrators that
specialize in particular vertical market niches. VARs bring together a number of
different components, only one of which is the firm's product, and tailor these
components to provide complete or "turnkey" systems to end-users. Electronic Data
Systems (now a subsidiary of General Motors) is an example of a large VAR that has
combined and customized outside vendors' software and peripherals with its own
software packages for application to IBM mainframe environments. It has successfully
penetrated market niches that include insurance, banking, and government agencies.
The fourth distribution channel, non-manufacturing, non-value added resellers, consists
of distributors that do not add value and offer lower levels of support to end-users than
in the previous channels. Distributors sell a range of products from different suppliers.
In the area of low-end computer products, the microcomputer store is an example of this
type of reseller. Independent sales representatives are a component of this channel of
distribution. Lastly, the firm may decide to undertake mail order distribution by
advertising in publications read by their customers or by direct mail campaigns.
"Direct
mail” is different than "direct sales" within this typology of distribution channels because each requires a different type of organizational activity.

The adoption of any one of the five channels identified above does not preclude the use of any other channel. Similarly, as firms grow, they may shift channels or add new channels of distribution to those employed for earlier products. An example of shifting distribution channels is Lotus Development Corporation, a Cambridge software company. Starting with the development of a microcomputer version of a popular graphics and statistics package used at M.I.T., the founder of the firm developed a graphics package that was compatible with the popular Visicalc "spreadsheet" package. The graphics package was sold as an OEM product through Apple Computer. Then, the firm developed an integrated system, combining its graphics software with its own "spreadsheet" and simple text editing software, 1-2-3 product. A distribution agreement was signed with a large non-value added reseller that brought the product to hundreds of retail computer outlets. With additional financing, Lotus expanded its market and captured the margins previously sacrificed to distributors by creating its own direct linkages to retail stores. Finally, direct selling to large corporate accounts has also used more recently by the firm.

Using these parameters of user functions, customer groups, and distribution channels, a matrix for the measurement market applications change can be constructed and is shown in Figure 3.4.
## Figure 3.4
Levels of Change in the Market Applications Dimension

<table>
<thead>
<tr>
<th>Level</th>
<th>Customer Groups</th>
<th>Usage Functionality</th>
<th>Distribution Channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Same</td>
<td>Same</td>
<td>Same</td>
</tr>
<tr>
<td>2</td>
<td>A New Group</td>
<td>Same</td>
<td>Same</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>A New Function</td>
<td>Same</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>Same</td>
<td>A New Channel</td>
</tr>
<tr>
<td>3</td>
<td>A New Group</td>
<td>A New Function</td>
<td>Same</td>
</tr>
<tr>
<td></td>
<td>A New Group</td>
<td>Same</td>
<td>A New Channel</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>A New Function</td>
<td>A New Channel</td>
</tr>
<tr>
<td>4</td>
<td>A New Group</td>
<td>A New Function</td>
<td>A New Channel</td>
</tr>
</tbody>
</table>

The first level of change is no change, e.g., when all three parameters remain unchanged from previous products. If one of any of the three parameters changes, either a new user functionality, a new customer group, or the adoption of a new channel, the product is measured as containing the second level of market applications change. Similarly, if any two of the three parameters change with the release of the new product, the third level of change is reached. Lastly, if all three parameters change, the new product contains the fourth and highest level of market applications newness.
As with the technology dimension, patterns of market applications strategy were identified in data from the pilot study against the framework presented in Figure 3.4. The first of these patterns is a *focused* market applications strategy which is the pursuit of a single product/market area with stable channel selection. The firm’s products offer solutions for the same set of problems, are applied to a single set of customers, and are sold in one basic fashion for the life of the company. The high-speed line printer company described in the technology section illustrates this strategy pattern. The firm has always sold its printers, designed for high speed data processing facilities, through OEMs.

The second pattern in the market applications dimension is the *leveraged* market applications strategy. Firms that fit into this category have released one or more products that address different customer groups, typically sharing the same basic functional need. Existing distribution channels are often to reach the new customer groups. "Leveraged" products that are sold to different yet related customer groups also tend to be based on a single key technology which is customized to specific niche requirements. The case of the access control systems vendor described in the technology strategy section above illustrates this strategy pattern. Its magnetic-strip card readers can be found in banks (for restricting access to Automated Teller Machines), the computer facilities of large corporation, and residential complexes. In more recent product offerings, the company has developed a set of applications software for "time-in, time-out" management, selling turnkey systems where dozens of its card readers may be attached to a microcomputer. Its direct sales channel has also been enhanced to include sales representatives who cover particular geographic areas and vertical markets.

The third and last strategy pattern in the market dimension is a *diversified*
market applications strategy. This strategy is distinguished by products that contain changes in all three parameters in the market dimension. Illustrating this strategy is a small company from the pilot study that initially developed calibration machines for the production of magnetic tape storage devices. These production testing machines were sold to large computer manufacturers. Finding the growth potential of this market limited, the firm then developed its own read/write heads for tape machines, sold as components to its manufacturing customer base. This product addressed a new user functionality. A third product line was subsequently developed that was unrelated to prior activities. The firm tried to enter the microcomputer business. A proprietary operating system was developed to run on a popular microcomputer. In a following product release, the firm also developed small business applications software. These software packages entailed major changes in the firm's earlier user functionality, its customer groups, and in its channels of distribution, where the direct sales used for its calibration devices and magnetic heads were abandoned for office systems dealers and computer retail stores.

4. A Product Innovation Model for the Technology-Based Firm

The two dimensions of change in new product strategy may be presented as a single model shown in Figure 3.5. This will be referred to as the Product Innovation Model in subsequent discussion. The use of the term "Innovation" reflects the perspective that innovative activities within the realm of new product strategy are not confined only to technology development, but rather, encompass the components of two distinct dimensions, being the technology embodied in products and their market
A firm's historical product portfolio can be plotted on the grid, where each product is measured along both the technological and market applications dimensions for its respective level of change compared to the product developed before it. There are four generic labels of strategy characterization placed on the grid, representative of "average" levels of combined technological and market applications newness for a firm's entire product sequence. The Highly Constrained pattern is one where the firm chooses
to perform only minor enhancements to a single core technology and sells its products to a particular market niche for one usage and with an unchanging sales mechanism. The Focused pattern is characterized by major enhancements for technological activity that are leveraged into products for several or more customer groups. The firm aggressively employs new component technologies to provide new levels of functionality to its users. The third pattern, called "Mixed", may be described as a new product strategy where the firm has ventured into new product areas by developing new core technology and integrating it with existing core technology. New functionality, different customer groups, and different distribution channels are encountered in such efforts. Other firms in this strategy group may also be companies that have tried various product development efforts before settling down into a more focused strategy. Lastly, the Unfocused strategy represents wide diversity along both dimensions in the firm's product sequence.

The product strategy grid can also be used to provide a "snapshot" or portrait of the firm product activities at any point in time. Figures 3.6, 3.7, 3.8, and 3.9 respectively show product sequence "portraits" for four companies from whom data was gathered in the present study. Figure 3.6 is an example a microcomputer graphics company whose new product strategy has been "Highly Constrained"; Figure 3.7 shows a very successful printer manufacturer that had adopted a "Focused" strategy; Figure 3.8 presents the products of another software company that has specialized in operating systems and applications development tools; and lastly, Figure 3.9 contains the product sequence of a firm that has made text editing composition systems for small newspaper companies, graphics terminals, and graphics input tablets. This last firm has been highly "Unfocused" in its new product strategy. Each figure shows an increasing level of diversity in new product strategy. Although not fully pursued in this research,
snapshots of company portfolios may be compared, in a manner illustrated in the following pages, searching for specific, isolated patterns and obtaining feedback from company managers regarding the placement of major successes and failures on the grid. When employed in this fashion, the grid can be a useful tool for managers to evaluate the implications of new product development proposals for the firm’s historical progression in the two dimensions of new product strategy.
Figure 3.6
An Example of A Highly Constrained Strategy
A Graphics Software Company: Case 21

CORE TECHNOLOGY

New, -
Unrelated

New, -
Related

Major
Enhancement - 3

Minor
Improvement - 5 4 2

-------------------------------------------
Level1 Level2 Level3 Level4

MARKET APPLICATIONS

Product Sequence Description

1 Technology: 3 - Presentation graphics package: none really existed for micro's
Market Appl: - Hardware OEMs; Users: business and education; Func: Graphics

2 Technology: 1 - Ported to new computer
Market Appl: 2 - New channel: distributor (for Apple); same usage and customers

3 Technology: 2 - New user interface, and hardware port
Market Appl: 1 - Same

4 Technology: 1 - Minor work for a new port
Market Appl: 1 - Same

5 Technology: 2 - New revision and ports
Market Appl: 1 - Same
Technology: 1 - New features and peripherals support
Market Appl: 1 - Same
Figure 3.7
An Example of A Focused Strategy
A Printer Manufacturer: Case 15

<table>
<thead>
<tr>
<th>CORE TECHNOLOGY</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>New, Unrelated</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New, Related</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major Enhancement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minor Improvement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>13</th>
<th>10</th>
<th>17</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8</td>
<td>12</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>6</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

---------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Level 1                        | Level 2                        | Level 3                        | Level 4                        |

MARKET APPLICATIONS

Product Sequence Description

1 Technology: 3 - Computer gambling machine
Market Appl:  - Las Vegas casinos, gambling and hotel management, direct sales

2 Technology: 3 - First dot-matrix printer; used at first with gambling machine
Market Appl: 4 - New users: minicomputer users; general purpose printing; OEMs

3 Technology: 1 - Refined first printer
Market Appl: 1 - Same

4 Technology: 2 - Redesigned printer for cost reduction
Market Appl: 1 - Same

5 Technology: 1 - Refined previous model
Market Appl: 1 - Same
Technology: 2 - Higher breed, matrix line printer (two printing heads)
Market Appl: 1 - Same

Technology: 2 - Acquired a high breed line printer and enhanced it
Market Appl: 2 - Same applications; new channel of independent sales reps.

Technology: 2 - New generation of dot matrix printers
Market Appl: 1 - Same

Technology: 1 - Refined dot-matrix, very low cost version
Market Appl: 2 - New users: first dot matrix for personal computer owners

Technology: 2 - Major redesign of desktop dot-matrix printer
Market Appl: 1 - Same applications, still OEM and reps

Technology: 1 - Quick upgrade to smaller, less expensive dot-matrix printer
Market Appl: 1 - Same: only OEMs, microcomputer usage

Technology: 2 - New desktop version Num 10 with faster and paper handling.
Market Appl: 1 - Same

Technology: 2 - Added color capability to dot-matrix line
Market Appl: 2 - New basic function: color graphics presentation printing

Technology: 1 - Refinements and repackaging of desktop line
Market Appl: 1 - Same

Technology: 1 - Acquired and refined very low cost printer
Market Appl: 1 - Same

Technology: 1 - Acquired another, even cheaper printer and refined it
Market Appl: 1 - Same

Technology: 2 - A band line printer: a new key technology, but acquired and enhanced.
Market Appl: 2 - New users: DP shops, still OEMs.

Technology: 1 - Paper handler and sheet feeder; peripheral technology development
Market Appl: 1 - Sold with existing printers
**Figure 3.8**
An Example of A Mixed Strategy
A UNIX Software Company: Case 26

**CORE TECHNOLOGY**

<table>
<thead>
<tr>
<th>New, Unrelated</th>
</tr>
</thead>
<tbody>
<tr>
<td>New, Related</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Major Enhancement</td>
</tr>
<tr>
<td>Minor Improvement</td>
</tr>
</tbody>
</table>

---

**MARKET APPLICATIONS**

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>9</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
</tbody>
</table>

**Product Sequence Description**

1. Technology: 2 - Unix Operating System, PDP-11 with real time data acquisition extensions
   Market Appl: - Scientists, academics; general UNIX usage and experiments; direct sales

2. Technology: 2 - Major enhancement, with upgrade Version 7 UNIX
   Market Appl: 2 - New users: first commercial Users

3. Technology: 2 - First UNIX port to Intel 8088 architecture
   Market Appl: 3 - New users; microcomputer market; new channel: distributors; still for software development

4. Technology: 1 - Licensed an existing database system, ported it to own UNIX
   Market Appl: 1 - Same; birth of integrated UNIX applications concept
5  Technology: 2 - Licensed a word processor and ported it to UNIX
Market Appl: 2 - New usage: end-user text editing; same customers and channels

6  Technology: 2 - New release of UNIX for PC's, major bug fixing
Market Appl: 1 - Same

7  Technology: 1 - Implemented Kanjii language shell to UNIX
Market Appl: 3 - New users: software developers in Japanese market; new channel: Japanese subsidiary

8  Technology: 2 - Licensed another DBMS, major recoding and new features
Market Appl: 2 - New Users: target DBMS software niche; mainly direct sales

9  Technology: 2 - UNIX OS ported to DEC microcomputers
Market Appl: 2 - New channel: large OEM agreement

10 Technology: 3 - Developed spreadsheet and graphics, (new core technologies), to DBMS
Market Appl: 1 - Same
Figure 3.9
An Example of An Unfocused Strategy
A Newspaper Composition Systems Company: Case 10

CORE TECHNOLOGY

New,            -            3
Unrelated

New,            -            9
Related

Major Enhancement - 2 6 4

Minor Improvement - 7 5 8

-------------------------------------|----------------|
Level 1       Level 2       Level 3       Level 4

MARKET APPLICATIONS

Product Sequence Description

1 Technology: 3 - High resolution graphics terminal; among the first
Market Appl:  - Academic users; graphics; direct Sales

2 Technology: 2 - Major upgrade of terminal
Market Appl:  1 - Same

3 Technology: 4 - Graphics tablet
Market Appl:  4 - For CAD workstations; engineers as users; OEM CAD company

4 Technology: 2 - Text editor (software and z-80 computer), new core techs but licensed and enhanced
Market Appl:  4 - New Usage, editing; new customers, offices; new channel
- new sales force

5 Technology: 1 - Upgrade of text editor - multi-user version
Market Appl:  2 - New usage: multi-user editing
Technology: 2 - Implemented new 16-bit chip set in editor, purchased from National Semiconductor
Market Appl: 2 - New channel: OEM

Technology: 1 - New version of 16-bit editing station
Market Appl: 1 - Same

Technology: 1 - Minor revision of software - newspaper text composition
Market Appl: 4 - New usage: newspaper copy; new customers: newspapers; new sales channels

Technology: 2 - Add composition applications software
Market Appl: 3 - New users: publishing niche; new channel: graphics supply houses

Technology: 2 - Developed wire service package
Market Appl: 2 - New usage: wire service for newspapers

Technology: 2 - Developed communications package
Market Appl: 2 - New usage: intercomputer telecommunications

Technology: 1 - Developed classified ads package
Market Appl: 2 - New usage for advertising function

Having developed a framework for assessing new product strategy, we can now investigate the significance of strategy. This significance is defined in terms of the relationship between levels of change for both the technology and market applications dimensions and measures of the company performance. The primary research goal is to identify particular strategy patterns that correlate with strong performance. To accomplish this end, a set of hypotheses regarding new product strategy and performance will be developed in the next chapter, Chapter 4, and in the one following it, Chapter 5, the methods for gathering and analyzing the needed data will be described.
Chapter 4

RESEARCH HYPOTHESES
Chapter 4

RESEARCH HYPOTHESES

1. Strategic Focus

1.1. The Hypothesis

The main hypothesis of this research is that technology-based firms that exhibit "focus" in their new product strategies will tend to show stronger performance that firms whose strategies are less focused. Strategic focus can be measured by two elements. The first element is the focal point of a company's new product strategy. It is based on the four levels of changes of each of the two dimensions of technology and market applications. These levels of change or newness, as defined in the research framework developed in the last chapter, employ certain key parameters. In the technological dimension, the degree of change uses the concept of the core technology, and depends on the levels of improvement to a core technology and the relatedness between different core technologies. In the market dimension, the key parameters are the functionality, the customer groups, and the channels of distribution. The focal point

---

1. The author is indebted to the participation of Professor Edward Roberts in developing a number of the concepts presented in this chapter.
of product strategy measures the cumulative average newness for all the firm's products. It can be derived for each dimension separately or for the two dimensions combined, as shown in the Equation Set 1.

**Equation Set 1**

**Focal Point Calculations**

\[
FP(T) = \frac{\sum_{i=2}^{N} |\Delta T_p|}{N-1}
\]

\[
FP(M) = \frac{\sum_{i=2}^{N} |\Delta M_p|}{N-1}
\]

\[
FP(TM) = \frac{\sum_{i=2}^{N} |\Delta T_p \times \Delta M_p(i)|}{N-1}
\]

FP = Focal Point  
T = Technology Dimension  
M = Market Applications Dimension  
TM = Combine Technological and Market Applications  
Delta T = Level of Technological Newness  
Delta M = Level of Market Applications Newness  
N = Total Number of Products  
p = A product

Since the first product of a company firm is used only as the basis for assessing levels of change for subsequent products, the *focal point* uses as a divisor the total number of products made by the firm minus one. The combined *focal point* is the result of multiplying the two dimensions.

In previous research, the method for calculating the the combined measure was to add the technology and market newness scores for each product (Meyer 1982).
In subsequent work with Bow (1984) and Ishikawa (1985) the method for the combined score was changed to multiplication of the two dimensions. The difference between the additive and multiplicative methods for combined newness is shown in Figure 4.1. It can be seen from that Figure that the geometric area under the multiplicative method more accurately represents the combination of the two dimensions.
Figure 4.1
A Comparison of Representations Of Strategic Focus

An Additive Method For Combining Dimensions

A Multiplicative Method For Combining Dimensions
Using the multiplicative method, the continuum of possible combined newness levels for a firm is represented by a series of convex lines. Any particular level of combined newness can be achieved with an unlimited number of alternative combinations that result in the same focus score. Three of these combinations can be summarized as a) high technological newness relative to a lower market newness in the cumulative strategy; b) low technological newness relative to higher market newness; and c) relatively similar levels of newness in both dimensions.

The second element of strategy determination is the variance of a firm's new product strategy. Companies with the same mean level of newness, or focal point of strategy, may have substantially different applied strategies by virtue of the placement of individual product points around the mean focal point. This is illustrated with two hypothetical companies in Figure 4.2. The two product sequences in that Figure result in the same focal point of product strategy, but reach that end through highly dissimilar paths. One firm consistently shows moderate levels of technological and market applications change in its products; the other shows a mix of very high levels of change for some products and low levels for others.
Figure 4.2
The Importance Of Variance In New Product Strategy
Four Products For Each Firm

KEY TECHNOLOGY

<table>
<thead>
<tr>
<th>New, Unrelated</th>
<th>A1</th>
<th>A3</th>
</tr>
</thead>
<tbody>
<tr>
<td>New, Related</td>
<td></td>
<td>B1</td>
</tr>
<tr>
<td>Major Enhancement</td>
<td></td>
<td>B2</td>
</tr>
<tr>
<td>Minor Improvement</td>
<td></td>
<td>A2</td>
</tr>
</tbody>
</table>

---

Level 1 Level 2 Level 3 Level 4

MARKET APPLICATIONS

A common focal point but
Company A has high variance and Company B has low variance

The variance, as a second measure of product strategy, may be used to distinguish the two cases. It provides a measure of the consistency with which a firm pursues a given new product strategy, or in other words, adheres to the level of product diversity indicated by the focal point. Variance is defined as the average of the absolute value of the incremental change between levels of newness for successive products. For example, if a firm's third product contains a major enhancement to technology and is a level 2 in market applications newness, and the next product score is a minor enhancement and a level 3 in market newness, then the variance for that product
interval is \((1 + 1)\) or 2 for both dimensions combined. The total \textit{variance} of new product strategy is the average of the individual \textit{variances}, where the divisor is the number of products minus 1 (leaving out the first product once again). Another perspective on \textit{variance} is that it is the average arc length between product points on the grid, for example, as those shown in Figure 4.2. The equations for calculating the \textit{variance} of new product strategy are shown in Equation Set 2.

\textbf{Equation Set 2

Variance Calculation

\[ V(T) = \frac{\sum_{i=2}^{N} |\Delta T_{p_i} - \Delta T_{p_{i-1}}|}{N-1} \]

\[ V(M) = \frac{\sum_{i=2}^{N} |\Delta M_{p_i} - \Delta M_{p_{i-1}}|}{N-1} \]

\[ V(TM) = \frac{\sum_{i=2}^{N} |\Delta T_{p_i} - \Delta T_{p_{i-1}}| \times |\Delta M_{p_i} - \Delta M_{p_{i-1}}|}{N-1} \]

\(V\) = Variance

\(T\) = Technology Dimension

\(M\) = Market Applications Dimension

\(TM\) = Combine Technological and Market Applications

\(\Delta T\) = Level of Technological Newness

\(\Delta M\) = Level of Market Applications Newness

\(N\) = Total Number of Products

\(p\) = A Product

The degree of \textit{focus} of new product strategy is the combination of the \textit{focal point} and \textit{variance}, derived with the formulas in Equation Set 3. The focus measure is the \textit{focal point} multiplied by the square root of the dispersion. The reason for taking
the square root of the dispersion is that in the overall context of new product strategy, variance is not considered to be as important a factor as the focal point. Taking the square root therefore serves the purpose of weighting variance less heavily than the focal point. An alternative method for deriving strategic focus might be to add the separate measures. Multiplication has been selected, however, because it more strongly emphasizes inconsistency in product strategy and better differentiates the strategic difference between the two hypothetical cases shown in Figure 4.2. The additive method will be used, however, in the data analysis to provide sensitivity testing for this decision.

\textbf{Equation Set 3}  
*Strategic Focus Calculations*

\begin{align*}
SF(T) &= FP(T) \times \sqrt{V(T)} \\
SF(M) &= FP(M) \times \sqrt{V(M)} \\
SF(TM) &= FP(TM) \times \sqrt{V(TM)}
\end{align*}

$SF = \text{Strategic Focus}$  
$T = \text{Technological Dimension}$  
$M = \text{Market Applications Dimension}$  
$TM = \text{Combine Technological and Market Applications}$

Revisiting the strategic focus hypothesis, a high degree of focus will be indicated by a low strategic focus measure. The main hypothesis is that firms with low strategic focus scores will show stronger performance than firms with comparatively higher measures of focus. The dependent variable, being a measure of performance, will be described in the next chapter on research methods. For now, the reader can assume that "performance" will some fair measure of the firm's growth that will be based on annual sales. A graphic representation of the relationship between the focus of product
strategy and performance is shown in Figure 4.3.

Figure 4.3
The Strategic Focus Hypothesis
Strategic Focus Versus Performance

A further review of the hypothesis indicates that certain refinements to it are necessary. The limits of the hypothesis are that first, the highest possible levels of strategic focus are most strongly associated with the weak performance, and second, that the lowest possible levels of focus are most highly correlated with success. The first, outer limit to the hypothesis is congruent with the observations of the pilot study. An organization that pursues the ultimate unfocused strategy will implement for every product a new, unrelated core technology, and will target new functional uses, different customers, and distribution channels. It is difficult to imagine that any single
organization could effectively manage this diversity as well as fund it. Cooper's (1979) findings support this reasoning. The "High Budget, Diverse" product strategy pattern in his research, characterizing firms whose products have unrelated technologies and are scattered in their market orientation, contained the weakest performers.

Unlike the first outer limit, the inside limit of the focus hypothesis does not as readily withstand criticism. In the extreme focused product strategy the firm will undertake for all its products only minor improvements to a single core technology used in the first product. In the market application dimension, all products are also sold exclusively to one set of customers, for one specific function, and through a single stable channel of distribution. This is the "Highly Constrained" strategy pattern shown in the previous chapter in Figure 3.5.

There are several reasons for hypothesizing that the Highly Constrained strategy is not most highly correlated with success, and that the "Focused" strategy should assume the top position with respect to performance. In our definition of the competitive environment facing technology-based firms that was adopted from Davis and Smith (1984), the distinguishing feature of the environment is the presence of rapidly changing technologies that continuously and substantially affect competing products over time. Additionally, the technology-based business environment is subject to the frequent emergence of new markets that may represent important opportunities for growth. The technological component of this environment suggests that successful firms must keep their active product lines current with respect to new and emerging technologies. In terms of the levels of change in the technology dimension, keeping abreast with the pace of technological change translates into well-timed major enhancements to internal core technology that, at a minimum, integrate new component
technologies with the main product design to achieve higher levels of functionality.

Similarly, a company often cannot be satisfied with a single customer group for its entire products line. First, a specific customer group may be limited in size or the subject of greater competition as time progresses. Second, new markets for technology products tend to evolve into more well defined subgroups, and products targeted for the initial market undergo "differentiation" to better satisfy the requirements of the emerging market niches. Lastly, in conjunction with the evolution of existing markets segments, new markets for technologies are continually born, and may present attractive opportunities for the firm to leverage its core technology into new functional applications and customer groups.

An example of keeping pace with technological change in the competitive environment is IBM's upward migration in its personal computer product line. Beginning with the simple PC, an Intel 8088 based machine with two floppies, IBM next introduced the PC-XT, which used the same chip but included a Winchester hard disk. More recently, IBM has released the PC-AT which employs a new generation of Intel processors, the 80286. Included with this more powerful chip are new peripherals such as high density floppies and a larger, faster winchester disk. This product shows substantial technical change, and like the PC-XT before it, the PC-AT is targeted to a more experienced end-user group and a new set of functionality that requires more computer power and sophistication. IBM's microcomputer migration is not dissimilar to other microcomputer manufacturers, who have chosen increasingly powerful computer chips, peripherals and consoles for successive members of their respective product lines through a process of major enhancement. Many have also followed the progression of microcomputer usage from home or hobbyist usage to small business and networked,
corporate applications.

Therefore, a company that performs major enhancements to its product line and aggressively pursues new customers is very different from a firm that relies on a single, familiar customer set with successively repackaged and customized technology. A "Focused" versus a "Highly Constrained" strategy is also potentially more successful because the firm seeks new, but related growth opportunities. The lowest levels of combined strategic focus may reflect a lack of creativity and aggressiveness in the firm that can be hypothesized to negatively affect the performance over time. The new product strategy most favorably correlated with performance will be one that shows some levels of highly directed change in either the technology or market applications dimensions. This adjustment to the focus hypothesis is shown in Figure 4.4.
1.2. Implications of the Focus Hypothesis

The focus hypothesis suggests that extensive diversification in terms of technologies and markets will tend not to lead to favorable economic outcomes. Rosenbloom and Abernathy (1982) have stated, however, that "Since the 1950's, a penchant for diversification has lead many U.S. firms away from their technologies and markets." Several major concepts have been used to both support and guide wide-scale diversification in corporations. The most noteworthy of these methods is growth,
market share matrix analysis. A sample portfolio matrix is shown in Figure 4.5 (Henderson 1973).

**Figure 4.5**
A Company Product Portfolio Plotted On Growth Market Share Matrix

![Figure 1](image)

**Figure 1**
A Typical Product Portfolio Chart (Growth-Share Matrix) of a Comparatively Strong and Diversified Company

The premise of the matrix analysis used in portfolio analysis is that the positioning of a product with respect to market share and growth evolves predictably over time. Using the matrix analysis, the activities of the firm are first divided into "business units". Some units will be comparatively stable and cash-generating, and are suited for a "harvesting" strategy. Others will be relatively young and will require substantial cash inflows, but offer growth opportunities in terms of capturing market share. These are the "stars". Another type of business unit, the "question mark", is one that is uncertain in its ability for either market share growth or cash generation. Finally, business units that show no promise in either aspect are the "dogs", and should be divested. Using the growth share matrix, new product strategy becomes a process of recognizing where products are positioned and managing their evolution within the "portfolio" concept. A successfully diversified company will own a portfolio of businesses and products that serve different markets. The attractiveness of the matrix, and the unrelated diversification that it induces, is asserted to be risk reduction. The impact of a failure in a particular product area is theoretically offset by other businesses in the portfolio that are more successful.

The growth, market share model has the benefit of imposing a discipline of cashflow analysis of alternative businesses. Gluck (1981) also presents some of the difficulties in applying the matrix model, the foremost of which is the accurate definition of business units. Portfolio strategy, by analyzing businesses as autonomous units, may also overlook the benefits of synergy between the products and services of different business units. Another, more basic weakness of the growth, market share portfolio concept lies in its limited perspective on product diversity. Diversity is seen as "good" because it offers risk reduction. However, there are other aspects to diversity. The one that is most pertinent to the present discussion is the difficulty of implementing effective
product development and marketing for a diverse set of products or services. The maintenance of these diverse portfolios, while ignored in discussions of the growth, market share technique, is an heavy burden for management. The problem is even more acute in the technology-based competitive environment because each business area will require complex technology and perform marketing in rapidly changing markets.

The findings of the PIMS study, an ongoing survey of large American corporations, have supported the importance of market share for business strategy and its favorable relationship with performance. (Schoeffler et al. 1974) PIMS has correlated 37 distinct factors with performance in its survey sample. Its major finding is that the firm's market share and the life cycle stage of its products are significant predictors of performance which is defined as return on investment. Two additional important factors have been found to be "investment intensity", which is the firm's working and fixed capital, and the growth rate of the markets in which the company participates.\(^2\) PIMS is not without its critics, however. Lubatkin and Pitts (1983) applied a surrogate model that approximated the PIMS analysis to the brewing industry, and while finding support for the market share conclusion, also found basic inconsistencies in the PIMS model. Anderson and Paine (1978) and Leontiades (1982) have also criticized PIMS on a number of points, all of which concern the "absolute truths" that participants of the study have widely extended to business strategy at large. Specifically, PIMS does not discern its findings for their relevancy to different industrial sectors, different time

---

2. Several peripheral findings of the PIMS project are of further interest and somewhat surprising. For example, high R&D spending when market share is weak is found to hurt performance. Similarly, a rapid rate of new product introduction in fast growing markets is also negatively correlated with performance. However, these two negative variable are common phenomena in technology-based firms that enter new markets with a series of technically sophisticated products.
periods, and small businesses versus large corporations. Lubatkin and Pitts (1983) also observed significant multicollinearity, or interdependency, between the "distinct" variables that are correlated with performance through regression in the PIMS model.

The experience curve and the product life cycle are two additional concepts that have been teamed with portfolio analysis, leading to conclusions that run counter to the strategic focus hypothesis. The experience curve "has been observed in a wide range of products including automobiles, semiconductors, petrochemicals, long-distance telephone calls, synthetic fibers, airline transportation, the cost of administering life insurance ... indicating a wide range of applicability." (Abell and Hammond 1979, p. 106). The hypothesized impact of the experience curve is that with each doubling of manufacturing output, the total cost in real terms can be made to decline by a characteristic percentage. Hedley (1976) has stated that this percentage decline is in the range of of 20-30 per cent. The decline in costs with increases in production is often called the learning rate. Figure 4.6 shows the experience curve documented for four different industries by the Boston Consulting Group. Abell and Hammond (1979) attribute the experience curve effect to many factors. These include improved labor efficiency, improvement in production methods and the redesign of production towards greater work specialization. Other factors include process innovations, the substitution of components with less expensive alternatives, and product standardization are other factors forming the experience curve effect.
Figure 4.6
Evidence of the Experience Curve
For Four Industries

Steam Turbine Generators
(1946-1963)
- Westinghouse
- Allis-Chalmers
- General Electric

Integrated Circuits
(1964-1974)

Broiler Chickens (1934-1975)

Courtauld's Viscose Rayon (1930-1966)
The literature has also suggested however, that the experience curve cannot be applied blindly. For example, Abernathy and Wayne (1974) argued that the market share objective can lessen the firm's ability to respond to changing market needs. A market share product strategy is described in Abernathy and Wayne's analysis of the Ford Model T. The Model T was the first high-volume, relatively inexpensive car "for the masses". Nonetheless, Ford's large scale production lines limited the company's responsiveness to the market. When car buyer's preferences evolved towards more luxurious, full-bodied automobiles, Ford was unable to respond for a number of years. During that period, its competitors were able to respond with more appropriate automobiles. The result was that Ford's market share fell dramatically. Fruhan (1972) also documented how the market share strategy pursued by General Electric and R.C.A in their fledgling mainframe computer businesses led to unrealistic cash outlay requirements and was responsible for both firms' withdrawal from that marketplace.

Strategies that accentuate rapid movement towards large scale production may can lead to undesirable results in situations where the ability to make changes in a product's design are critical to competitive success. In technology-based environments where products are relatively "complete" solutions to users' needs, this flexibility is important because the firm often needs to adapt its products to changing user demands. On the other hand, a cost-efficiency strategy may be more appropriate in product areas where the product is primarily a component used by other manufacturers. The chips made by Intel, Motorola, and National Semiconductor that are sold to computer manufacturers are examples. Component manufacturers can benefit greatly by improving cost structures through large scale production. They may also find that their customers expect stability in the component's design because their own product engineering plans span periods of considerable time. However, it can also be argued
that lower cost structures for a given product can be generated from concentrated technical effort to improve the product's internal design and the integration of more cost effective components as easily as from larger scale production.

Lastly, the product life cycle concept has been used to support a strategy of diversified product holdings. The evolution of a firm's businesses through a series of phases on the growth, market matrix is based on the idea that products and service have life cycles. Specifically, product technologies evolve through stages that are sequential and relatively predictable. Three stages are generally identified: growth, maturity, and decline. A product technology in the first of these stages, growth, mandates a policy of increasing market share. Second, products in the maturity stage are suitable candidates for policies that concentrate on reducing production costs to increase profit margins. Product technologies in the decline phase are candidates for a strategy of "withdrawal". Carried forward into new product planning, this further suggests that the firm should not invest exclusively in a single product market area. As Day (1975) states, "eventually all product categories become saturated or threatened by substitutes, and diversification becomes essential to survival ... a company should have a mix of products in each stage of growth (p.1)".

It can be seen from the discussion above that the hypothesis of focus of product strategy argues against these concept that encourage the development of diverse technologies and markets. The focus hypothesis is itself based on the premise that successful technology-based companies must be leaders in the core technology essential in their respective product areas. Rather than allocate resources to the development of a diverse portfolio of products and pursue an unfocused product strategy, the technology-based firm must first target a technology field that offers wide possibilities
for growth and market application, and then, be able to quickly adapt this technology in response to changing market environments. The firm cannot abandon its primary core technologies based on life cycle theory unless technological substitution is imminent in its industry. In short, to excel in a product technology and by consequence in its competitive environment, the technology-based firm must develop the internal skills necessary to consistently enhance the core technology of its products and to take advantage of new component technologies. For the smaller firm, this effort will generally consume all available resources for technology development and will not permit serious venturing into diverse product areas.

Technology strategy can also contribute additional strengths to the new product strategy of the firm, being reliability or consistency in the firm’s product offerings and a customer-perceived longevity of the firm as a focused problem-solver. From the perspective of the buyers of a given product technology, the product generating firm, especially the smaller one, must be recognized as a reliable supplier of new generations of the technology. The product acquisition decision made by the customer entails a commitment to learn the systems and user interfaces contained in the product. It also entails an investment in learning and cooperating with the business practices and service mechanisms of the supplier - "intangibles" that extend beyond the respective time horizons of individual products. Therefore, the customers of a technology-based firm’s products seek a combination of short and long term benefits. On one hand, technological excellence is expected in products currently available; on the other, the supplying firm must communicate to its customers the commitment, skills,

3. The threat of technology substitution has been discussed by Utterback and Brown (1972), Cooper and Schendel (1976), and Ketteringham and White (1983).
and commercial longevity needed to inspire the confidence that the firm will be a continuous source of product solutions in the future.

2. The First Product: Business Entry Strategy

The first product has been used in an ancillary mode for measuring strategic focus, being the first contributor to the pool of technological and market experience. There is no explicit score for it, however, in determining the measure of strategic focus; rather, descriptive data are gathered for the first product concerning its core technology and market applications so as to evaluate the following products. Nonetheless, the first product can be an important event in the firm's new product strategy. If the first product is successful, it begins a product line that will typically be extended with closely related, complementary products, and contributes an element of focus to the firm's overall product strategy. If the first product fails or is only marginally successful, an element of lesser focus may be produced because management must explore different product technologies and markets to stay in business. In the pilot study, for example, there were several companies that seemed to experiment with different technology applications in their early years before settling down into a more stable product direction. In the discussion below, the first product will be separated from other products and treated as a distinct research entity.

Abell and Hammond (1979) have posited several "product entry" strategies that are useful in considering the first product issue. Their first entry strategy is called an "effectiveness" strategy. Products that reflect this strategy emphasize technical
merit and high margins. Such products compete on functionality, not price. The firm’s marketing effort is to find customers that seek the high level of functionality offered by the product and will tolerate its comparatively higher price. Abell and Hammond use the example of Hewlett Packard in the calculator industry. Hewlett Packard has consistently introduced calculators that display extensive functionality and at the same time, are more expensive than competitors’ products.

Extending the effectiveness strategy to the new, technology-based firm, a first product that emphasizes functional superiority and that is accurately targeted in its market applications offers a major benefit in addition to the short-term revenues that it may generate. The product can create significant barriers to entry for would-be competitors. First products of this nature are often sold in an opportunistic fashion, where the top management of the firm is directly involved in obtaining the first set of major accounts. The barrier to entry created by the product can then provide management with the slack time to build more formal marketing and sales mechanisms. The proclivity to adopt this type of entry strategy may also be correlated with strong technical, versus marketing, inclinations on the part of the founders.4

An "effectiveness" startup product strategy may also have substantial risk. A new company that seeks to make a "one of a kind" product may fall prey to a "technology myopia" and channel large amounts of resources into research and development without adequate market validation. This is illustrated by a company

4. For example, among Boston area firms whose founders had educational experiences at MIT and who have pursued an effectiveness entry strategy are Apollo Computer (CAD/CAM workstations), Scitex (color imaging composition systems), and Symbolics (LISP computers). Their respective products are relatively "complete" or "turnkey" systems that have high unit prices and are aimed at specialized market applications. These three firms have shown impressive growth in recent years.
from the pilot study that was a supplier of speech recognition systems. Its first product contained two core technologies made by the firm: a new proprietary operating system for Digital Equipment hardware, and complex speech recognition algorithms. The need for speech recognition to improve the man-machine interface in industrial environments seemed clear to the founders and provided the motivation to continue the development of the first product for a number of years. Yet, that product, as well as subsequent versions of it, proved difficult to install and unreliable in industrial environments. This company, with such impressive internal technology, no longer exists.

The second entry strategy posited by Abell and Hammond posit is a "cost-price efficiency" strategy. Their example, again taken from the calculator industry, is Texas Instruments. T.I. has competed on price in the calculator market. It has relied on efficient production and market share to achieve profitability. From the perspective of a new, technology-based firm, "cost-price efficiency" is synonymous with modest technological accomplishment in the first product and comparatively rapid product introduction. It primary benefit for the startup company is that customers may be obtained and nurtured for successive products more quickly than in the "effectiveness" startup product strategy. With a quick initial product introduction, the firm can turn its attention to building other aspects of the business, such as marketing and customer service, that will be essential for future success. Additionally, an early customer base can become a sounding board for subsequent product development. If management chooses, following products can show the higher level of functionality, sophistication, and price that are lacking in the first product.

A strategy of low technical sophistication relative to competing products and fast market introduction can also have negative ramifications for the firm's product
strategy and long term performance. First, the factors upon which the firm's competitive advantage may be based, such as low cost structures, service and product reliability, can be most difficult for a new, startup firm to achieve. It should be noted however, that a technology-based firm does not always have to build large scale production capabilities to achieve competitive costs. Often, new methods for designing products and the integration of new generations of components can make a relatively low volume product price competitive. A high level of customer service is also usually associated with the development of a field service team, a capability usually associated only with larger companies. However, in some technology-based industries, an important element of service is willingness on the part of the supplier to customize its products for customers. New, small firms can be more responsive than larger, established organizations.

Another less obvious but equally important potential drawback of this entry strategy is the precedent that an technically undistinctive product can set for future product development. If, as it has been hypothesized above that technological distinctiveness is critical to long term success, a firm that consistently makes "me-too" products may face an ongoing market recognition problem if it later chooses to upgrade the level of functionality offered in its new products. This will not occur however, if the firm plans for a relatively quick succession of products that are more technologically distinctive and then markets these products appropriately.

The review of these two basic startup product strategy alternatives leads to another question for the present research. Do companies that introduce first products containing high levels of technical accomplishment relative to the current state of the art tend to have better long-term performance than firms whose first products are not
technically distinctive and may rely on other factors such as price and service? To answer this question with empirical data, we require a simple framework. Analogous to the four levels of newness in the product strategy grid, the technological content of the first product may also be assessed as being either:

1. undistinctive relative to the state of the art at the time of the product's introduction;

2. distinctive by virtue of a better engineering of existing, known technology;

3. highly distinctive, where substantial improvements have been made to an existing, known technology that affect the way it is used or perceived throughout the rest of the industry; and

4. a major technological breakthrough, where novel technology is pioneered and implemented for the first product.

The hypothesis is that technology-based firms whose first products have low or moderate degrees of technical difficulty relative to the existing state of the art will be more highly correlated with success than firms with high degrees of technical difficulty in their startup product strategy. The hypothesis may be somewhat surprising because the strategic focus thesis argues that maintaining technological distinctiveness is a key to long term success. However, technical excellence does not have to achieved in the first product; it is a long-term endeavor. In fact, a new firm that attempts to accomplish an inordinate level of technical superiority in its first product may postpone the development of marketing, sales, and service activities due to a lack of financial and human resources. As Roberts (1969) observed, the most attractive type of technology-based firm is one that displays balance in its management team: strong technical skills combined with effective and experienced marketing. Further, the firm runs the risk of
performing its product research and development in a vacuum of market feedback. Therefore, it suggested that the competitive advantage of technical excellence is best achieved in a step-wise fashion, an important element of which is that the early the customers of initial products are used as a sounding board for future technological enhancements.

3. **Strategy Dimension Comparisons**

The product strategy framework also provides the opportunity to contrast levels of technological and market application newness with respect to performance. One type of comparison is that between high technological newness and low market newness on one hand, and low technological newness and high market newness on the other. The first strategy alternative occurs when the firm develops, and perhaps combines, separate core technologies in a series of products. These products either address different functional applications in the same customer set, which is rare, or more commonly, target the same functional usage across different but closely related customer groups. An example is the firm described in the previous chapter that developed an image scanner, a image composition system, and a text editing systems all for the newspaper industry. This case shows how a number of core technologies may be engineered for different functional applications that exist within a single customer group. This produces a relatively high technological newness score and low market newness.

The counterpart to that strategy is low technological newness and high market application newness. This occurs when a firm has the opportunity and ability to
leverage a single core technology across different customer groups. In this strategy pattern the user groups are substantially different, require the development of new channels of distribution, and have functional applications that may be only tangentially related. The technology scores tend to be 2 or less, whereas the market newness scores, on the introduction of several milestone products, are high.

The working hypothesis is that focus in the market applications dimension will be more highly correlated with success than focus in the market applications dimension. The strategic focus hypothesis clearly asserts that high levels of newness in either dimension are ill-advised. While it would appear difficult for a firm to implement multiple core technologies, the negative ramifications of substantial diversity in the key parameters of the market applications dimension are deemed to be greater. One basic reason for this hypothesis is that diverse market applications program will require effective coordination of numerous groups within the organization, and also perhaps, between the organization and external companies that may include geographically dispersed distributors. New technology development, on other hand, while by no means a lesser feat of the mind, may be less organizationally complex than the implementation of widely different marketing and support programs. This hypothesis can be tested with the individual strategic focus scores for technology and market applications, as defined above, compared with performance. Another approach is to observe frequencies of companies that have incidences of high technological change and all low market applications scores, and frequencies of companies having the opposite pairing. These two subsets of the sample can then be compared with respect to performance. These methods, as well as the other techniques used to test the hypotheses of this chapter, will be described more fully in the next chapter.
4. The Rate of Product Innovation

A final question for the research has been suggested by Roberts and Ishikawa (1985), who used the product strategy framework to explore "innovation intensity". This is the rate of innovation exhibited by the firm in its products. Concentrating on the technology dimension, rather than looking at the average rate of change per product (which is the focal point of technology strategy), innovation intensity examines average change per year of company existence. In terms of the Product Innovation Model, innovation intensity can be used to differentiate two companies that have similar levels of technological focus but have achieved it within different time periods. One company might have developed its products over five years for example, while a second company took ten years to accomplish the same result.

There are two measures that may be generated to examine this issue. The first, called Average Product Releases, is the average number of products commercially released per year. However, since the basis for assessing technological innovation in this research is to examine the technological content of products, and not to count the number of products themselves, a second measure may be more appropriate. This measure, which will be called Innovation Intensity, is generated by finding the average level of technological change per year for the firm. The two formulas for deriving these measures are provided in Equation Set 4.

---

5. In private communication.
Equation Set 4
Innovation Intensity

\[ \Phi = \frac{N}{\text{Age}} \frac{\sum \Delta T_p}{N} \]
\[ \Psi (T) = \frac{i=2}{\text{Age}} \]

\( \Phi = \text{Average Product Releases} \)
\( \Psi = \text{Innovation Intensity} \)
\( T = \text{Technological Dimension} \)
\( p = \text{A Product} \)
\( N = \text{Number of Products current to 1984} \)
\( \text{Age} = \text{Age of Firm current to 1984 or Last Year of Business Operations} \)

It is first hypothesized that the number of products made by a firm will have no significant relationship with performance, since it is the content of those products that is the important strategic component, and not the products in and of themselves. Second, an increasing average annual level of technological change is hypothesized to have an inverse or negative relationship with performance, and is thus a corollary hypothesis to the main thesis of strategic focus.
5. **Summary**

In this chapter, the product strategy framework developed in the previous chapter was applied to the development of research questions. These questions may be summarized as:

A. Is a focused product strategy adopted by the technology-based firm more strongly related with high performance than an unfocused strategy?

B. Do firms that seek moderate levels of technical difficulty in their first products more like achieve high performance than firms that have displayed high levels of technical accomplishment in their first products?

C. Is technical diversity in the products of the firm less favorably correlated with successful performance than high levels of market applications newness?

D. Is there any relationship between the rate of product introduction and performance, and also, is a lower level of technical change per year of firm existence more strongly associated with performance than high average rates of technical change?

The first question can be addressed through the measure proposed for strategic focus, which is a combination of the *focal point* and *variance* for both the technology and market applications dimension. A simple framework for measuring levels of technical accomplishment in first products has also been proposed to investigate the second research question. Next, for the comparison of the two dimensions with respect to performance, it has proposed that the individual strategic focus scores for technology and market applications may be used as a basis for analysis. Lastly, innovation intensity measurement employs the same approach for product newness.
information used to test the strategic focus hypothesis, but substitutes company age for the number of products in the calculation.

Just as the product strategy framework was applied for the purpose of hypothesis generation, in the next chapter it will be adapted to the collection of product data. Other important issues, such as the performance measure, the design of the research sample, and methods for analyzing both product and performance data, will also be discussed in that chapter. Any field research effort is prone to ambiguities that emerge outside the context of a highly controlled environment. We hope to show that through the design of the specific elements of the methods employed for the present research, these ambiguities have been reduced to an acceptable level.
Chapter 5

RESEARCH METHODOLOGIES
Chapter 5

RESEARCH METHODOLOGIES

1. Introduction

A methodology was developed for gathering and collecting data that was congruous with the research framework. In this chapter, the methodology is described with an emphasis on the the areas of:

1. the sample design,

2. the units of analysis for the product data collected,

3. the performance measure,

4. sources of the data,

5. the process of data collection,

6. methods for analyzing the data.

The decisions in each of these areas were made after considering alternative approaches that might have been adopted. In the following discussion, these alternatives and the reasons for rejecting them will also be described.
2. The Research Sample

The starting point for developing the sample design for the present research was the pilot study referred to in previous chapters. That research had used a sample of convenience comprised of ten small technology-based firms, none of which were direct competitors.¹ A general description of their product-related activities is that they were all involved in the manufacture of computer hardware and computer peripherals. The sample contained great diversity, including manufacturers of complete computer systems, others that built only computer peripherals, and also firms that made specialty products such as data acquisition boards. The general product areas of the pilot study firms is shown in Figure 5.1. Upon review of the pilot study, it was felt that this diversity of product activity would lessen the strength of future research results and that a new sample design was required.

---

¹ The ten firms were part of a larger study of Boston area firms described in Utterback (1982) and in which the author had participated. The ten firms had been interviewed by the author and could be easily revisited for further research. All firms in that sample were started in the ten year period between 1965 and 1975, and none had 1982 sales that exceeded 50 million dollars.
Figure 5.1
The Pilot Study Sample

<table>
<thead>
<tr>
<th>Case</th>
<th>Main Product Area</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Access Control Devices</td>
<td>3.25</td>
</tr>
<tr>
<td>2</td>
<td>IBM Plug Compatible Computers</td>
<td>17.20</td>
</tr>
<tr>
<td>3</td>
<td>Printers</td>
<td>31.07</td>
</tr>
<tr>
<td>4</td>
<td>OCR/Cameras/W.P. Systems</td>
<td>15.00</td>
</tr>
<tr>
<td>5</td>
<td>EFT Terminals</td>
<td>2.59</td>
</tr>
<tr>
<td>6</td>
<td>Speech Recognition Sys.</td>
<td>0.02</td>
</tr>
<tr>
<td>7</td>
<td>Peripheral Processors</td>
<td>9.60</td>
</tr>
<tr>
<td>8</td>
<td>Tape Calibration Devices</td>
<td>1.35</td>
</tr>
<tr>
<td>9</td>
<td>Portable Terminals</td>
<td>19.43</td>
</tr>
<tr>
<td>10</td>
<td>Small Business Computers</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Four design alternatives were considered for a new sample design. The first alternative was to gather a larger sample of firms, still maintaining product diversity but improving the statistical significance of any results found in the research. An example of the "large" sample approach is the PIMS project described in the previous chapter. It has gained the participation of more than six hundred Fortune 1000 corporations. Other studies that followed this approach are those conducted by Chandler (1982) and Rumelt (1972), whose samples contained approximately 100 corporations.

Large, highly heterogeneous samples, however, would not by themselves address the qualitative issues that were essential for the present research. Since this is a study of new product strategy in technology-based firms, it seems appropriate not to rely solely on the comparison of the strategies and performance of firms making very different types of products and participating in dissimilar competitive environments.
For example, could the strategic focus hypothesis be fairly tested by only comparing the products and performance of a biotechnology company with that of a computer manufacturer? There may be analogies in new product strategy between firms in these two industries, but basing research results on a direct comparison between their widely different products might have been misdirected. Therefore, while the differences between a set of homogeneous clusters and a single heterogeneous group of firms was not known prior to the research, the potential for such difference could not be ignored and had to be accounted for in the sample design.

The second possible sample design that was considered was a "common source" model. This design was used by Roberts (1969) in his study of the characteristics of entrepreneurs. His sample of approximately 200 firms were M.I.T. laboratories or academic departments where the founders had worked prior to their present businesses at M.I.T. or for quasi-affiliated institutions such Draper Laboratories or Lincoln Laboratories. While this design was appropriate for Roberts, it could still yield high diversity in the product development activities of a potential sample and an inappropriate basis for assessing new product strategy.

The third design alternative considered was the "paired" sample. This model was used most effectively by Allen (1978) who investigated communications and project performance within the research and development settings of twenty-seven pairs of firms that had won the same government contracts. Similarly, the SAPPHO research program employed forty-three pairs of successful and unsuccessful innovations in the

---

2. Criticisms of the "absolute truths" proposed by PIMS that have been made by Anderson and Paine (1978), Leontidades (1982), and Lubatkin and Pitts (1983), tend to focus on the problem of using heterogeneous samples.
chemicals and scientific instruments industries (Rothwell, et al 1972). The paired design provided the benefit of an identical unit of analysis for these two studies, being the project or task worked on by each member of a pair. However, given the Product Innovation Model of the present research, which is based on the combined impact of all a firm's products, this method was unsuitable. Product strategy is the result of all a firm's products. While a specific product of two separate firms could be effectively paired for analysis, it would be highly improbable to find a close matching between two firms for the entire sequence of product releases.

A sample design that addressed the issue of product diversity was a cluster model, where data would be gathered for individual groups of firms that were closely related by industrial activity. Analyses could then be performed on each cluster separately, and only then, perhaps, on the sample as a whole. This sample design alternative has ample precedent in the innovation literature. For example, Myers and Marquis' research used a sample was comprised of 564 innovations in five industries.\(^3\) Other research that has employed common industry origins for a sample is that of Utterback (1971), Berger (1975), and Von Hippel (1975, 1978). Utterback's sample contained scientific instrument innovations by Massachusetts firms that had been awarded achievement prizes by an engineering association from 1963 to 1968. Von Hippel used clustering in two studies. The first was his user innovation research for a group of of scientific instruments innovations. Later, he tested the user innovation hypothesis with a sample of semiconductor and electronic sub-assembly process

---

3. Mowery and Rosenberg (1979) have criticized this research for its lack of specificity in identifying clusters, pointing to the fact that Myers and Marquis had separate groups for the railroad industry and rail-road equipment suppliers and did not provide specific criteria for the placement of sample firms in each respective cluster.
innovations. As applied to the present research, the cluster model offered the benefit of testing new product strategy concepts against distinct pools of generic product types, or what may be called "like products". Within each group, the firms were participants in the same industrial environment and some were direct competitors. The result was that new product strategies and performance could be compared for homogeneous groups of product-makers.

Having chosen the cluster approach, the next step was to build individual clusters. The Standard Industrial Classification code scheme was first reviewed to see if it might be an appropriate basis for cluster definition. It was rejected for a lack of specificity. For example, all ten firms in the pilot study fall under the same SIC code for computer electronics products manufacturers. By examining the companies in the pilot study however, as well as the other firms in the Utterback (1982) sample, several cluster groups showed the promise of containing a sufficient number of firms. These initial clusters were 1) printer manufacturers, 2) terminal manufacturers, and 3) image processing systems suppliers. The basis for including a company in a given cluster was that its current main product or product line, at the time of the interview, was generally characterized by the cluster’s generic product description.

Our objective was to obtain at least five firms for each cluster. Fewer firms would offer comparatively meaningless results given the data analysis techniques that seemed appropriate for the research. Since no trade association or classification scheme was available that targeted these three clusters, a "snowball" technique had to be employed to identify prospective sample companies. The snowball technique was to gather prospective recruits during the course of field research, rather than enter the research from the start with predefined sample members. An initial set of interviews
was conducted with firms known from the author's experience. Interviewees were asked at the conclusion of data collection to identify their competitors or firms engaged in the same generic product area. In this way, the number of companies in the three clusters was incrementally increased.

As the interviewing progressed, the initial cluster design was modified in two ways. First, from the interviews in the terminal and image processing clusters, it became evident that some of the firms in the terminal cluster were making more complete, integrated systems targeted for special applications. These applications included the development of applications software. In particular, a common application was publishing and other photocomposition systems or subsystems. Similarly, a common application of the technology in the image processing cluster was photocomposition systems for newspapers and publishers. Thus, the image processing cluster was replaced with a cluster called "composition systems", filled with some of the firms from the original terminals cluster and appropriate firms from the image processing cluster. The image processing cluster, being no longer necessary, was dropped.

The second change made to the initial cluster design was that a fourth cluster, a group of firms engaged in the software business, was added to the sample. Specifically, this cluster was comprised of firms that produced packages for database management and other aspects of applications software development. Since all prior research had focused on "hardware" products, this cluster offered the to extend the research into a different arena.  

4 The software cluster was developed and interviewed with the participation of Jim Ishikawa (1985). The companies used in the present sample was a subset of the the companies presented in Ishikawa's masters thesis. Several of the firms in his sample were rejected for lack of appropriate financial data or did not make software products primarily for applications development.
four clusters of terminals, printers, composition systems, and software development tools, is summarized in Figure 5.2.
**Figure 5.2**  
Description of Companies in the Research Sample  
By Sample Code, Product Application and Approximate Sales*

**Terminals**

<table>
<thead>
<tr>
<th>Code</th>
<th>Product Description</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Passenger Airline Reservations Systems</td>
<td>5.00</td>
</tr>
<tr>
<td>2</td>
<td>Electronic Funds Transfer</td>
<td>3.00</td>
</tr>
<tr>
<td>3</td>
<td>CAD/CAM and Medical Imaging</td>
<td>25.70</td>
</tr>
<tr>
<td>4</td>
<td>Infrared Factory Process Control</td>
<td>0.50</td>
</tr>
<tr>
<td>5</td>
<td>Handheld Terminals, Process Control</td>
<td>3.00</td>
</tr>
<tr>
<td>6</td>
<td>General Purpose, Alpha and Graphics</td>
<td>47.00</td>
</tr>
<tr>
<td>7</td>
<td>Lottery Gambling Systems</td>
<td>26.50</td>
</tr>
<tr>
<td>8</td>
<td>General Purpose Terminals</td>
<td>16.50</td>
</tr>
</tbody>
</table>

**Composition Systems**

<table>
<thead>
<tr>
<th>Code</th>
<th>Product Description</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Large Newspapers and Publishers</td>
<td>83.00</td>
</tr>
<tr>
<td>10</td>
<td>Small Newspapers and Publishers</td>
<td>3.00</td>
</tr>
<tr>
<td>11</td>
<td>Newspapers</td>
<td>7.00</td>
</tr>
<tr>
<td>12</td>
<td>Text and Graphics Composition</td>
<td>5.36</td>
</tr>
<tr>
<td>13</td>
<td>Image Scanners</td>
<td>6.50</td>
</tr>
<tr>
<td>14</td>
<td>Color PhotoComposition for Publishers</td>
<td>104.00</td>
</tr>
</tbody>
</table>

**Printers**

<table>
<thead>
<tr>
<th>Code</th>
<th>Product Description</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Dot-matrix Printers</td>
<td>167.81</td>
</tr>
<tr>
<td>16</td>
<td>Color Ink Jet Printers</td>
<td>4.00</td>
</tr>
<tr>
<td>17</td>
<td>Letter Quality Impact Printers</td>
<td>1.75</td>
</tr>
<tr>
<td>18</td>
<td>Line Printers (Band, Chain)</td>
<td>28.00</td>
</tr>
<tr>
<td>19</td>
<td>Dot Matrix Printers</td>
<td>80.00</td>
</tr>
</tbody>
</table>

**Software**

<table>
<thead>
<tr>
<th>Code</th>
<th>Product Description</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Mainframe Spreadsheets</td>
<td>4.10</td>
</tr>
<tr>
<td>21</td>
<td>Microcomputer Presentation Graphics</td>
<td>2.25</td>
</tr>
<tr>
<td>22</td>
<td>Mainframe Databases</td>
<td>120.04</td>
</tr>
<tr>
<td>23</td>
<td>UNIX Database</td>
<td>.15</td>
</tr>
<tr>
<td>24</td>
<td>Mainframe Database</td>
<td>6.60</td>
</tr>
<tr>
<td>25</td>
<td>Compilers</td>
<td>.20</td>
</tr>
<tr>
<td>26</td>
<td>UNIX Operating System and Database</td>
<td>1.50</td>
</tr>
</tbody>
</table>

* In millions, for fiscal year 1884 or last year of business operations
Another factor pertaining to the sample design was the location of the firms. All the firms were based located in the New England region.\footnote{Localized studies have been conducted of Canadian firms (Cooper 1979) and of firms based in the "Silicon Valley" in California (Cooper 1970).} However, cultural influences emerging from specific regions did not appear to be a significant intervening variable in the study of the new product decision-making strategy. Both the sources of component supply and of competition were truly international, with the exception of perhaps the availability of engineering talent.

The sample design also had to contend with the related issues of organizational affiliation and operational independence. The intent of the design was to gather data for operationally independent entities, and not for departments or divisions of large corporations. Financial independence was rejected as a sample selection criterion because an "independent" firm may equally influenced by its outside investors, such as venture capitalists, as a firm that has been acquired by a larger corporation but still acts as independent entity.

It is not uncommon that technology-based firms that have built successful track records are acquired by larger concerns. The possible motives for the acquisition are numerous. The technological resources of the acquired company may provide a "window" on a particular technology for the parent company. Similarly, the product marketing skills of the acquired company may provide the parent concern with a competitive presence in a particular market area of strategic interest. Or, the

\footnote{The geographic constraint entered into the sample composition because it met the limitations of the travel budget for the research. The author's car could only reach firms in the New England.}

\footnote{R.G. Cooper for the Canadian study, and A.C. Cooper for the Californian study.}
acquisition may be on parent company's agenda for financial diversification. From the acquiree's perspective, a number advantages are also possible. These include the use of the marketing and production capabilities of the parent company and the financial gains achieved by the firm's founders and investors. Whatever the motive, acquisition does not necessarily mean that the acquired company ceases to operate as an independent unit.

Therefore, in the process of building the sample, some of the companies that had been acquired still met the selection criterion of operational independence. Mergers were judged against an additional criterion, being that of abnormal changes to the firm's product portfolio. Mergers presented the possibility the firm's product strategy and product line could be substantially altered by an external force, which in this case, is the addition of the partner company's products. If this occurred, the composition of the product portfolio in the resulting entity would show high levels of newness by virtue of the combination of two formerly distinct product lines. As a result, firms that had been involved in mergers that had a substantial and sudden impact on the firm's product line were rejected from the sample, whereas mergers where there was no major new product contribution were viewed more tolerantly.

Of the 26 companies in the final sample, six had been acquired. In fact, of the five firms in the printers cluster, three had been acquired by larger manufacturers. Similarly, two companies in the composition systems cluster had also been acquired. All six acquired companies remain operationally independent with respect to their parent

---

7. Both of these companies were recently purchased by the same large corporation wishing to diversify into new technology areas. Its traditional product technology has been been subject to technology substitution in recent years.
companies. The evidence for operational independence is the continuity in their respective product development programs and top management personnel, as stated during by interviewees during the initial data collection process. These firms had been acquired because of their prior success, and the new parent companies have shown little inclination to tamper with that success. Additionally, one of the firms in the sample had been a partner in a recent merger. This merger did not alter the company's product line, although a significant pooling of marketing and manufacturing resources occurred after the merger. The criterion of operational independence was enforced in the rejection of several firms that had been prospective candidates for the sample.

It can be seen from Figure 5.2 that the sample contains a broad range of company sizes in terms of annual sales. The sample includes firms that went bankrupt and are no longer operating concerns. Other firms remain financially unstable. There are also firms that have been highly successful. The highest level of 1984 sales achieved by any firm in the sample was approximately $167 million. Figure 5.3 provides the maximum, minimum and mean level of sales in millions of dollars for 1984 or the most recent year of active operations before 1984. This data are presented both by cluster and for the sample as a whole. The 'co' column contains the companies' sample case number. The 'age' column holds the age of the firm as of 1984 or its last year of business operations, whichever was earliest. Similarly, the 'sales' column contains the annual sales Figure for the firm's fiscal year 1984, or its latest year of business operations if that was before 1984.

The printers cluster has the highest mean level of sales. The respective averages for each cluster were: printers $55.0 million, composition systems $34.81 million, software $19.0 million, and terminals $15.9 million. Additionally, the mean
level of sales for the software cluster was heavily skewed by one highly successful firm, which, having achieved sales of approximately $120 million in 1984 was among the largest companies in the software industry. If this firm was removed from the software cluster, the mean level of sales in that group was only $2.4 million. This shows that compared to the other clusters in the sample, the software cluster contains relatively small companies, reflecting the high fragmented nature of that industry.

The mean level of sales for the entire sample was $28.69 million for 1984. This is shown in the last table in Figure 5.3. Of the 26 companies, 16 had 1984 (or most recent year of active operations) sales less than $10 million. On the other hand, there are also large companies in the sample: 5 of the firms had sales exceeding $75 million.

Figure 5.3 also shows average statistics for the age of the sample firms, where the mean is rounded to the nearest integer. Age had been a screening criterion in the pilot study as an attempt to provide a degree of commonality to the firms. However, the clustered design of the present research made screening by age unnecessary. The oldest firms in the sample were started in 1968 and the youngest in 1981. The average age for all the firms as of 1984 was 10 years. The software cluster has the youngest average age in the sample at 7 years. If the one highly successful software company mentioned above was removed from that cluster, the software cluster mean age would only be 5 years.
### Figure 5.3

**Statistics For Age And Sales Of Companies In The Research Sample**

#### Terminals

<table>
<thead>
<tr>
<th>co</th>
<th>age</th>
<th>sales</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
<td>---</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>25.70</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>11</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>47.00</td>
<td>maximum</td>
</tr>
<tr>
<td>7</td>
<td>9</td>
<td>26.50</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>16</td>
<td>16.50</td>
<td></td>
</tr>
</tbody>
</table>

#### Composition Systems

<table>
<thead>
<tr>
<th>co</th>
<th>age</th>
<th>sales</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
<td>---</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>83.00</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>3.00</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>4</td>
<td>7.00</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>15</td>
<td>5.36</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>15</td>
<td>6.50</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>14</td>
<td>104.00</td>
<td></td>
</tr>
</tbody>
</table>

#### Printers

<table>
<thead>
<tr>
<th>co</th>
<th>age</th>
<th>sales</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
<td>---</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td>167.81</td>
<td>maximum</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
<td>4.00</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>7</td>
<td>1.75</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>14</td>
<td>21.45</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>7</td>
<td>80.00</td>
<td></td>
</tr>
</tbody>
</table>

15  | 167.81 | maximum |
4   | 1.75   | minimum |
9   | 55.00  | mean    |
### Software

<table>
<thead>
<tr>
<th>co</th>
<th>age</th>
<th>sales</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>4</td>
<td>4.10</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>4</td>
<td>2.25</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>17</td>
<td>120.04</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>4</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>10</td>
<td>6.60</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>8</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>4</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>120.04</td>
<td></td>
<td>maximum</td>
</tr>
<tr>
<td>4</td>
<td>0.15</td>
<td></td>
<td>minimum</td>
</tr>
<tr>
<td>7</td>
<td>19.26</td>
<td></td>
<td>mean</td>
</tr>
</tbody>
</table>

### The Entire Sample

<table>
<thead>
<tr>
<th>age</th>
<th>sales</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>167.81</td>
<td>maximum</td>
</tr>
<tr>
<td>4</td>
<td>0.15</td>
<td>minimum</td>
</tr>
<tr>
<td>10</td>
<td>28.69</td>
<td>mean</td>
</tr>
</tbody>
</table>

Further insights are gained from a brief review of the descriptive characteristics of each cluster. The terminals cluster contains a mixed group of products, ranging from general purpose terminals such as alphanumeric or graphics terminals, to specialized applications terminals. Products that today are called "terminals" contain substantial local intelligence for display and communications, and are approaching the status of diskless microcomputers. For example, one of the firms in this cluster has successfully provided "terminals" used in state and national (foreign) lottery systems. These terminals have extensive communications software and also have an internal printer for generating lottery tickets. Another firm in this cluster has made terminals containing in its PROM memory chips extensive communications software for airline reservation systems. Similar communications technology was bundled into the
teller and cash dispensing "terminals" that another member of the cluster had sold to banks and supermarkets. Specialized terminals found in this group of companies included products for manufacturing environments. For example, one firm had made small, hand-held terminals, and another produced infra-red "touch screen" terminals. The general purpose terminal manufacturers have marketed their products through OEMs, distributors, and sales representatives. The manufacturers of special purpose terminals, on the other hand, have succeeded by winning "design-ins" for systems being developed by end-user organizations. This sales process is one of showing prospective clients that the particular terminal technology can be tailored to meet highly specialized system's specifications.

The composition systems cluster contains firms that either have made complete computer systems for text editing or digital photo composition, or have produced components such as digitizers included in complete systems. In fact, one of the firms in the cluster has supplied components to another cluster member. The composition systems cluster contains exciting technology for the interactive creation, coloring, and manipulation of images or objects. Other companies' systems have perform text layout and allow typeset previewing. Not surprisingly, many of the products made by this group of companies were very expensive systems, that once purchased by publishing organization, were augmented with extensive training and support programs. In contrast to these "high ticket" systems, this cluster also contains lower cost products for small corporate publishing departments. Firms that have

---

8. One of the interviewees, for example, showed on his firm's million dollar photocomposition system how a digitalized photograph of a sailboat could be enhanced with the image of an attractive young lady, generated completely from a computerized library of numerous figures and clothing objects.
competed in this market segment however, have generally fared poorly.

The third cluster, printer manufacturers, has recently been beset by intense competitive pressures. The most successful firms in this group have viewed themselves as the "printer divisions" of large computer manufacturing companies, providing a range of printer products and customized printer design services. These firms rode the wave of personal computer usage by producing low-cost dot-matrix printers. Another company in the sample targeted traditional data processing shop environments with higher throughput line printers. Other companies have made specialized products, such as high resolution, multi-color, multi-font printers for scientific and computer aided design applications. One firm, for example, has produced color ink-jet printers. However, the strategies of all the firms in this cluster have been affected by several key events. The first of these events is the emerging dominance of the Japanese in manufacturing low cost impact printers. Second, non-impact, laser printing technology has recently become a viable alternative for microcomputer and minicomputer applications. Laser technology is profoundly changing the printing industry. The majority of firms in this cluster are not only working on the development of laser printers, but have also reoriented their strategies for both manufacturing and technology acquisition. Laser engines, and many of the other components for the new generation of non-impact printers are most cost effectively produced in Japan. While American printer "manufacturers" are buying these components from Japanese suppliers, preventing these suppliers from becoming direct competitors is a challenging dilemma facing many of the companies in this cluster.

Lastly, the group of software firms shows the marked changes that have occurred in that industry. What once was an unlimited, fast paced arena for
technological entrepreneurship has become a mature, price competitive, and difficult environment. The most successful firm in this cluster has developed the capability to solve large, transactional database problems. The service that it provides to customers is just as important as the technology embodied in its products. The other firms in the sample were, as of 1984, modest in size. Some of these companies were profitable, and others, highly unstable. With few physical assets upon which to leverage bank financing, a software company typically relies on sales or outside equity investments to fund its growth. The products made by these firms include databases, spreadsheets, and programming language compilers. The problem that was most serious for many of the firms in this cluster was not the development of new products, but rather, the creation of effective mechanisms to sell existing ones.

3. Rules For The Research Data

Data were gathered for both products and performance up to each firm's fiscal year 1984, or its last year of doing business, whichever was earlier. In developing the methods for gathering both types of data, a number of issues required clarification and rule-making. These issues will be discussed below. The performance variable, which up to this point has been assumed to be based on annual sales data, will also be described in detail.
3.1. Rules For The Product Data

The product strategy grid was used to track the products a firm along the two dimensions of technological and market applications newness. This was shown in Figures 3.5 through 3.8. The four levels of technological change in order of increasing newness are: 1) minor enhancement to an existing core technology, 2) major enhancement to an existing core technology, 3) the development of a new core technology that is combined with existing core technology, and 4) the development of new core technology that is not combined with existing core technology in an operational product. The degree of change is relative, where the assessment of any given product is based on the collective technology of all previous products.

Similarly, in the market dimension, change in three basic parameters yielded the respective levels of market newness. These parameters are user functionality, customer groups, and the channels of distribution. The levels of change were shown in Figure 3.4. No change in all three parameters constitutes the first level of market change. Change in one parameter is the second level of newness. The third level of newness occurs when changes are experienced in two of the parameters. Lastly, if change exists for all three parameters, the fourth and highest level of newness in market applications is achieved.

For the first product of a firm, the technological dimension was assessed relative to the state-of-the-art external to the firm at the time of the product’s release. The four levels of newness for first products range from breakthrough technology at the highest level of achievement down to no technological distinctiveness at the lowest level. The market data collected for the first product was a description of the product/market functionality, the customer group, and the initial distribution channels adopted by the
company. While no market score was generated for the first product, it was the basis for evaluating the second product and contributed to the assessment of all subsequent products.

All products after the first product were then scored along the four levels of change for each dimension separately. For a company with ten products, for example, the result would be one technology score for the first product, and one technology and three market parameter scores for the next nine products. This would yield a total of 37 product data points. Descriptions were also collected for each product to help support its scoring, as well as the approximated date of the product's commercial introduction.

While the Product Innovation Model provided the framework for evaluating products, additional criteria were also necessary. The first was a definition of what development activities could be considered a "product" for the research. As was observed in the pilot study, technology-based firms can undertake contracted projects for other companies on a paid services basis. Such activity does not constitute a "product" for the firm, although it may lead to products released by the contractor. While technical service projects performed for clients were not included as product data, they could serve as the origins of products that were released at a later date and that were included in the research data. For example, one of the highly successful firms in the composition systems cluster had on several occasions entered into joint development projects with metropolitan newspaper organizations. This experience was subsequently leveraged into "new generation" products. There were two advantages to such a strategy: first, the firm's technology development benefited from the closeness of end-user interaction in the process design and prototype testing; and second, a substantial portion of research and development costs were funded by client company.
Another potential grey area in the definition of a "product" occurred when a product was made specifically to meet the design requests of an OEM customer. Such products are often "private-labeled" by the OEM. In the printers cluster, for example, one of the firms built a color printer to the specifications of a large computer company. This project was included in the product data, and not considered a technical service project, because the method of payment for the printer was on per unit volume discount schedule rather than an hourly or project consulting basis. Therefore, the method of payment became the discriminating element in judging the appropriateness of the development effort for the research data. This rule was employed to accept or reject approximately one dozen private-labeled products in the process of gathering data.

Another area that required rule-making were products purchased or licensed from other companies and then were redistributed by the firm. It is not uncommon for larger technology-based firms to acquire completed products from other organizations in the effort to extend its own product line. However, for this research, products where the firm acted only as a distributor and where its technical effort was not directed towards product re-engineering or customization, but rather, only to customer support, were not included in the research data. The lowest level of technological change in the Product Innovation Model requires at least some degree of improvement to a core technology embodied in the product. For example, if a printer manufacturer were to private-label a low-cost printer from a Japanese concern and performed no further engineering then that product would be excluded from the research data. This assured

---

9. We wanted to avoid the criticism that was made by Mowery and Rosenberg (1976) with respect to the research of Myers and Marquis (1989): while that research sought to identify key elements of innovation inside a company, 23 percent of the "innovations" in the data were actually licensed or acquired from external and therefore had little relevance to the sample firms' innovative activities.
a body of product data that was homogeneous with respect to some tangible degree of technical contribution made to products by the sample firms.

Identifying the source of technology in a product was also critical for differentiating between the first two and second two levels of technological change. While a product might include a new core technology, if that technology was licensed or acquired from an outside concern, the product was scored as one of the first two levels of change. If substantial engineering was performed on the technology, which would happen when the new technology was employed as a component for a product, then the new product was viewed as a major enhancement effort. If little work was performed the product was scored as a minor improvement, even through it contains a new core technology. A new product warrants either the third or fourth third level of technological change only when the new core technology was internally developed by the firm.

This distinction was frequently useful in the course of our investigations. A common situation occurred when a company engaged primarily in making hardware products licensed applications software to sell with its machines. An illustration of this is a firm from the research that developed a graphics engineering workstation. This product used a high resolution graphics terminal that had been an earlier product. For the new graphics workstation, the firm developed a set of computer-aided design applications software. Since this was a new core technology and was combined with the graphics terminals, the product was evaluated as having the third level of technological change. In a subsequent version of the workstation however, the firm provided text editing software to its customers. This text editing software was purchased from an independent software company and then integrated into the workstation after extensive
customization. The new release of the workstation therefore justified a second level of technological change. However, it did not warrant the third level of technological change because the text editing software had been purchased from another company.

A last issue in the technology evaluation process was the difference between the first two levels of change, minor improvement and major enhancement. Minor enhancement includes products that involve either repackaging of older products or relatively simple customizations that are achieved by one or several engineers in short periods of time. Major enhancement describes projects where the integration of new component technology occurs or where the firm substantially reengines its existing core technology. Another case from the current sample illustrates how this distinction was applied. A firm in the printers cluster has made dot-matrix printers for the microcomputer market. Many of its products have been minor enhancements, either providing faster printing speeds or incremental new functionality such as 132 column output versus the standard 80 columns. Several products, however, have been major enhancements such as the development of a color printer. This project required three engineers working approximately nine man-months to complete. From the pilot study, a rule was established that to warrant a score of major enhancement, a new product must require at least six man-months of development effort.10

Turning to the market applications dimension, the three parameters within that dimension proved robust in assessing the products of the sample firms. The individuals interviewed clearly identified the user functionality and customer sets of

10. While this criterion was useful in approximately a half dozen new product events within the entire sample, the interviewees were comfortable with the distinction between the two lowest levels of technological change and helped to score products in both levels with substantial confidence.
their products. Interviewees were also familiar with the typology for distribution channels that was described in the third chapter. An issue that did emerge was when a single product was marketed through several distinct channels. Any addition of a new form of distribution channel, even if existing channels were also employed for the product, was scored as a moment of change for the product evaluation. This duality in a parameter of market applications did not arise for either customer groups or end-user functionality, although if it had, the evaluation would have been treated in similar manner, e.g. any change of in parameter takes precedence in the scoring of that product. While the levels of market applications change for the products could be evaluated in direct manner, the ability to call interviewees for clarification of events did prove useful on several occasions.

The implementation of these methods for scoring the products of a firm can be illustrated with one of the terminal manufacturers. Figure 5.4 shows the product data for one of the terminals manufacturers.
### Figure 5.4
Product Data for A Printer Manufacturer: Case 15

<table>
<thead>
<tr>
<th>Case</th>
<th>Number</th>
<th>Year</th>
<th>Technology Score</th>
<th>Market Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>1</td>
<td>69</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>2</td>
<td>71</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>72</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>4</td>
<td>73</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>5</td>
<td>73</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>6</td>
<td>75</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>7</td>
<td>76</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>8</td>
<td>77</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>9</td>
<td>78</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>10</td>
<td>79</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>11</td>
<td>81</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>12</td>
<td>82</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>13</td>
<td>83</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>14</td>
<td>84</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td>84</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>16</td>
<td>84</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>17</td>
<td>84</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>18</td>
<td>84</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Examining the data in that Figure, the firm's first product was a novel computer-based gambling machine which was sold to Las Vegas casinos through direct sales. The second product was among the first dot-matrix printers on the market. The technology in this product at first appeared completely new and unrelated to the firm's prior technology; however, closer investigation showed that it had been first combined with the company's gambling systems and was therefore score as a new, related core technology. The market application of printer had the highest level of change: the printer was sold through OEM computer manufacturers, was employed for minicomputer printing, and used by small data processing facilities. Subsequent products generally show steps of major enhancement and minor improvement to the firm's dot-matrix printers, as well as a consistent focus on OEM channels for
distribution. Several interesting product developments are illustrative of the product evaluation process. Product number 7, for example, is noteworthy in that the firm added independent sales representatives to its distribution channels, and was thus scored as a 2 in market applications. Product 10, which was a major enhancement to the firm's dot-matrix technology, was among the first low-cost dot-matrix printers targeted for the microcomputer marketplace. This new user group (the firm had previously sold its printers for minicomputer applications) warranted a score of 2 in the market applications dimension. In Product 13, the firm enhanced its dot-matrix printer technology to handle a range of colors. This product was scored a 2 in the market application dimension by virtue of addressing a new user functionality: color printing. Lastly, Product 17 was a "band" line printer. This was a new key technology for the firm. However, the band printer technology was acquired from another company and subsequently improved. Because the new key technology was developed externally, and then enhanced by the firm, the product was scored a 2 in the technology dimension. While the band printer was again sold through OEMs, it addressed a new functionality in high-speed printing, and was targeted for a new set of users, high volume data processing facilities. Therefore, in the market applications dimension, the product was scored as a 3.

The product data for all the companies in the sample are contained in Appendix A. The total product sample comprises 262 products events. 26 of these events are first products. Figure 5.5 presents the frequency distributions for the levels of change in the technology and market applications dimensions respectively for non-first products. As might be expected, the data show that third and fourth levels of change for both dimensions have been incurred relatively infrequently among the sample firms. However, the testing of the strategic focus hypothesis will show that products
exhibiting these high levels of newness have a impact on the firm's strategy and performance far exceeding their frequency.

Providing some element of surprise was the fact that there was a higher observed frequency of major enhancement in the technological dimension (46.19%) than for minor improvements (38.56%). One might have expected that the frequencies would follow a pattern more similar to that in the market applications dimension where the frequency of first level of change (55.08%) was almost twice that of the second level (29.84%). The fact that there was a greater number of major enhancements than minor improvements underscores the degree of rapid and substantial technological change embodied in the products of companies in the sample. While the direction of research and development and marketing activities remains to be explored in the context of strategic focus, the data in Figure 5.5 show that firms in the sample have generally been strong technological achievers. Figure 5.6 presents the level of technological accomplishment in the first products of the sample firms with respect to the state of the art in the industry at the time of the introduction of those products. It further indicates the general aggressiveness of these firms in research and development activities, as seen in the combination of a high observed frequency of the third level of technical accomplishment, "highly distinctive" technology, and a low level of technologically undistinctive first products.
### Figure 5.5
**Distributions Of Product Data For The Entire Sample**
*For Levels of Technological and Market Applications Change*

<table>
<thead>
<tr>
<th>Level of Change</th>
<th>Frequency Technology</th>
<th>Freq % Technology</th>
<th>Frequency Market</th>
<th>Freq % Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>91</td>
<td>38.56</td>
<td>130</td>
<td>55.08</td>
</tr>
<tr>
<td>2</td>
<td>109</td>
<td>46.19</td>
<td>69</td>
<td>29.24</td>
</tr>
<tr>
<td>3</td>
<td>29</td>
<td>12.29</td>
<td>27</td>
<td>11.44</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>2.97</td>
<td>10</td>
<td>4.24</td>
</tr>
</tbody>
</table>

Total Products: 246

### Figure 5.6
**Distributions of First Product Technology**
*For the Research Sample*

<table>
<thead>
<tr>
<th>Level of Achievement</th>
<th>Frequency</th>
<th>Percent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>0.08</td>
<td>Undistinctive</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>0.31</td>
<td>Somewhat Distinctive</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
<td>0.50</td>
<td>Highly Distinctive</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>0.12</td>
<td>A Major Breakthrough</td>
</tr>
</tbody>
</table>
3.2. Rules For The Performance Measure

During the course of the pilot study, interviewees were asked to identify the measures that they used to monitor their companies' performance on a yearly basis. Most responses tended to focus on a combination of growth in annual sales and and profitability in terms of pretax cashflows.\textsuperscript{11} Utterback (1982), in his research on innovation using a sample of Swedish and American firms, collected data for a broad range of performance variables. These included sales growth, employment growth, growth in the firm's capital, and growth of assets. A series of cross correlations were performed on these data and it was found that positive correlations between them were high, ranging in the area of .85 to .95. This meant that a performance measure based on sales growth was as good as any of the other measures employed in that study.

Annual sales, as the basis of a performance measure, also had the benefit of being more accurately reported than measures requiring data such as the profitability of the company or the size of its assets. An important objective of constructing the performance measure was that it should include data comprising all the years of a firm's existence, rather than, for example, to take only the current past three or four years sales. Given that the data had to be collected for the earliest years of the firm's existence, it was observed that while interviewees could track down annual sales levels, they often could not find data regarding profitability or assets. Further, in the course of the present research, it was observed that for the software cluster that the reporting of "assets" could be a misleading indicator of performance. Often, even successful software

\textsuperscript{11} Nonfinancial measures of performance, while not considered for the present research, have also been described in the literature. Cooper (1984a), for example, developed three different measures of success, two of which were nonfinancial in nature.
companies have relatively few physical assets: their "inventory" consists of documentation sets, storage media, and computers, although the latter are frequently provided free to the firm by OEM clients and are not included in the firm's balance sheets. For these reasons, the annual product-related sales of the firm was chosen as the basis for the performance measure with which the research hypotheses would be tested.

Another significant finding of the Utterback study was that age, as a separate variable, was negatively correlated with all the various performance measures. These measures were based on percentage changes in elements such as sales, employment, and assets. Older successful firms tended to show poorer performance than younger successful ones. This finding was logical in that a young firm that doubles relatively small amounts of sales shows higher percentage changes than an older, larger company growing at annual rate of thirty percent. Therefore, if our performance measure was to be based on annual sales, the age of the firm for each reported year of sales data also had to be factored into the calculation. Otherwise, the performance measure would be biased in favor of the younger companies.

An initial approach for normalizing the sales data for age was developed, and then rejected after testing. The first step of this method was to fill yearly "buckets", ranging from Year 1 of existence to year N, with the sales data of all the sample firms for each year of possible growth. An average sales figure across the entire sample for each yearly "bucket" was then calculated. Next, an individual firm's performance measure was derived by taking average of its percentage above or below the sample sales mean for each respective year of existence. This method offered substantial promise until it was realized that the oldest firms in the sample were, for their most recent years, being increasingly compared against themselves. This defeated the original
purpose of the normalization. The sample contains several companies started in 1968, and others in 1981. If the firm's in the sample had been closely clustered around a mean age, then this performance measure would have been more appropriate.

Another alternative was to use the average sales growth for all the years of existence of a firm, derived as follows:

\[
\text{ASG} = \frac{\sum_{i=2}^{Y} \frac{Sales_i - Sales_{i-1}}{Sales_{i-1}}}{Y - \text{Start}}
\]

ASG = Average Sales Growth  
Start = Year of Startup  
Y = The Most Recent Fiscal Year, 1984 or Last Year of Business Operations

It was found however, that this measure was misleading in cases where a company had experienced highly volatile growth in either positive or negative directions. Consistently growing firms can show lower average sales growth than firms that have had erratic sales. This is illustrated in Figure 5.7, which shows the sales data for two firms in the terminals cluster.
**Figure 5.7**
Annual Sales Revenues (in millions) of Two Terminal Manufacturers
Cases 6 and 7

Company A: Alphanumeric Terminals

<table>
<thead>
<tr>
<th>Case</th>
<th>Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>1978</td>
<td>1</td>
<td>0.00</td>
</tr>
<tr>
<td>6</td>
<td>1979</td>
<td>2</td>
<td>0.74</td>
</tr>
<tr>
<td>6</td>
<td>1980</td>
<td>3</td>
<td>7.53</td>
</tr>
<tr>
<td>6</td>
<td>1981</td>
<td>4</td>
<td>18.04</td>
</tr>
<tr>
<td>6</td>
<td>1982</td>
<td>5</td>
<td>25.81</td>
</tr>
<tr>
<td>6</td>
<td>1983</td>
<td>6</td>
<td>47.00</td>
</tr>
</tbody>
</table>

Company B: Lottery Transaction Terminals

<table>
<thead>
<tr>
<th>Case</th>
<th>Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1976</td>
<td>1</td>
<td>0.00</td>
</tr>
<tr>
<td>7</td>
<td>1977</td>
<td>2</td>
<td>16.40</td>
</tr>
<tr>
<td>7</td>
<td>1978</td>
<td>3</td>
<td>5.50</td>
</tr>
<tr>
<td>7</td>
<td>1979</td>
<td>4</td>
<td>4.20</td>
</tr>
<tr>
<td>7</td>
<td>1980</td>
<td>5</td>
<td>2.40</td>
</tr>
<tr>
<td>7</td>
<td>1981</td>
<td>6</td>
<td>2.30</td>
</tr>
<tr>
<td>7</td>
<td>1982</td>
<td>7</td>
<td>17.50</td>
</tr>
<tr>
<td>7</td>
<td>1983</td>
<td>8</td>
<td>25.57</td>
</tr>
<tr>
<td>7</td>
<td>1984</td>
<td>9</td>
<td>26.50</td>
</tr>
</tbody>
</table>

Using this measure, the first firm has an average sales growth of 14.14, and the second firm, 182.85. Yet, the second firm never achieved a level of sales equal to that of the first firm. The second firm's "superior" performance is attributable only to the volatile pattern of its annual sales. For this reason, average sales growth was rejected as a performance measure.

As a result of these investigations, a measure based on annual sales was selected that avoided percentage comparisons. This measure was called "Average Normalized Sales". It is the mean of all yearly reported sales for the product related...
activities of the firm. To derive this measure for each firm, each annual sales figure was first divided by the age of the firm for that year plus 1. This is shown in Equation Set 5.

\[
\text{Equation Set 5} \\
\text{Average Normalized Sales Calculation}
\]

\[
\begin{align*}
\text{ANS} & = \frac{\sum_{j=\text{Start}}^{Y} \text{Sales}_j}{Y - \text{Start}} \\
& \quad \text{Current} - \text{Start} + 1
\end{align*}
\]

\[
\begin{align*}
\text{ANS} & = \text{Average Normalized Sales} \\
\text{Start} & = \text{Calendar Year of Company Startup} \\
\text{Sales} & = \text{Annual Sales, Product-related revenues} \\
\text{Current} & = \text{Current Calendar Year} \\
Y & = \text{The Most Recent Fiscal Year, 1984 or Last Year of Business Operations}
\end{align*}
\]

The addition of 1 to the normalization divisor was required to allow for the inclusion of the first year of sales, else the division would be by zero. Using this calculation, the performance measures for the two companies shown in Figure 5.7 are 3.398 and 2.287 respectively. All the sample firms' performance measures were derived by this method and used in the testing of the hypotheses. Performance rankings were also calculated without dividing annual sales by relative ages, the purpose being to observe the effect of the normalization by age upon the rank correlations. For the two firms above, the unnormalized measures are 16.520 and 11.152 respectively. This second performance measure was called "Average Unnormalized Sales". The sales data for the firms in the sample are contained in Appendix B. The programs used to generate the performance measures are included in Appendix F.\textsuperscript{12}
In the process of collecting the sales data for the sample firms, it was also necessary to differentiate product-derived revenue streams from service or consulting revenues. Two categories of performance data were requested from interviewees: the first was the total annual revenues of the company, and the second, the revenues attributable directly to sales of the commercial, "packaged" products. The importance of making the distinction between commercial product sales and contract revenues is illustrated by two companies in the present sample. The first of these firms was a member of the terminals cluster and has made infra-red, touch sensitive terminals for application in industrial manufacturing environments. Fifty percent of its revenues, as of 1984, were still derived from a range of engineering contract services provided to large manufacturing companies. The second firm is a image-scanner manufacturer whose products have been used in newspaper automation systems. This company has also actively participated in defense-related systems projects for the government and defense contractors. For these and other firms in the sample, the differentiation between product and contract revenues was essential to provide an accurate performance measure to be compared against the product data.13

12. These programs, and others employed for the data analysis are a combination of UNIX shell programming and a set of relational database commands written by the author. The advantage of these shell programs is that they can be typed into any computer running the UNIX operating system, and run against tables of ASCII text of the format shown in Appendix A and Appendix B. The database commands are available as applications software from VenturCom, Inc of 215 First Street, Cambridge, MA. Readers having similar data analysis requirements are encouraged to modify the programs in Appendix F and may receive additional assistance at that company.

13. "Contract" services that were highly product-related were not excluded from the sales data. Many technology-based firms provide such services to customers who buy their products and require additional customizations. In the research, computer systems containing applications software were example of this, as seen in the composition systems and software clusters. Since this particular type of service was directly linked with the sale of the firm's product, the sales derived from it belonged within the performance measure.
4. Data Collection Methods

Direct interviewing was selected as the primary method for gathering data because of the detailed nature of the information that had to be collected. Some empirical studies on product innovation have had respondents complete mailed questionnaires in a relatively unsupervised manner. Cooper (1979, 1984a, 1984b), for example, had respondents select single "successes" and "failures" as products and then answer questions for those products on an extensive range of issues. There are more examples, however, of direct contact research in the innovation research. Roberts (1969), Myers and Marquis (1969), Utterback (1971), Langrish (1972), Rothwell (1974), and Von Hippel (1976,1977) all employed interviewing to gather data. If the research subject is suitable, another possible method is to monitor behavior "on-site" in a targeted environment. Allen is among the best examples of monitoring behavior (Allen 1977, Allen, Tushman and Lee 1979, Allen, Lee, and Tushman 1980). He investigated communications in research and development laboratories by developing data collection forms that were completed by project participants in the course of their daily work activities.

The objective of the interviewing for the present research was to collect information on the specific technological content and market applications of all the firm's products. This demanded a highly participative effort by the author and the interviewees. Telephone conversations were also used to clarify any issues that emerged during the review of the interview data. From the pilot study, it was observed that the primary investigation period could not exceed the either attention span or time availability of the interviewees, all of whom were senior management personnel. Two hours interviews were scheduled for each company. Given that there was an average of
approximately 10 products per company for the sample, this time allotment proved sufficient for complete scoring of the products.

4.1. Interviewee Criteria

The primary qualification of interviewees was that they possess accurate knowledge of all the products that had been made by the firm. It was expected that the most difficult part in collecting product data would be gathering accurate information for the early products of older companies that had also experienced high turnover in senior management. This led to the selection criterion that the interviewee had to have been part of the organization for the majority of its existence, and preferably had been a founder. The top candidates were company presidents who had also been founders. Approximately half of the interviews were conducted with such individuals. The remaining interviewees were senior managers, typically vice presidents of engineering and of sales or marketing, all of whom had been with their respective firms for substantial durations and were closely familiar with all the firm’s products. After founding presidents, the next preferred interviewee was a director of research and development, followed by sales or marketing vice presidents, and thereafter by senior managers responsible for strategic and new product planning. This order of preference was motivated by the greater subtlety in the identification of the core technologies in products, and the origins and work performed on those technologies, than that required for the identification of customer groups, end-user functionality, and distribution channels.
4.2. The Interview Process

Effective interviewing required a regimen for collecting data. The interview process was divided into three parts: 1) introductory information exchange; 2) collection of product data; and 3) collection of performance data. Follow-up questions that emerged regarding product data were resolved over the telephone with interviewees. The first step of the process began with telephone contact to prospective interviewees, who were then qualified for inclusion in the research. Both companies and individuals were qualified against the cluster definition and interviewee criteria described above. In many cases, multiple contacts had to made inside a single company to reach the correct individuals and schedule interviews. During this initial contact phase, the research program was described to prospective interviewees at a broad level. In some cases, interviewees offered to prepare ahead of time by itemizing the products of their respective organizations and tracking down release dates for those products. Similarly, in some cases, performance data was also gathered prior to interview to expedite the process. Assurances were also provided by the author that all data would remain confidential, and be disguised if used for any publications.

The introductory information exchange was continued at the beginning of the actual interview. One important benefit of the Product Innovation Model that emerged was that it was quickly understood by interviewees. The core technology concept, the idea of technology "relatedness", and the parameters constituting the market application dimension were described, and if necessary, illustrated with a brief example from the pilot study. While the general purpose of investigating the relationship between product data and performance was explained to interviewees, care was taken not to describe the details of the research hypotheses so as not to bias the
data.

The collection of product data was started with the interviewee's description of the origins of the company, the backgrounds of the founders, and the development of the first product. At this point, the assessment of the first product's technology relative to the state of the art was made. Competitive products at the time of release of that product were identified where possible to assist in correct evaluation. Then, each successive product was discussed and scored for each dimension of the Product Innovation Model separately. Notes were taken with respect to specific core technologies and their origins, amounts of technological enhancement, and the three parameters of the market applications dimension. Where appropriate, products were categorized and analyzed by product line. Date tracking for each product was by the calendar year in which the product was introduced to the marketplace or provided to a particular OEM for redistribution.

The gathering of performance information was done after the product data was collected. In most cases, the interviewees had the sales information on hand; in other instances, a form prepared by the author was completed by the interviewee or by financial officers of the firm and returned by mail to the author.
5. Data Processing Methods

The selection and development of methods for analyzing the research data was performed with several basic decision inputs. The first of these inputs was the type of data collected, being both technological change data and market applications change data for products, and performance data. A second basic constraint is the nature of the research hypotheses, where various forms of product data variables (e.g. strategic focus, first product strategy, and innovation intensity) had to be compared with performance measures. Lastly, a third input was the sample design, which provided clusters of firms that were relatively small in number. Therefore, the analysis methods had to consolidate these "raw" product and performance data into measures that could be used to test the hypotheses. Further, the statistical methods that were chosen had to be appropriate for small sample sizes.

The general thrust of testing the research hypotheses was to compare consolidated levels of technological and market applications change to the performance, first for each of the four clusters, and then for the entire sample. "Strategic focus", first product technological achievement, and "innovation intensity" were the assorted independent variables for testing; performance, as defined in the previous section, was the dependent variable. Since the relationship between the independent variables and the dependent variable could not be assumed as linear (in fact, for strategic focus, a bell-shaped curve was hypothesized as shown in Figure 4.3), regression analysis was not appropriate. A curve fitting technique, where a Poisson distribution was created and fitted with the product newness measures, was developed and assessed. While curve fitting can be used to analyze nonlinear relationships between data, the author felt that the nature of the relationship between strategic focus and performance, and the data
collected to test it, could not be modeled precisely as a pre-known equation. This also made the analysis of variance of a fitted curve inappropriate as the primary tool of analysis. While curve fitting could not be used in this fashion, however, however, it could provide an intuitive understanding of the relationship between strategic focus and performance. As will be shown in the next chapter, curve fitting was used to "eyeball" the relationship between certain data.

A third alternative for data analysis was to perform cross tabulations of the variables, followed by a chi-square test. This technique is useful for testing general hypothesized relationships between variables and was used to test several of the research hypotheses. However, to use cross tabulation, arbitrary boundaries for each variable must be chosen, (e.g. Variable X should be grouped from 1 to A, B to C, and so forth). While there are specific break levels for individual product scorings on both technological and market applications newness, the final measures for strategic focus for a sample of firms are nonordinal. The author saw no reasonable criteria for choosing one set of groups within a variable (except for first product technology) over any other set of groups for nonordinal measures, such as strategic focus. Also, the small sample sizes of the clusters created a problem because the observed frequencies in each "cell" of a contingency table could easily be zero. This nullified the use of the chi-square test for statistical significance. For some of the data analysis, when cross tabulations and the chi-square were inappropriate, an analysis of variance followed by an F statistic test were used instead.

The method chosen for statistical analysis of much of the data, including for example, the strategic focus measure, was the Spearman rank coefficient. This in turn dictated precisely how both the product and performance data had to be processed and
consolidated. The Spearman rank coefficient was generated for the data by comparing two sets of ranks for the firms in each cluster. The first rank was for one of the independent variables such as combined strategic focus (STM in Equation Set 1), and the second, for the performance measure. In the case of the strategic focus hypothesis, for example, the consolidated measures for product newness for each of the firms in a cluster were ranked from low to high, and the performance measures from high to low (greater focus should correlate with high performance). The rank coefficient was then generated to test the relationship between these two variables by analyzing the differences in the two rank positions for each firm.\textsuperscript{14} Equation Set 6 shows the formula was generating the Spearman rank coefficient.

\textsuperscript{14} Copies of the programs used in this section are included in Appendix E.
Equation Set 6
The Spearman Rank Coefficient

\[
\rho = 1 - \frac{6 \times \sum_{i=1}^{N} (Rank_i(SF_{TM})-Rank_i(P))^2}{N^3-N}
\]

\(\rho = \textit{Spearman rank coefficient}\)
Rank = Rank position
SF = Strategic Focus
TM = Combined Technological and Market Applications
P = Performance
N = Number of Companies in Test

The implementation of the Spearman rank procedure for this research can be illustrated with a trial test of the strategic focus hypothesis for the printers cluster. The procedure for the strategic focus test involved four basic steps:

1. rank the firms by the independent variable, e.g. combined technological and market applications strategic focus, from low to high;
2. rank the firms by performance, from high (most successful) to low;
3. compare the two sets of ranks, generating the Spearman coefficient. To generate the Spearman coefficient, the difference in rank order for all the firms in the sample set is squared, and then summed. This sum of the squares of the rank order differences is then entered into the formula shown in Equation Set 6 to produce the Spearman coefficient;
4. look up the rank coefficient in a standard probability values table to see if the rank comparison shows statistical significance. A copy of this matrix is provided in Appendix D.

The analysis procedure began with two databases for each cluster, one containing the product data gathered for the firms, and the other, the sales data. A number of formulas presented with the hypotheses in the previous chapter will be used in the discussion below. All the equations used in this research are contained in Appendix C for the reader's convenience.

**Figure 5.8**
Formulas Presented With The Research Hypotheses

**Equation Set 1**
Focal Point Calculations

\[
FP(T) = \frac{\sum_{i=2}^{N} |\Delta T_p|}{N-1}
\]

\[
FP(M) = \frac{\sum_{i=2}^{N} |\Delta M_p|}{N-1}
\]

\[
FP(TM) = \frac{\sum_{i=2}^{N} |\Delta T_p \times \Delta M_p(i)|}{N-1}
\]

FP = Focal Point
T = Technology Dimension
M = Market Applications Dimension
TM = Combine Technological and Market Applications
Delta T = Level of Technological Newness
Delta M = Level of Market Applications Newness
N = Total Number of Products
p = A product
Equation Set 2
Variance Calculation

\[
V(T) = \frac{\sum_{i=2}^{N} |\Delta T_{p_i} - \Delta T_{p_{i-1}}|}{N-1}
\]

\[
V(M) = \frac{\sum_{i=2}^{N} |\Delta M_{p_i} - \Delta M_{p_{i-1}}|}{N-1}
\]

\[
V(TM) = \frac{\sum_{i=2}^{N} |\Delta T_{p_i} - \Delta T_{p_{i-1}}| \times |\Delta M_{p_i} - \Delta M_{p_{i-1}}|}{N-1}
\]

V = Variance
T = Technology Dimension
M = Market Applications Dimension
TM = Combine Technological and Market Applications
Delta T = Level of Technological Newness
Delta M = Level of Market Applications Newness
N = Total Number of Products
p = A product

Equation Set 3
Strategic Focus Calculations

\[
SF(T) = FP(T) \times \sqrt{V(T)}
\]

\[
SF(M) = FP(M) \times \sqrt{V(M)}
\]

\[
SF(TM) = FP(TM) \times \sqrt{V(TM)}
\]

SF = Strategic Focus
T = Technological Dimension
M = Market Applications Dimension
TM = Combine Technological and Market Applications
Equation Set 4
Innovation Intensity

\[
\Phi = \frac{N}{\text{Age} \ \sum \Delta T_{p_i}} \\
\Psi (T) = \frac{i=2}{\text{Age}}
\]

φ = Average Product Releases
ψ = Innovation Intensity
T = Technological Dimension
p = A Product
N = Number of Products current to 1984
Age = Age of Firm current to 1984 or Last Year of Business Operations

The reader is also encouraged to scan the product data for the printers cluster in Appendix A. Using the Equation Set 1, the product data were first used to calculate the focal point for each dimension separately. The variance was also calculated concurrently using Equation Set 2. These two measures were derived for each firm in the test, and then, the strategic focus measure was calculated for each company using Equation Set 3. Figure 5.9 shows the table that results from these calculations. The columns in that table are "co" (case number), "ftm" (combined technology and market focal point), "vartm" (combined technology and market variance), and "stm" (combined market and technological strategic focus). The combined focal point is the mean of the multiplication of the level of change for each product for each respective dimension. Similarly, the formula in Equation Set 2 for combined variance may be viewed as the average "arc length" between successive product points on the product strategy grid. The combined strategic focus measure is the result of multiplying the combined focal point by the square root of the combined
variance, using Equation Set 3.

**Figure 5.9**
Product Means for the Printers Cluster

<table>
<thead>
<tr>
<th>co</th>
<th>ftm</th>
<th>var tm</th>
<th>stm</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
<td>-----</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>15</td>
<td>2.529</td>
<td>0.8235</td>
<td>2.083</td>
</tr>
<tr>
<td>16</td>
<td>4.000</td>
<td>2.0000</td>
<td>8.000</td>
</tr>
<tr>
<td>17</td>
<td>7.000</td>
<td>2.6000</td>
<td>18.200</td>
</tr>
<tr>
<td>18</td>
<td>2.667</td>
<td>2.0000</td>
<td>5.333</td>
</tr>
<tr>
<td>19</td>
<td>2.133</td>
<td>0.7333</td>
<td>1.564</td>
</tr>
</tbody>
</table>

To obtain the rank ordering of the combined strategic focus point for the firms, a sort and numbering on the "stm" column was performed next. This produced the table shown in Figure 5.10.

**Figure 5.10**
Ranking by Strategic Focus
The Printers Cluster

<table>
<thead>
<tr>
<th>Rank</th>
<th>co</th>
<th>stm</th>
</tr>
</thead>
<tbody>
<tr>
<td>----</td>
<td>--</td>
<td>-----</td>
</tr>
<tr>
<td>1</td>
<td>19</td>
<td>1.564</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>2.083</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>5.333</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>8.000</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>18.200</td>
</tr>
</tbody>
</table>

The next step was to process the sales data. The reader may wish to scan the sales data for the printers cluster in Appendix B. The measure of performance was the mean sales normalized by age, which is the formula in Equation Set 5. Figure 5.11 shows the rankings of the printer manufacturers, where the "growth" column contains the performance measures for each firm.
Figure 5.11
Ranking By Normalized Sales
The Printers Cluster

<table>
<thead>
<tr>
<th>Rank</th>
<th>co</th>
<th>growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>-------</td>
</tr>
<tr>
<td>1</td>
<td>15</td>
<td>7.486</td>
</tr>
<tr>
<td>2</td>
<td>19</td>
<td>4.636</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>1.928</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>0.583</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>0.582</td>
</tr>
</tbody>
</table>

The final step in the procedure was to calculate the Spearman rank coefficient. Figure 5.12 presents the results of this step. The Spearman rank coefficient for the printer manufacturers was .90. In that Figure, the "residual" column is the square of the "difference" column, itself being the difference between the rank for the strategic focus measure and the performance rank for each firm in the cluster. The Spearman coefficient uses the sum of the residual column values and was derived with the formula in Equation Set 6. The coefficient value could then be compared to the table of values in Appendix D. That table shows for a range of sample sizes the coefficient values that must be achieved to reach the 95 per cent confidence level. This level of confidence is the probability that that the observed relationship between strategic focus and performance did not occur by random chance. The necessary coefficient value for a sample size of five, which is the size of the printers cluster, is .90. Therefore, the result of this trial test of strategic focus versus performance for the printers cluster was positive and confirmed the strategic focus hypothesis.
**Figure 5.12**

Spearman Rank Correlation Of Strategic Focus Versus Performance
The Printers Cluster: Combined Technology and Market Applications

<table>
<thead>
<tr>
<th>co</th>
<th>product rank</th>
<th>sales rank</th>
<th>diff</th>
<th>residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>18</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>19</td>
<td>1</td>
<td>2</td>
<td>-1</td>
<td>1</td>
</tr>
</tbody>
</table>

The Spearman Rank Coefficient is : 0.900

In addition to testing the research hypotheses on the four separate clusters, all clusters were combined into a "mega-cluster" so that the hypotheses could be tested for the entire sample.

Sensitivity testing was also conducted on the data. One form of sensitivity testing was on the derivation of the strategic focus measures, where instead of multiplying the focal point of new product strategy and the variance, these two measures were added. Another variation on the basic method described above was to vary the performance measure by leaving out the step of normalizing the sales data by dividing each annual sales figure by the age of the firm for that year. Thus, for each test of the strategic focus hypotheses, four separate tests were performed rather than one. Lastly, sensitivity testing for Spearman rank tests was performed by switching the rank orders of firms closely together in their product rankings, and observing the impact of the test switch on the final results.
6. The Significance Of The Research Methods

The methodology of this research is central to all the results that will be discussed in the next and final chapter. Therefore, before delving into the analyses of the data, it is appropriate to see where this methodology stands with respect to past research in the fields of strategy and innovation.

New product strategy, when viewed as a distinct entity of corporate strategy and innovation, has historically been treated in two ways: the first, as an implicit subset within the "larger" phenomenon of business diversification, and the second, as an explicit factor observed by studying single product successes and failures. At the outset of this research effort, these approaches were seen as inadequate for methodological reasons when applied to new product strategy in relatively small technology-based firms. As a result, the author was motivated to develop an alternative approach.

The alternative method created by the author drew upon the designs of work done in other fields of innovation. It has two major characteristics. First, new product strategy was treated as an explicit factor in the innovation and business activities for the particular set of firms that were studied, called "technology-based" firms that were engaged in industries continuously and profoundly affected by changes in primary technologies. Second, in contrast to case-based innovation studies that include the SAPPHO project (1974), Myers and Marquis (1969), and Cooper (1970, 1984a, 1984b), our methodology viewed its topic, new product strategy, as the cumulative result of all the directly relevant events, being actual products, that had occurred within the sample firms. New product strategy was thus framed in the context of all the commercial products made by the firm, not just single successes or failures. This provided a
historical characteristic to the empirical data research. Subsequently, guidelines as to what would constitute a "product" had to be developed. Consulting or services, contract projects, and products where the firm made no concrete technical contribution during the development phase were rejected from the product data.

While new in its application to the field of product strategy, this approach had already been used to good advantage by researchers working in other fields. For example, an empirical and historical method was employed by Chandler (1962) and Rumelt (1972) to study the relationship between strategy and structure, by Roberts (1969) in the area of entrepreneurship, by Allen (1978) in laboratory communications, and Old (1982) in comparing technology investment to operating income. By using this approach, we did not have to be concerned with criteria for picking individual "successes" or "failures" for the product data because all products were included as data. Past studies that have not adopted this inclusive approach have relied instead on industry award programs (Langrish et al. 1972, Utterback 1974) or the subjective opinions of company executives (Myers and Marquis 1969, Cooper 1979, 1984a, 1984b). For the present research, neither of these methods would have generated a sample of product data that was reflective of a firm's new product strategy in toto.

A second basic contribution of the research methodology is that it segmented the domain of new product strategy into specific components rather than treat the subject as one monolithic entity. Each product was seen as having two logical components: the technology embodied in the product and its market applications. The works of Ansoff (1965), Abell and Hammond (1979), and Porter (1980) in the corporate strategy field have focused on market issues to assess the attractiveness of new business and product opportunities. While the methodology of the present research incorporated
the market dimension, its most important contribution from the perspective of past literature was that it explicitly identified the technological dimension and proposed a technique to differentiate between different types of technology strategy. This research shows that in the examination of growth strategy for technology-based firms, the evolution of product technology is critically important and may be studied in an empirical manner. This stands in contrast to and also augments the traditional perspectives on technological entrepreneurship which have examined organizational aspects of new ventures, market planning and competitive assessment, financial planning, and the characteristics of entrepreneurs.

The basis of the technological evaluation in the Product Innovation Model was the concept of the core technology, which was distinguished from base technologies that are integrated with core technologies in final products. The core technology concept was adopted from the work of Ketteringham and White (1983). The technology strategy was subsequently measured by the mean level of change to the body of a firm's core technologies in any given product compared to the products released before it. This measure of change was called the focal point of technology strategy. The icvels of change proposed were: a) minor improvement to an existing core technology, b) major enhancement to an existing core technology, c) new core technology(ies) used with an existing core technology, and d) new core technology not combined with a previous core of the firm. The second component of technology strategy that was proposed in the research framework was the consistency with which a firm adhered to a given pattern of technological change between products. This measure of consistency was called the variance of the technology strategy, and was factored into the overall assessment of the degree of strategic focus in the technological dimension of a firm's new product strategy.
Not withstanding this emphasis on the role of technology in strategy, the research methodology treated market strategy as an equally important factor, and also generated measures for the *focal point* and *variance* of strategy in the market applications dimension. The parameters for market strategy developed by Abell (1980), being the targeted customer groups and the basic user functionality of products, was adopted and then extended with the addition of channels of distribution as a third parameter. These three parameters were then used to assess historical levels of change in the market applications dimension for a firm. Change in any one of these parameters, or no change in all of them, for a given product was factored into the evaluation of the market strategy embodied in the firm’s product sequence.

In summary, the research framework as summarized in the Product Innovation Model, provided a method for empirical investigation of new product strategy in technology-based firms that offered two major benefits, being a) a high degree of specificity for assessing new product strategy along two key dimensions, and b) a historical perspective where new product strategy was viewed as a dynamic, changing phenomenon. The result was that new product strategy was defined as the cumulative effect of all the individual product events of the firm. Within this definition, relatively marginal technology improvements and market application reorientations could, by their frequency, be equally and perhaps more important in a strategic context as a few singular accomplishments or failures encountered by a company in its evolution.
Chapter 6

RESEARCH RESULTS
Chapter 6

RESEARCH RESULTS

The proceeding chapters have presented the conceptual framework, research hypotheses, and methodologies used in this study of new product strategy. The research hypotheses presented in Chapter 4 addressed four basic issues: the concept of strategic focus, the significance of technology focus compared to market focus in terms of performance outcomes, first product entry strategy, and the rate of product innovation. This chapter reexamines the motivation and meaning of these research hypotheses and reports the results of testing them with the data collected in the course of the study.

1. The Concept of Strategic Focus

The concept of strategic focus is that companies have varying levels of concentration on specific core technologies and market applications. This concept was used in this research to differentiate among a group of firms by the degree to which they had directed technology development activities on a single core technology, as opposed to multiple core technologies, and had targeted a
homogeneous set of customer groups, user functions, and distribution channels that constituted the market applications of their respective products. The hypothesis that emerged is that firms that have historically shown "focus" in their new product strategy perform better, over extended periods of time, than firms that have endeavored to create multiple core technologies and implement diverse market applications.

The motivation behind the development of this concept came from the author's review of the strategy literature, and the realization of the limitations of that literature as it might be applied to growth strategies for technology-based firms. The concept of diversification has been extensively studied and supported in the strategy literature as an important vehicle for achieving corporate growth. Empirical strategy research has tracked patterns of diversification and their influence on company structure. Other research has described theories and strategy analysis tools that lead to a prescription of product diversification for a firm's new product strategy. These tools include the growth-market share matrix (Henderson, 1973) which proposes that a firm should have a "portfolio" of businesses or products in different product/market areas, each characterized by varying degrees in their rates of growth and in the market share that the firm can realize in each market with its own products. Similarly, the product life cycle concept, which views products as having three sequential phases, being growth, maturity, and decline, indicates the desirability of a mixed portfolio of products (Day 1975). Any specific product has a "withdrawal" phase following earlier periods of investment (Abell and Hammond, 1979). Both of these concepts strongly suggest that a single technology embodied in a firm's products has a limited duration of commercial viability and must therefore be augmented by new technologies created for a
diverse set of product offerings. A third major theory, the experience curve, also places constraints on the longevity of a firm's pursuit of a single core technology by encouraging the rapid implementation of large scale manufacturing to reduce unit costs. Abernathy and Wayne (1974) described how the experience curve tends to limit improvements that may be made to a product technology.

For the group of firms that held the author's interest, being relatively small and medium-sized technology-based firms, the precepts of the corporate strategy literature as the models to achieve growth appeared ill-advised. The author believed that if a technology-based firm followed the tenets of the strategy literature, the firm would likely find itself with technically mediocre products and a marketing effort that was ineffective by trying to accomplish an inordinately diverse set of objectives. The author also believed that successful technology-based firms originally enter product areas that have complex, challenging technology, so that if a high level of quality in technology implementation is achieved, such firms can market highly distinctive products and enjoy significant competitive advantage. To reach that level of accomplishment and maintain its technological competitive advantage, the firm must concentrate its development resources on that single technology and its related component technologies, rather than meander into other, unrelated technological fields. In turn, this focus in the technological dimension of new product strategy was seen as congruent with focus in the market applications dimension, where the firm concentrates its resources on reaching a homogeneous set of customer groups that share common functional needs.

While placing this emphasis on the role of strategic focus, it was also felt that there were practical qualifications to the concept. Firms that have shown
a lack of technological aggressiveness, in terms of not making major enhancements to their proprietary core technologies, were hypothesized to gradually lose technological distinctiveness in their products. Similarly, in the market dimension, firms that had been able to find new creative applications of their technology by targeting different but related customer groups were hypothesized to have gained an advantage over firms that had remained isolated in one specific market niche.

In summary, if the data collected from the sample firms supported the hypothesized desirability of strategic focus in technology-based firms, the research would provide empirical support for a perspective on new product strategy that a) takes a critical view of wide-scale diversification, and b) recognizes the role for technology in strategy that is at least the equal of market factors. These ideas are not entirely novel: they had been suggested quite strongly by Rumelt (1972), who found "single" product-line companies to be most successful, and by Utterback and Abernathy (1975), whose innovation model emphasized the importance of technological product innovation in early product-line phases. In parallel with the author's own research, Roberts (1985) has also discussed strategic focus and applied a variant of the concept in a study with Berry of internal venturing in large corporations. The goal of the present research was to continue this collective challenge to the conventional wisdom on corporate diversification. Now, let us see what the data showed.

In the previous chapter, Chapter 5, the description of the analysis procedures used to test the strategic focus hypothesis and the trial run of those procedures on the printers cluster illustrated how the product data were compared to the performance measures for the sample firms. The Spearman rank coefficient
was used to determine the statistical significance of the observed relationship. The strategic focus measure for a firm, referred to as SF(TM) in the Equation Set 1, was the combination of degrees of change in both the technological and market applications dimensions. As described above, the method for calculating SF(TM) was to first take the modified mean (the number of products - 1 ) of change in each dimension, producing the focal point of strategy for that dimension. We also determined the variance for that dimension, which was the difference between levels of change for successive products. Then, the focal points and variances of the two dimensions were multiplied to obtain joint-dimension measures. Finally, the combined focal point was multiplied by the square root of the combined variance to derive the firm's measure of strategic focus. This procedure, described as a "multiplicative" method, was also the "preferred" method of the analysis. Another method, where addition was used, was employed for a reanalysis of the data and the results were compared with those achieved by multiplication.

As with the product data, there was also a preferred method for calculating the performance measure. This method was to first divide each year's annual sales by the age of the firm for that year, and then to take the average of this result for every year of the firm's existence up to 1984. This measure of performance was called Average Normalized Sales.

These measures for strategic focus and performance were computed for each firm and were compared separately for each of the four product-area clusters of the sample. Then, the firms were combined into a single megacluster, and the measures were computed once again. For both the cluster-based analyses and for the sample-wide analysis, the strategic focus measures were ranked from low to

New Product Strategy
high, and the performance measures, from high to low. This reflected our hypothesis that low product newness, synonymous with strategic focus, should correlate with strong performance. For the cluster-based analyses, the Spearman rank coefficient was then employed to test the strength of the correlation between the two rank orders.

Turning to the results, the rank order correlations strongly support the strategic focus hypothesis. High levels of strategic focus in new product strategy correlate favorably with performance for all four clusters of technology-based firms and for the sample taken as a whole. Figure 6.1, 6.2, 6.3, and 6.4 present both the dual rank orders and Spearman rank coefficient for the individual clusters. In each of these figures, the "co" column is the assigned case number of the specific firm in the sample. In the "productrank" column are the rank orders of the firms on the strategic focus measure. The "salesrank" column contains the rank orders by the performance measure. The difference between these two ranks is provided under the "diff" column, which is then squared in the "residual" column. The Spearman rank coefficient generated from the data is then presented at the bottom of each Figure. Figure 6.5 presents the rank orders and the Spearman rank coefficient calculated for the entire sample. Figure 6.6 shows the significance of the respective Spearman rank coefficient values that were derived from the data.
### Figure 6.1
Comparison of Rank Orders for Strategic Focus and Performance Technology and Market Applications Combined
The Composers Cluster

<table>
<thead>
<tr>
<th>co</th>
<th>productrank</th>
<th>salesrank</th>
<th>diff</th>
<th>residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>5</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The Spearman Rank Coefficient is: 0.943

Multiplicative Processing Method and Average Normalized Sales

### Figure 6.2
Comparison of Rank Orders for Strategic Focus and Performance Technology and Market Applications Combined
The Printers Cluster

<table>
<thead>
<tr>
<th>co</th>
<th>productrank</th>
<th>salesrank</th>
<th>diff</th>
<th>residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>18</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>19</td>
<td>1</td>
<td>2</td>
<td>-1</td>
<td>1</td>
</tr>
</tbody>
</table>

The Spearman Rank Coefficient is: 0.900

Multiplicative Processing Method and Average Normalized Sales
Figure 6.3
Comparison of Rank Orders for Strategic Focus and Performance Technology and Market Applications Combined
The Software Cluster

<table>
<thead>
<tr>
<th>co</th>
<th>productrank</th>
<th>salesrank</th>
<th>diff</th>
<th>residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>1</td>
<td>2</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>21</td>
<td>2</td>
<td>4</td>
<td>-2</td>
<td>4</td>
</tr>
<tr>
<td>22</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>23</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>24</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>25</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>26</td>
<td>4</td>
<td>5</td>
<td>-1</td>
<td>1</td>
</tr>
</tbody>
</table>

The Spearman Rank Coefficient is : 0.750

Multiplicative Processing Method and Average Normalized Sales

Figure 6.4
Comparison of Rank Orders for Strategic Focus and Performance Technology and Market Applications Combined
The Terminals Cluster

<table>
<thead>
<tr>
<th>co</th>
<th>productrank</th>
<th>salesrank</th>
<th>diff</th>
<th>residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>5</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>7</td>
<td>-2</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

The Spearman Rank Coefficient is : 0.881

Multiplicative Processing Method and Average Normalized Sales
Figure 6.5
Comparison of Rank Orders for Strategic Focus and Performance
Technology and Market Applications Combined
The Entire Sample

<table>
<thead>
<tr>
<th>co</th>
<th>productrank</th>
<th>salesrank</th>
<th>diff</th>
<th>residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>17</td>
<td>-5</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>19</td>
<td>-3</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>26</td>
<td>26</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>13</td>
<td>23</td>
<td>-10</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>4</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>6</td>
<td>-2</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>15</td>
<td>11</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>3</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>21</td>
<td>18</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>11</td>
<td>19</td>
<td>9</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>12</td>
<td>22</td>
<td>16</td>
<td>6</td>
<td>36</td>
</tr>
<tr>
<td>13</td>
<td>23</td>
<td>21</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>14</td>
<td>17</td>
<td>5</td>
<td>12</td>
<td>144</td>
</tr>
<tr>
<td>15</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>16</td>
<td>18</td>
<td>13</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>17</td>
<td>24</td>
<td>14</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>18</td>
<td>14</td>
<td>8</td>
<td>6</td>
<td>36</td>
</tr>
<tr>
<td>19</td>
<td>1</td>
<td>2</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>6</td>
<td>12</td>
<td>-6</td>
<td>36</td>
</tr>
<tr>
<td>21</td>
<td>7</td>
<td>20</td>
<td>-13</td>
<td>169</td>
</tr>
<tr>
<td>22</td>
<td>8</td>
<td>7</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>23</td>
<td>25</td>
<td>25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>24</td>
<td>11</td>
<td>15</td>
<td>-4</td>
<td>16</td>
</tr>
<tr>
<td>25</td>
<td>20</td>
<td>24</td>
<td>-4</td>
<td>16</td>
</tr>
<tr>
<td>26</td>
<td>9</td>
<td>22</td>
<td>-13</td>
<td>169</td>
</tr>
</tbody>
</table>

1034

The Spearman Rank Coefficient is : 0.646

Multiplicative Processing Method and Average Normalized Sales

Figure 6.6 summarizes the results of these analyses. It shows the
threshold significance level for the appropriate rank coefficient at each test sample,
using a .05 confidence level, and rank coefficients computed from the data.\(^1\) For all
four clusters in the sample, the null hypothesis of the strategic focus theory was rejected at a .05 level of confidence. Only the terminals cluster passed the .01 level of confidence for rejecting the null hypothesis. Given the inherent value of comparing like products in the study of new product strategy, the individual cluster results were the most significant evidence supporting the strategic focus hypothesis. Still however, for the entire sample the null hypothesis was rejected at the .05 level of confidence, and in fact at the .01 level.

![Table](image)

### Figure 6.6
**Summary of Comparison of Rank Orders Between Strategic Focus and Performance (Spearman Rank Coefficients)**

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Number of Cases</th>
<th>Threshold .05 Prob Level</th>
<th>Observed Rank Coefficient</th>
<th>Reject H0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composers</td>
<td>7</td>
<td>.829</td>
<td>.943</td>
<td>Yes</td>
</tr>
<tr>
<td>Printers</td>
<td>5</td>
<td>.900</td>
<td>.900</td>
<td>Yes</td>
</tr>
<tr>
<td>Software</td>
<td>7</td>
<td>.714</td>
<td>.750</td>
<td>Yes</td>
</tr>
<tr>
<td>Terminals</td>
<td>8</td>
<td>.643</td>
<td>.881</td>
<td>Yes</td>
</tr>
<tr>
<td>Mega</td>
<td>26</td>
<td>.329</td>
<td>.646</td>
<td>Yes</td>
</tr>
</tbody>
</table>

The next step of this part of the data analysis was to undertake

---

1. These threshold levels of significance are extracted from the matrices provided in Appendix D.
2. The null hypothesis (H0) is that there is no relationship between strategic focus and performance. There are two types of possible errors that may result from the testing of this hypothesis: first, a Type I error, which is that the null hypothesis is true even though it has been observed to be false; and second, a Type II error, which is that the null hypothesis is accepted even though it is false. These rank orders correlations were tested for the one-tail test.
sensitivity testing. The sensitivity testing that was performed generally supported the original findings. The test that was conducted was to switch the rank orders between pairs of firms, within each cluster, that were within a specific range in the closeness of their respective strategic focus measures. Then, the rank correlations were recalculated and compared to the original correlations. Figures 6.7 provides the supporting data of the product rankings by strategic focus for each cluster.

<table>
<thead>
<tr>
<th>product</th>
<th>co</th>
<th>ftm</th>
<th>disptm</th>
<th>stm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>2.333</td>
<td>0.7500</td>
<td>1.750</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>3.111</td>
<td>2.1111</td>
<td>6.568</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>3.500</td>
<td>2.5000</td>
<td>8.750</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>5.818</td>
<td>2.4545</td>
<td>11.826</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>5.500</td>
<td>2.1667</td>
<td>11.917</td>
</tr>
<tr>
<td>6</td>
<td>13</td>
<td>7.333</td>
<td>2.3333</td>
<td>17.111</td>
</tr>
</tbody>
</table>

Printers:

<table>
<thead>
<tr>
<th>product</th>
<th>co</th>
<th>ftm</th>
<th>disptm</th>
<th>stm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19</td>
<td>2.133</td>
<td>0.7333</td>
<td>1.564</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>2.529</td>
<td>0.8235</td>
<td>2.083</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>2.667</td>
<td>2.0000</td>
<td>5.333</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>4.000</td>
<td>2.0000</td>
<td>8.000</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>7.000</td>
<td>2.6000</td>
<td>18.200</td>
</tr>
</tbody>
</table>

Software:

<table>
<thead>
<tr>
<th>product</th>
<th>co</th>
<th>ftm</th>
<th>disptm</th>
<th>stm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>2.455</td>
<td>1.0000</td>
<td>2.455</td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>1.600</td>
<td>1.6000</td>
<td>2.560</td>
</tr>
<tr>
<td>3</td>
<td>22</td>
<td>2.517</td>
<td>1.0345</td>
<td>2.604</td>
</tr>
<tr>
<td>4</td>
<td>26</td>
<td>3.444</td>
<td>1.0000</td>
<td>3.444</td>
</tr>
<tr>
<td>5</td>
<td>24</td>
<td>2.571</td>
<td>1.5714</td>
<td>4.041</td>
</tr>
<tr>
<td>6</td>
<td>25</td>
<td>5.429</td>
<td>2.0000</td>
<td>10.857</td>
</tr>
<tr>
<td>7</td>
<td>23</td>
<td>8.000</td>
<td>4.0000</td>
<td>32.000</td>
</tr>
</tbody>
</table>

*New Product Strategy*


Terminals:

<table>
<thead>
<tr>
<th>product rank</th>
<th>co</th>
<th>ftm</th>
<th>disptm</th>
<th>stm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>2.182</td>
<td>0.9091</td>
<td>1.983</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>2.750</td>
<td>0.7500</td>
<td>2.063</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>2.909</td>
<td>1.2727</td>
<td>3.702</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>3.333</td>
<td>1.4444</td>
<td>4.815</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>3.571</td>
<td>1.3571</td>
<td>4.847</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>3.091</td>
<td>1.7273</td>
<td>5.339</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>4.625</td>
<td>1.3750</td>
<td>6.359</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>11.000</td>
<td>4.0000</td>
<td>44.000</td>
</tr>
</tbody>
</table>

A sensitivity range separating paired companies of 0.5 was adopted for the testing. Figure 6.7 indicates that several companies in three of the clusters, being composers, software, and terminals, had less than that amount of difference between them in their strategic focus scores. For the purposes of the sensitivity test, this means that if several of their products had been scored differently, e.g. some lower for the higher ranked companies, and some higher for the lower ranked companies, then the rank orders might have changed and had an adverse affect on the rank order correlations reported above. Specifically, the switch of rank orders for close consecutive companies was performed for cases 10 and 12 in the composers cluster (under the column "co" in Figure 6.7). For the software companies, two rank order switches were performed: for cases 20 and 21 first, and then for cases 21 and 22. For the terminals cluster, two rank reorders were also necessary, the first being a switch in the ranks of cases 7 and 6, and the second, between cases 1 and 5. The rank order correlations were recomputed, with the following results:

3. The fact that there was a good margin between all the firms in the printers cluster was fortunate, due to the high Spearman rank significance level associated with the small size of that cluster. Any change in the rank orders in that cluster would have probably produced an observed coefficient less than the threshold of .90.
When the ranks orders of cases 9 and 11 were switched, the observed Spearman rank coefficient was 1.00. In other words, an arbitrary rank order switch generated a perfect correlation.

After switching cases 20 and 21, the observed Spearman rank was .67, which was marginally below the .05 confidence level of .714; however, when cases 21 and 22 were reversed in rank order for the strategic focus measure, the observed Spearman rank increased to .85.

The Spearman rank coefficient, after reordering cases 7 and 6, was higher than the original ranking at .67. Upon switching cases 6 and 3, the Spearman coefficient dropped to .904, but this was still comfortably over the .05 confidence level of .643.

Experimentation was also conducted on the basic computation methods used to test the theory of strategic focus. Two areas existed for modifying the analysis methods, being a) in the calculation of the strategic focus measures for the product data, and b) in the performance measure calculation. Originally, for the product data the components of strategic focus were multiplied to obtain final measures. The multiplication was first performed between the focal points for the separate technological and market applications dimensions to create a joint measure. This was also replicated for the variance measures. Lastly, the combined focal point was multiplied by the square root of the combined variance to obtain the strategic focus measure. The multiplicative method had been chosen as the
preferred method for processing the data because it more accurately reflected the geometric combination of the two dimensions, a concept that was illustrated in Figure 4.1. The variation on this method that was used for testing was to substitute addition for multiplication.

For the performance data, the variation adopted for method testing was to forgo the normalization of the annual sales figures for each firm by the respective age of the company for that year. Normalization had been originally chosen as the preferred method because of observations from previous research that age can bias sales measures in favor of younger, fast-growing firms.

The rank correlations were reexecuted on the data with different combinations of these alternative methods. The results are provided in Figure 6.8. The information is presented in terms of product and performance method combinations. Multiplication for the product data is abbreviated as "Mult"; addition is abbreviated as "Add". Similarly, normalization for the performance data is abbreviated as "Norm." and nonnormalization as "NonNormal".

---

4. These calculations were provided in Equation Sets 1,2, and 3 in Chapter 4.
Figure 6.8
Strategic Focus Tested with Alternative Computation Methods
(Spearman Rank Coefficients)
Technology and Market Applications Combined

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Threshold .05 Prob Level</th>
<th>Analysis Method for Test</th>
<th>Observed Rank Coefficient</th>
<th>Reject H0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composers</td>
<td>.829</td>
<td>Add/Normal</td>
<td>.940</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Add/NonNormal</td>
<td>.714</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mult/NonNormal</td>
<td>.714</td>
<td>No</td>
</tr>
<tr>
<td>Printers</td>
<td>.900</td>
<td>Add/Normal</td>
<td>.900</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Add/NonNormal</td>
<td>.800</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mult/NonNormal</td>
<td>.800</td>
<td>No</td>
</tr>
<tr>
<td>Software</td>
<td>.714</td>
<td>Add/Normal</td>
<td>.786</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Add/NonNormal</td>
<td>.750</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mult/NonNormal</td>
<td>.600</td>
<td>Yes</td>
</tr>
<tr>
<td>Terminals</td>
<td>.643</td>
<td>Add/Normal</td>
<td>.976</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Add/NonNormal</td>
<td>.905</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mult/NonNormal</td>
<td>.738</td>
<td>Yes</td>
</tr>
<tr>
<td>Mega</td>
<td>.329</td>
<td>Add/Normal</td>
<td>.701</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Add/NonNormal</td>
<td>.577</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mult/NonNormal</td>
<td>.527</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Add = Additive Strategic Focus Method
Mult = Multiplicative Strategic Focus Method
Normal = Normalized Average Sales Method
Nonnormal = Unnormalized Average Sales Method

Two observations emerged from the testing of these alternative methods. First, there was no significant difference between the multiplicative and additive methods for the significance of the results of the relationship between strategic focus and performance. As shown in Figure 6.8, the rank coefficients achieved with the additive method passed the necessary threshold levels for all four
clusters and for the entire sample. On the other hand, there was a difference in the results by not factoring age into the calculation of the performance measure. For the two smallest clusters, composers and printers, the nonnormalized method produced Spearman coefficients that were well below the .05 confidence levels. The results were still good, however, for the larger software and terminals samples, as well as for the the overall mega sample. These mixed results did not cause the author undue concern. First, failure might be explainable solely on the basis of the smaller sample size. Secondly, age deserves to be a component of performance measures for technology-based firms because of the volatility in the sales growth of such firms.

In summary, the original analysis of the data and the subsequent sensitivity tests provided clear and strong empirical support for the strategic focus hypothesis. This result challenges the traditional bias in corporate strategy literature towards unrelated diversification and unfocused product portfolios. Focus in the development of product technologies and in market applications orientation is essential to successful growth strategies in small to medium-sized technology-based firms.

The procedures for deriving the strategic focus measure were applied to the data for the technology and market applications dimensions separately. These results were employed to test the comparative significance of the two dimensions of the Product Innovation Model, and will be reported later in this chapter.
2. **The Limits Within Strategic Focus**

Having demonstrated the significance of strategic focus for new product strategy in technology-based firms, attention was turned to exploring the limits of the concept with the data. In the description of the research hypotheses, Chapter 4, the original presentation of the relationship between strategic focus and performance was illustrated as a straight, downward-sloping line (Figure 4.2). This implied that the highest degree of strategic focus, i.e. the lowest levels of technological and market applications change, would correlate most favorably with performance.

Upon review of the hypothesis, this modeling of the strategic focus concept seemed inappropriate: a firm that showed the very lowest levels of cumulative change in its products for both technology and market applications would be demonstrating a lack of aggressiveness and creativity that, over extended time periods, should be expected to have a negative impact on its performance. As a result, the straight line was substituted with a bell-shaped curve (Figure 4.3). On the left-most side of the Figure, the most focused new product strategy pattern, called the "Highly Constrained" strategy, was placed at an assumed less favorable performance level than the "Focused" strategy alternative. When translated into actual events that may occur inside the historical evolution of a technology-based firm's product sequence, the bell-shaped curve meant that a firm that undertakes a significant number of major enhancements to its core technology and has extended its product offerings to more than just a single group of customers would enjoy the best performance. The differentiation in targeted customer groups would also tend to have an impact on distribution channels, where existing channels might be
augmented with new methods of distribution. Basic user functionality, on the other hand, would generally remain consistent across the related customer groups to which the firm’s product technology had been applied.

The objective of this next phase of the analysis was to search for the presence of firms in the sample that represented a Highly Constrained new product strategy and showed poorer performance than other companies with higher levels of change and better performance. The experimental nature of the analysis did not provide the opportunity to specify beforehand a model for a bell-shaped curve that was based on key factors in the Product Innovation Model against which the data could be fitted. Rather, a more intuitive procedure was pursued. First, using the entire sample, the companies were sorted in ascending order and plotted with their respective performance measures as the Y-Axis, shown in Figure 6.9. These values were computed with the multiplicative method referred to above for the product data, and with normalization of the annual sales data. Additionally, the X-axis for strategic focus in Figure 6.9 has a logarithmic scale, which was necessary for effective presentation of the data on the left side of the chart.
Next, the data were entered into an equation modeling package to estimate a curve that fit the data. Using a decay curve as the basis of that modeling, coefficients were generated that, when applied against the formula shown in Equation Set 7 and fitted against the data, had acceptable variances. This curve

---

5. The modeling package is TEQ, authored by Bill Spencer, and is in use at the Physics Department, M.I.T.
was plotted and is presented in Figure 6.10. The range for the X-Axis, strategic focus, was set from 0 to 8. A ceiling of 8 for strategic focus was chosen by referring back to the plot of the actual data in Figure 6.9 where it was observed that companies with strategic focus scores above 8 had no additional bearing on the shape of the curve.

**Equation Set 7**

**The Relationship between Strategic Focus and Performance**

\[ y = A \times e^{-B \times x} \]

\( y = \) Performance  
\( x = \) Strategic Focus  
\( A = 8.970 \)  
\( B = .514 \)  
range=(0,8)
Figure 6.10
A Hypothetical Curve of Strategic Focus Versus Performance

The next step of the analysis was to superimpose the actual data of firms with strategic focus measures of 8 or less on top of the hypothetical curve. This is shown in Figure 6.11. The boxes linked with a perforated line represent the actual data; the darker line connecting small dots represent the modeled curve.
Even though the data, as plotted against the modeled curve, show substantial noise, they provide support for the hypothesized exponential decay curve. To better test for an inside limit to the concept of strategic focus, the data were also fitted against a bell-shaped curve, but that fit was poor when compared to the fitting against the decay curve. Therefore, while we believe that the Highly Constrained new product strategy, noted for its prominent lack of technological and market applications change, does not favor performance as much as a Focused
strategy, a larger sample size and further investigation will be required to empirically test this idea.

3. The Role of Technology in New Product Strategy

Just as strategy research has shown a traditional bias towards diversification, it has also emphasized the role of market factors in the assessment of new product or growth opportunities. For example, Ansoff (1965), Abell and Hammond (1979), and Porter (1980) have described how market segmentation and competitive analysis may be used to evaluate new business opportunities. Similarly, the growth-market share matrix concept concentrates on the market factors of market growth and the firm's current market share.

Despite this orientation, technology has not been completely ignored in the strategy field. Abell (1980), for example, analyzed technology in terms of its contribution to product differentiation. Porter (1984) suggested that technology contributes to the firm's competitive advantage, using the concept of the firm's "value-chain". Utterback and Abernathy (1975) focused on rates of change in embodied product technology over the life cycle of product lines. In a different vein, Fusfeld(1979) and Petrov (1983) have applied technology profiling to business strategy, where the technologies of a firm's products may be examined along many dimensions that include functionality and the sources of technology. Ketteringham and White (1983) provided conceptual definitions of product technology which have also been extensively used in the present research. Lastly, Cooper (1979, 1984a,
1984b) correlated technology "newness" and functionality in successful product introduction.

While these works represent a movement towards treating technology as a distinct variable of strategy, no past research has offered an empirical method for measuring changes in the firm's product technology over time or for assessing technology's influence relative to market factors in a strategic context. The research that is closest in this regard was that performed by Rumelt (1972), who studied the degree of "relatedness" between different business areas of large corporations and found that single product line companies achieved the highest levels of performance. However, Rumelt did not specifically address technology nor did he differentiate it from other elements of product strategy. Using company reports for his data, the best that could be done was to combine the technology and market orientations of distinct product lines and subjectively determine degrees of difference between them.

Our Product Innovation Model has separated technology from market factors. One motivation for this was to show that technology was equally important from a research perspective as market factors in the study of new product strategy in technology-based firms. Further, we wanted to show that technology, once identified as a research variable, could be measured and compared to both market factors and performance. As described before, the basis of technology measurement was the concept of the core technology, being a cohesive set of skills and techniques developed by the firm and that may transcend formal product boundaries. A single core technology may be extended and diversified from its original product use to new, and perhaps, very different types of products made
by the firm at later points in time. The fact that this aspect of the model did serve as a useful tool for tracking changes in product technology over time was itself an important result of the research.

Having incorporated technology in the strategic focus measure, the effort was made to give technology additional meaning by comparing it to the other variable we have examined in new product strategy, the market applications dimension. If we could effectively contrast technology with market applications, in terms of the strategic focus in each dimension versus long term performance, it would help strategy researchers and practitioners better understand the role of technology in strategy by placing it in perspective with a familiar concept, e.g. the role of market factors in strategy.

Technology development was hypothesized to be a less "difficult" resource to manage for relatively small technology-based firms than their market applications "resources". The hypothesis proposed that high levels of market applications newness in a firm’s sequence of products would be even less favorably correlated with performance than high levels of technological change. Conversely, strategic focus in the market applications dimension would correlate more strongly with performance than focus in technology. The reasoning behind this hypothesis came from widespread observations regarding technology-based companies that had achieved outstanding technical feats, particularly in light of the small size of these firms, but had often failed to demonstrate comparable ability in the development of effective sales programs to sell their products. Perhaps one reason for this is the engineering background of many technological entrepreneurs (Roberts 1969) and the lack of market people within many founder groups (Roberts 1983). Similarly,
new technology development may often be achieved with a relatively small number of talented engineers, whereas the implementation of sales programs warranted by the market applications of new products requires the participation of many groups of individuals, some of whom may be external to the organization. The range of activities that may extend from the market applications dimension include, for example, end-user product documentation, the development of marketing materials and advertising, the implementation and maintenance of sales programs, and the creation of effective product support mechanisms. In terms of the research framework, the hypothesis translated into the idea that a diversity of customer groups, user functions, and attempted distribution channels multiplied the complexity of these tasks. Market applications diversity would therefore be most difficult for a small technology-based firm to manage effectively, and in fact, more challenging even than the development of multiple core product technologies.

The testing of this hypothesis required that rank correlations for the two dimensions of the Product Innovation Model be computed separately and then compared. Once again, the multiplicative method for the calculation of the strategic focus measures was employed, as was normalization of the annual sales data for the performance measure. The formulas for the focal point, the variance, and the strategic focus for each dimension were presented in Equation Sets 1, 2, and 3. The next step, identical to the procedure used above for testing strategic focus versus performance for the combined dimensions, was to correlate these two sets of product data rank orders with the rank orders for the firms' performance. This was performed for the clusters individually and for the sample as a whole. The results of the analysis are shown in Figure 6.12.
The analysis of the data supports the hypothesis that high levels of technological change were more manageable than high market application diversity. In three of the four clusters, strategic focus for the market applications dimension was more strongly correlated with performance than technological strategic focus. There was no statistical test performed to measure the significance of the difference between the respective technological and market applications strategic focus scores, although the data show a clear leaning towards the hypothesis. This meant that the penalty for technological diversity was not as high in terms of performance as that for market applications. The research framework defines technological diversity as the existence of multiple core technologies in a firm's products, and market applications diversity, as presence of multiple customer groups, basic user functionality, and distribution channels. This result was also confirmed for the sample as a whole, as seen in the table entries for "Mega" in Figure 6.12. Further evidence supporting this hypothesis will also be provided with an analysis of variance on the data in the following section of this chapter.
Figure 6.12
A Comparison of Strategic Focus in Technology and Market Applications (Spearman Rank Coefficients)

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Threshold at .05 Level</th>
<th>Technology Strategic Focus</th>
<th>Market Strategic Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composers</td>
<td>.829</td>
<td>.028</td>
<td>.886</td>
</tr>
<tr>
<td>Printers</td>
<td>.900</td>
<td>.800</td>
<td>.600</td>
</tr>
<tr>
<td>Software</td>
<td>.714</td>
<td>.428</td>
<td>.679</td>
</tr>
<tr>
<td>Terminals</td>
<td>.643</td>
<td>.429</td>
<td>.786</td>
</tr>
<tr>
<td>Mega</td>
<td>.326</td>
<td>.375</td>
<td>.615</td>
</tr>
</tbody>
</table>

The application of the hypothesis may be illustrated by a recent diversification undertaken by one of companies in the sample. This firm has been a successful manufacturer of general purpose terminals. It has shown a high level of strategic focus, marked by well-targeted major technological enhancements that have created new terminals for emerging but highly related market niches. Recently, however, management sought to diversify and embarked on a program to develop a powerful, multi-user "super-microcomputer". On the technology side, the effort required the introduction of several new core technologies. Using existing hardware engineers, the computer's architecture and main "mother" boards were developed internally. Secondly, an operating system for the computer was licensed.

---
6. Since this new product effort occurred after 1984, it was not included in the product data nor has it had any effect on the firm's performance measure used in the tests above.
from AT&T, as were a set of applications programs from a number of software vendors. Several software engineers were hired to maintain this new software. These tasks were accomplished with surprising rapidity, and the new product was ready for production within a year after the project was formally started.

The marketing side of the project proved far more difficult to achieve. The list of necessary tasks was extensive, and entailed change in all three parameters of the market applications dimension. For example, whereas the firm had previously marketed its terminals for general purpose end-user computer usage on multi-user systems, the new computer was targeted for the small business and software development microcomputer market segments. The basic user functionality of the product was also widely different: the computer was designed for "turnkey" small business applications. Lastly, having sold terminals through distributors and OEMs, the firm sought Value-Added Resellers who would target specific vertical markets with the new computer.

The firm not only failed with this new venture, but its financial position was jeopardized. Many larger computer companies, including Digital Equipment Corporation, Tandy, Altos, and IBM offered equivalently positioned products in a similar time frame and achieved better results. While these are substantial competitors, this particular company's failure appears to be due largely to its inexperience in the market applications of the new product. Our analysis of the data suggested that this case could be generalized to small to medium-sized technology-based firms as a whole. It also showed the dynamic, changing quality of new product strategy where a single company, having chosen and succeeded with a focused strategy for many years, reversed that policy and sought major
diversification into new technological and market applications areas.

4. Strategy Pairings

The data analyses presented above had all employed a comparison of rank orders for measures of strategic focus and performance. This technique treated each measure as a continuum of values representing the measures for each company. Taking a different tack, steps were taken to identify specific pairs of strategy patterns and to compare them to the performance measures. The effect of this was to break up the continuums of strategic focus and performance into specific groups that could be employed for analysis of variance along each dimension of the Product Innovation Model. It was useful to create a chart with four groups of companies:

A. firms that showed high strategic focus in both product technology and market applications,

B. firms that showed high strategic focus in technology and a lack of focus in market applications,

C. firms that had low strategic focus in technology but had been highly targeted in their market applications strategy,

D. and lastly, firms that had been unfocused in both dimensions of the Product Innovation Model.

Figure 6.13 presents the sample divided into quadrants based on the
new product strategy pairs listed above. Contained in that Figure are the frequencies observed in the sample for each quadrant. Figure 6.14 shows the placement of the companies into "high" or "low" categories based on their strategic focus measures for each respective dimension.\textsuperscript{7} The 'co' column contains each firm's sample identification number. The next columns, 'sf t' and 'tech' contain the measure and group assignment for the companies for product technology. Similarly, 'sf m' and "mkt" contain the measures and assignments for the market application dimension. The last column, 'growth', contains the performance measures. Using these data, the range of the observed strategic focus scores for the technological dimension was from .579 to 4.50, and the median point which divided the sample in half was 1.556. Similarly, the range for the market applications strategic focus scores was 1.44 to 12.25, with a median of 2.678.

\textsuperscript{7} The strategic focus measures were calculated with the multiplicative method described before.
Figure 6.13
The Sample Divided into Product Strategy Quadrants
Based on Technology and Market Applications Strategic Focus

<table>
<thead>
<tr>
<th>Technology</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Quad 1</td>
<td>9</td>
</tr>
<tr>
<td>High</td>
<td>Quad 2</td>
<td>5</td>
</tr>
</tbody>
</table>

Low  High

MKT APPLICATIONS
### Figure 6.14
Research Data: Strategic Focus Measures by Dimension, Group Assignments, and Performance

<table>
<thead>
<tr>
<th></th>
<th>co</th>
<th>st</th>
<th>tech</th>
<th>sm</th>
<th>mkt</th>
<th>growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.259</td>
<td>low</td>
<td>2.420</td>
<td>low</td>
<td>0.450</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.500</td>
<td>low</td>
<td>4.516</td>
<td>high</td>
<td>0.382</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.488</td>
<td>low</td>
<td>2.388</td>
<td>low</td>
<td>0.885</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3.000</td>
<td>high</td>
<td>12.250</td>
<td>high</td>
<td>0.076</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1.469</td>
<td>low</td>
<td>3.719</td>
<td>high</td>
<td>0.172</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.579</td>
<td>low</td>
<td>2.678</td>
<td>low</td>
<td>3.398</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1.688</td>
<td>high</td>
<td>1.563</td>
<td>low</td>
<td>2.287</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1.413</td>
<td>low</td>
<td>2.678</td>
<td>low</td>
<td>0.857</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1.111</td>
<td>low</td>
<td>2.250</td>
<td>low</td>
<td>4.168</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1.653</td>
<td>high</td>
<td>6.025</td>
<td>high</td>
<td>0.382</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>3.750</td>
<td>high</td>
<td>2.250</td>
<td>low</td>
<td>1.104</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>2.000</td>
<td>high</td>
<td>6.250</td>
<td>high</td>
<td>0.457</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>1.556</td>
<td>low</td>
<td>9.000</td>
<td>high</td>
<td>0.249</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>1.667</td>
<td>high</td>
<td>2.778</td>
<td>high</td>
<td>2.344</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>1.121</td>
<td>low</td>
<td>1.993</td>
<td>low</td>
<td>7.486</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>2.000</td>
<td>high</td>
<td>4.000</td>
<td>high</td>
<td>0.583</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>2.600</td>
<td>high</td>
<td>5.760</td>
<td>high</td>
<td>0.582</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>2.222</td>
<td>high</td>
<td>1.778</td>
<td>low</td>
<td>1.905</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>0.920</td>
<td>low</td>
<td>1.960</td>
<td>low</td>
<td>4.636</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>1.413</td>
<td>low</td>
<td>2.116</td>
<td>low</td>
<td>0.845</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>1.680</td>
<td>high</td>
<td>1.440</td>
<td>low</td>
<td>0.332</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>1.373</td>
<td>low</td>
<td>1.541</td>
<td>low</td>
<td>1.968</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>4.500</td>
<td>high</td>
<td>6.250</td>
<td>high</td>
<td>0.080</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>1.959</td>
<td>high</td>
<td>1.474</td>
<td>low</td>
<td>0.518</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>1.633</td>
<td>high</td>
<td>4.592</td>
<td>high</td>
<td>0.112</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>1.049</td>
<td>low</td>
<td>3.568</td>
<td>high</td>
<td>0.198</td>
<td></td>
</tr>
</tbody>
</table>

Having segmented the sample firms in this fashion, a two-way analysis of variance was performed, testing the strength of the overall strategic focus model as well as the contribution of each dimension of the model in explaining the variance in the performance variable. The analysis is provided in Figure 6.15. Once again, the technological and market applications variables were each divided into groups on the median of their strategic focus measures. The performance variable was not divided into groups, but rather analyzed as its appears in Figure...
6.14. Given the small size of the sample, twenty-six firms, the results were very strong. First, as can be seen in Figure 6.15, the F statistic for the overall model was most significant, being 21.699 and had an effective probability of error of .001 when rounded to three significant digits. The resulting F statistic for the strategic focus measure in the technological dimension was 3.640, meeting a .07 level of confidence. The analysis of variance of strategic focus in the market applications dimension yielded an even higher confidence level, being .009 with an F ratio of 8.254. No significant interaction effect between the technology and market applications variables was observed in the analysis. The results for the technology and market applications variance analyses also provided clear support for the earlier statement that high levels of relatedness in the market applications of products had an even stronger correlation with performance than technological strategic focus.
Figure 6.15
Two-way Analysis of Variance between Technology and Market Applications
Yielding F Statistics and Levels of Confidence

<table>
<thead>
<tr>
<th>FACTOR</th>
<th>cases</th>
<th>tech</th>
<th>mkt</th>
<th>growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEVELS</td>
<td>26</td>
<td>2</td>
<td>2</td>
<td>26</td>
</tr>
<tr>
<td>TYPE</td>
<td>RANDOM</td>
<td>BETWEEN</td>
<td>BETWEEN</td>
<td>DATA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean</td>
<td>51.1169</td>
<td>1</td>
<td>51.1169</td>
<td>21.699</td>
<td>0.001</td>
</tr>
<tr>
<td>c/tm</td>
<td>51.8265</td>
<td>22</td>
<td>2.3558</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tech</td>
<td>8.5756</td>
<td>1</td>
<td>8.5756</td>
<td>3.640</td>
<td>0.070</td>
</tr>
<tr>
<td>c/tm</td>
<td>51.8265</td>
<td>22</td>
<td>2.3558</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mkt</td>
<td>19.4440</td>
<td>1</td>
<td>19.4440</td>
<td>8.254</td>
<td>0.009</td>
</tr>
<tr>
<td>c/tm</td>
<td>51.8265</td>
<td>22</td>
<td>2.3558</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SS = Sum of Squares
df = Degrees of Freedom
MS = Mean Squares
F = F statistic
p = Level of Confidence

5. Technological Entrepreneurship and First Product Strategies

Prior research has examined the role of technology as an element of the process of company formation. In his sample of M.I.T. "spin-offs" Roberts (1969) found that a high level of technology transfer from prior places of employment correlated significantly with company success. Similarly, Utterback (1984) observed the importance of technology transfer in a sample comprised of both Swedish and
American firms. Alternative product entry strategies were reviewed by Abell and Hammond (1979) as part of market planning in large corporations. They contrasted an "effectiveness" entry strategy with one of "efficiency", where the former strategy emphasizes technical distinctiveness and the latter, low costs achieved through aggressive high volume production. The success of each strategy was illustrated with cases.

The author's interest in the subject was the technical content of the first products made by technology-based firms and the degree of achievement that these products represented compared to the state of the art at the time of their release. The entrepreneur's decisions regarding the technological field for the first product and the level of technological competitiveness to be created for the first product are critical startup decisions that have widespread financial, engineering, and market ramifications. For example, technically complex products often require marketing programs that specifically address a technically sophisticated audience. Uncomplex products, on the other hand, often compete as "commodities" or as well understood technology that is evaluated equally on price as it is on functionality.

For highly complex first products, a high degree of technology transfer from previous places of employment, observed in technology-based firms from previous research, can serve as an effective mechanism for reducing the cost of generating complex technology for a first product. The author also believed that new technology-based firms that enter challenging technological fields, and are able to succeed in developing technologically distinctive first products, gain the advantage of building a barrier to entry to other competitors. Part of the motivation behind this belief was that the alternative strategy, which is to build
technologically undistinctive first products and rely instead on price competitiveness, demands a level of production capacity and efficiency which is beyond the resources of the new, small firm. Furthermore, state of the art technologies that are developed by a startup company can contribute equally to the price-performance ratios offered in its products as might volume production.

Cases from the research sample showed the advantages of a product entry strategy that emphasizes distinctive technology. The most successful firm in the photocomposition systems cluster, for example, began business by making state of the art imaging software used for cartographic applications. This company has consistently applied its technology to new vertical markets, and today, is a major dominant player in the image composition business for newspapers and magazines. Similarly, the leading performer in the software cluster had pioneered large scale, transactional database technology for its first product. On the other hand, both the printers and terminals clusters show an opposite pattern, where the leading performers introduced first products that gained substantial market share as general purpose products that competed by a combination of price and functionality.

There is also substantial risk in an "effectiveness" product entry strategy. The firm may either fail or be late in delivering its technologically advanced first product. A recent example is a new computer company in the Boston area, Encore Computer, whose first main product is a powerful mid-sized computer that employs "parallel" or multi-processing for greater speed. Encore had a guaranteed, multi-year revenue stream from this product with a large OEM commitment by Sperry Corporation. However, Sperry has canceled its commitment
because of Encore's failure to deliver a functional product. This cancellation has severely affected Encore's financial stability and image in the industry. In the Fourth Chapter, a similar case of speech recognition systems was described. That firm's technology was highly advanced, but its products proved overly complex and prone to noise complications when installed in the industrial environments that the firm had targeted. Today, that firm is no longer in existence. This case also demonstrated that a firm that attempts highly complex first products faces the danger of spending too much time in the laboratory with a lack of close user interaction or feedback.

Even if successful in the long-run, a distinctive technology entry strategy may prove financially difficult for the new enterprise. A case that illustrates this is a company in the terminals cluster that has produced a variety of hand-held terminals. Stating that his company's technology was simply "ahead of its time", the founder of this firm indicated that his company took approximately six years from startup to achieve a modest degree of financial stability. His technological gamble has been rewarded in recent years, however, and the company enjoys a wide range of commercial and military applications for its products.

While the author felt that there would be no "magic answers" on this issue of first product entry strategy, a method was developed to study the technological content of first products. Data for the first products of the sample firms were gathered and scored as containing one of four levels of technical accomplishment relative to the state of the art in their respective industries at the time of product release. These levels of achievement specified were, in increasing order of sophistication in product technology:
1. first products that were undistinctive relative to the state of the art at the
time of the product’s introduction,

2. first products that were distinctive by virtue of a better engineering of
existing, known technology,

3. highly distinctive first products, where substantial improvements were to an
existing, known technology that affected the way that technology was used
and perceived throughout the industry, and

4. first products that represented a major technological breakthrough, where
novel technology was pioneered and implemented.

As the data were collected, the striking point that emerged was that the
sample was comprised primarily of firms that had been technologically aggressive in
their startup product development activities. Only two firms were placed in the
first category; 8 in the second; 13 in the third; and 3 in the fourth and highest
category. These data are provided in Figure 6.16. The 'co' columns contains the
company case numbers; the 't' column indicates the first product technology scores;
and the 'growth' column shows the performance measures, where annual sales were
first normalized by relative age.


Figure 6.16
First Product Technology Scores and Performance by Case

<table>
<thead>
<tr>
<th>co</th>
<th>t</th>
<th>growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
<td>-</td>
<td>------</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>0.450</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0.382</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>0.885</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>0.076</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>0.172</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>3.398</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>2.287</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>0.857</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>4.168</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>0.382</td>
</tr>
<tr>
<td>11</td>
<td>4</td>
<td>1.104</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>0.457</td>
</tr>
<tr>
<td>13</td>
<td>3</td>
<td>0.249</td>
</tr>
<tr>
<td>14</td>
<td>4</td>
<td>2.344</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>7.486</td>
</tr>
<tr>
<td>16</td>
<td>3</td>
<td>0.583</td>
</tr>
<tr>
<td>17</td>
<td>2</td>
<td>0.582</td>
</tr>
<tr>
<td>18</td>
<td>1</td>
<td>1.905</td>
</tr>
<tr>
<td>19</td>
<td>2</td>
<td>4.636</td>
</tr>
<tr>
<td>20</td>
<td>3</td>
<td>0.845</td>
</tr>
<tr>
<td>21</td>
<td>3</td>
<td>0.332</td>
</tr>
<tr>
<td>22</td>
<td>3</td>
<td>1.968</td>
</tr>
<tr>
<td>23</td>
<td>3</td>
<td>0.080</td>
</tr>
<tr>
<td>24</td>
<td>3</td>
<td>0.518</td>
</tr>
<tr>
<td>25</td>
<td>3</td>
<td>0.112</td>
</tr>
<tr>
<td>26</td>
<td>2</td>
<td>0.198</td>
</tr>
</tbody>
</table>

Frequencies:

<table>
<thead>
<tr>
<th>t</th>
<th>Freq</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>-----</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

TOTAL 26

The next step was to correlate these data with long-term performance. It was expected that there would little correlation between first product technology
and performance because the underlying premise of our research model was that new product strategy was the cumulative result of all the firm's products. Therefore, having seen that there is a relationship between new product strategy and performance, through the conduit of strategic focus, it was reasonable that performance would not be significantly affected by any single product, including the first product.

For purposes of testing, a linear relationship between first product technology scores and performance was assumed, and a regression was performed on the two variables. The results are provided in Figure 6.17.
Figure 6.17
Regression Analysis of First Product Technology and Performance

Analysis For 26 Points of 2 Variables:
First Product Technology (FirstTech) and Performance

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>FirstTech</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIN</td>
<td>1.0000</td>
<td>0.0760</td>
</tr>
<tr>
<td>MAX</td>
<td>4.0000</td>
<td>7.4860</td>
</tr>
<tr>
<td>MEAN</td>
<td>2.6538</td>
<td>1.4022</td>
</tr>
<tr>
<td>STANDARD DEV</td>
<td>0.7971</td>
<td>1.7768</td>
</tr>
</tbody>
</table>

**CORRELATION MATRIX:**

<table>
<thead>
<tr>
<th></th>
<th>FirstTech</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>FirstTech</td>
<td>1.0000</td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td>-0.1511</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

**REGRESSION EQUATIONS**

<table>
<thead>
<tr>
<th>SLOPES</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FirstTech</td>
<td>-0.3368</td>
</tr>
<tr>
<td>Performance</td>
<td>-0.0678</td>
</tr>
</tbody>
</table>

| INTERCEPT   | 2.7489     | 2.2959     |
| SumSquare   | 15.8846    | 78.9275    |

| R-Square    | 0.0228     | 0.0228     |
| F(1,24)     | 0.5606     | 0.5606     |
| prob (F)    | 0.4613     | 0.4613     |

The low R-Square coefficient, and the poor level of confidence associated with the F ratio allow us to safely reject a hypothesized relationship between first product technology and performance. This finding reemphasized the importance of the historical perspective of new product strategy that the author adopted for the research.

In a similar vein, a premise of our approach to new product strategy is
that it is a dynamic phenomenon, where each individual product must be evaluated and incorporated into the strategic focus measure. The analysis of first product technology issue also provided the opportunity to test this premise by observing the degree to which technology-based firms carry forward their initial technology policies with respect to technological aggressiveness into subsequent products. The issue was operationalized to the question of whether companies that showed either the third or fourth levels of first product technical accomplishment also exhibited high levels of technological newness in their subsequent products. If the premise mentioned above was true, the data would not generally support this "carry forward" hypothesis.

To test the continuity of levels of technical aggressiveness between the first and subsequent products, another regression was performed between the first product technology scores and the strategic focus measures for the technological dimension. These results, shown in Figure 6.18, clearly reject a hypothesized correlation between levels of technical achievement in first products and levels of technological change in all subsequent products. The observed R-Square coefficient was only .33, and the F ratio was significant at a confidence level of only approximately .37. This result also provided support for the author's belief that firms that began business by successfully entering complex, difficult technological fields, were then able to exploit their technological advantage through a continued set of minor improvements and well-timed major enhancements, the latter used to integrate new component technologies and to perhaps extend existing product technology into new, attractive market opportunities.
Figure 6.18
Regression Analysis of First Product Technology and Subsequent Product Technology

Analysis for 26 points of 2 variables:
First Product Technology (First Tech) and
Technological Strategic Focus for Subsequent Products (RestTech)

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>FirstTech</th>
<th>RestTech</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIN</td>
<td>1.0000</td>
<td>0.5790</td>
</tr>
<tr>
<td>MAX</td>
<td>4.0000</td>
<td>4.5000</td>
</tr>
<tr>
<td>MEAN</td>
<td>2.6538</td>
<td>1.7924</td>
</tr>
<tr>
<td>STANDARD DEV</td>
<td>0.7971</td>
<td>0.8589</td>
</tr>
</tbody>
</table>

CORRELATION MATRIX:
| FirstTech | 1.0000 |
| RestTech  | 0.1825 | 1.0000 |

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>FirstTech</th>
<th>RestTech</th>
</tr>
</thead>
</table>

REGRESSION EQUATIONS

<table>
<thead>
<tr>
<th>SLOPES</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FirstTech</td>
<td>0.1967</td>
</tr>
<tr>
<td>RestTech</td>
<td>0.1694</td>
</tr>
</tbody>
</table>

| INTERCEPT        | 2.3503     | 1.2705   |
| SumSquare        | 15.8846    | 18.4445  |

| R-Square         | 0.0333     | 0.0333   |
| F(1,24)          | 0.8269     | 0.8269   |
| prob (F)         | 0.3722     | 0.3722   |
6. The Rate of Product Innovation

Utterback and Abernathy (1975), in part using research data gathered by Myers and Marquis (1969), developed an innovation model that contrasted the rates of innovation for product development and process improvement. They hypothesized that in early phases of the life cycle of a technology, product innovation remains high and process innovation low. Subsequently, once product design stabilizes, process improvements accelerate. In the final stages of the life cycle, process improvements are dominant and help lower the cost structures of the product line. This reasoning was extended by Abernathy and Wayne (1974) who suggested that premature investment in the large scale manufacturing of a new product can stifle necessary product design enhancements.

Our Product Innovation Model has measured types of technology development on a per commercial product basis. This should not be confused with the "rate" of innovation. In fact, it was argued in previous chapters that a series of major enhancements to a single core technology may prove equally challenging as the implementation of different core technologies, depending on the nature of the technologies involved. In other words, a company can be highly aggressive technologically in a focused manner.

Nonetheless, several measures were developed to gather data to investigate the rate of innovation in product technology. The first of these measures was called Average Product Releases. It was calculated as the mean number of commercial products released by a firm for its years of existence up to and including 1984. It was hypothesized that this measure would show no
significant correlation with long-term performance. The reasoning for this is that it
is the content of products, in terms of embodied technology, that has a relationship
with performance and not the number of products themselves. The measure was
therefore viewed in part as a countertest to the Product Innovation Model.

Average Product Releases, calculated for each company by dividing its
total number of products by its age current to 1984 or the last year of business
operations, was correlated with performance by a comparison of company ranks.\(^8\)
The results of the analysis, conducted for each cluster and then the sample as a
whole, are shown in Figure 6.19. The hypothesis that this measure would have no
significant correlation with performance was strongly supported.

\textbf{Figure 6.19}
\textbf{Spearman Rank Correlation Results Comparing}
\textbf{Average Product Releases with Performance}

\begin{tabular}{|c|c|c|c|c|}
\hline
Cluster & Number of Cases & Threshold at .05 Level & Observed Coefficient & Reject H0 \\
\hline
Composers & 7 & .829 & .600 & Yes \\
Printers & 5 & .900 & .500 & Yes \\
Software & 7 & .714 & .607 & Yes \\
Terminals & 8 & .643 & .42 & Yes \\
Mega & 26 & .326 & .164 & Yes \\
\hline
\end{tabular}

\(^8\) Where each annual sales figure was first divided by relative age.
Similarly, a regression analysis was performed between Average Product Releases and performance, where a linear relationship between the two variables was assumed for the test. The results, shown in Figure 6.20, also indicated no correlation between Average Product Release and performance, with the R-Square coefficient being only .02.
Figure 6.20
Average Product Release Measures and Performance Data by Company Followed by a Regression Analysis

<table>
<thead>
<tr>
<th>Case</th>
<th>AVGPROD</th>
<th>PERFORMANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.6666</td>
<td>0.450</td>
</tr>
<tr>
<td>2</td>
<td>0.6000</td>
<td>0.382</td>
</tr>
<tr>
<td>3</td>
<td>1.2000</td>
<td>0.885</td>
</tr>
<tr>
<td>4</td>
<td>0.6000</td>
<td>0.076</td>
</tr>
<tr>
<td>5</td>
<td>1.3636</td>
<td>0.172</td>
</tr>
<tr>
<td>6</td>
<td>2.0000</td>
<td>3.398</td>
</tr>
<tr>
<td>7</td>
<td>0.6666</td>
<td>2.287</td>
</tr>
<tr>
<td>8</td>
<td>0.7500</td>
<td>0.857</td>
</tr>
<tr>
<td>9</td>
<td>1.3000</td>
<td>4.168</td>
</tr>
<tr>
<td>10</td>
<td>0.8000</td>
<td>0.382</td>
</tr>
<tr>
<td>11</td>
<td>0.7500</td>
<td>1.104</td>
</tr>
<tr>
<td>12</td>
<td>0.4666</td>
<td>0.457</td>
</tr>
<tr>
<td>13</td>
<td>0.2666</td>
<td>0.249</td>
</tr>
<tr>
<td>14</td>
<td>0.7142</td>
<td>2.344</td>
</tr>
<tr>
<td>15</td>
<td>1.2000</td>
<td>7.486</td>
</tr>
<tr>
<td>16</td>
<td>0.5000</td>
<td>0.583</td>
</tr>
<tr>
<td>17</td>
<td>0.8571</td>
<td>0.582</td>
</tr>
<tr>
<td>18</td>
<td>0.4375</td>
<td>1.905</td>
</tr>
<tr>
<td>19</td>
<td>2.2857</td>
<td>4.636</td>
</tr>
<tr>
<td>20</td>
<td>3.0000</td>
<td>0.845</td>
</tr>
<tr>
<td>21</td>
<td>1.5000</td>
<td>0.332</td>
</tr>
<tr>
<td>22</td>
<td>1.7647</td>
<td>1.968</td>
</tr>
<tr>
<td>23</td>
<td>0.7500</td>
<td>0.080</td>
</tr>
<tr>
<td>24</td>
<td>1.5000</td>
<td>0.518</td>
</tr>
<tr>
<td>25</td>
<td>1.0000</td>
<td>0.112</td>
</tr>
<tr>
<td>26</td>
<td>3.5000</td>
<td>0.198</td>
</tr>
</tbody>
</table>

REGRESSION EQUATIONS

| SLOPES | : | 0.3213 |
| AVGPROD | : |       |
| PERFORMANCE | : | 0.0641 |
| INTERCEPT | : | 1.1193 |
| SumSquare | : | 15.7457 |
| R-Square | : | 0.0206 |
| F(1,24) | : | 0.5046 |
| prob (F) | : | 0.4843 |
The second measure used to examine the rate of product innovation was called *Innovation Intensity*. This measure was first proposed by Ishikawa (1985), who developed the concept in conjunction with Professor Roberts. It was calculated as the mean level of technological change per year for each firm. Like the strategic focus measure for the technological dimension, *Innovation Intensity* is based on the levels of technological change observed between successive products using the Product Innovation Model. However, the difference between these two measures is that *Innovation Intensity* divides the cumulative technological change by the age of the firm rather than the number of products minus one. As might be expected, the age of the companies in the sample did show a positive correlation with the number of products released by them. The correlation coefficient between age and number of products was .4069. Similar to the strategic focus measure, it was hypothesized that *Innovation Intensity* would be negatively correlated with high performance.

Spearman rank correlations were performed between *Innovation Intensity* and performance.\(^9\) The results were mixed as shown in Figure 6.21 . When the tests were run for each cluster separately, only the printers cluster achieved a significant result. However, for the entire sample, the observed Spearman rank coefficient was highly significant, supporting substantiating the concept that low levels of average technological change per year are favorably correlated with strong performance.

\(^9\) Normalized annual sales.
### Figure 6.21
Comparison of Ranks Between Innovation Intensity and Performance (Spearman Rank Coefficients)

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Number of Cases</th>
<th>Threshold at .05 Level</th>
<th>Observed Coefficient</th>
<th>Reject H0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composers</td>
<td>7</td>
<td>.829</td>
<td>.543</td>
<td>No</td>
</tr>
<tr>
<td>Printers</td>
<td>5</td>
<td>.900</td>
<td>.900</td>
<td>Yes</td>
</tr>
<tr>
<td>Software</td>
<td>7</td>
<td>.714</td>
<td>.500</td>
<td>No</td>
</tr>
<tr>
<td>Terminals</td>
<td>8</td>
<td>.643</td>
<td>.500</td>
<td>No</td>
</tr>
<tr>
<td>Mega</td>
<td>26</td>
<td>.326</td>
<td>.559</td>
<td>Yes</td>
</tr>
</tbody>
</table>

In summary, this set of analyses showed moderate support for the *Innovation Intensity* hypothesis. However, the concept introduces the research variable of time, that if used correctly within the Product Innovation Model might provide a better understanding of the dynamics of new product strategy. The time variable is analogous to the *variance* measure in this regard. *Variance* had been employed to distinguish between two companies that had achieved the same *focal point* of new product strategy, but had done so through widely different incremental new product steps. Similarly, the time variable might be used to differentiate two companies that had achieved equivalent strategic focus scores with markedly different time periods. This also suggests the possible applications of time series analysis on the product sequences of the sample firms to identify isolated subset patterns of new product strategy.
7. The Research As A Foundation

The operational design of our research has been to track product sequences for a particular group of firms along levels of proposed change for two dimensions within new product strategy, embodied product technology and the market applications of products. The objective was to employ the most concrete "facts" available for evaluating new product strategy, being all the commercially released products of a firm, and not simply single "successes" or "failures". The Model allowed us to examine what is "behind" products, and how their technological content and market applications change over time. For the technological dimension, a unit of analysis, the core technology, was used as the foundation for determining degrees of change, and specific criteria based on that unit of analysis were employed to identify levels of change. For the second dimension, the market applications of products, two parameters were adopted from Abell (1980), being the end-user customer groups and the basic product functionality. The distribution channels for each product was added as a third parameter. Another important aspect of the methodology was the sample design. To effectively study new product strategy, it was essential to compare like products, and thus, a clustered sample design was selected. The sample also comprised a broad range of firms in terms of performance, including companies that had been leaders in their respective industries as well as others that had succumbed to their competition. An equally important element of the methodology was that both the Product Innovation Model and data collection process proved to be easily understood by the entrepreneurs who were interviewed, thereby helping to assure the accuracy of the information that they provided.
A reexamination of the scope of the research centers on two basic definitions. The first is the *technology-based firm*, defined in the Introduction to include companies in industries that had and continue to be profoundly and continuously affected by technological change. The sample was constructed to contain four clusters of such firms. As a representative group of market segments, the four clusters, being computer-based photocomposition systems manufacturers, printer manufacturers, software development tools vendors, and terminal manufacturers, provided diversity and depth. Clearly, however, there are many more industry segments that might be included in future research efforts. For example, Computer Aided Design systems vendors are a homogeneous and exciting cluster of firms. Similarly, the market segment for inter-computer communications contains many firms making products from modems to "token-ring" or Ethernet communications interfaces. The software business also has a wide range of product groups for specific vertical applications and more recently, for artificial intelligence applications. Biotechnology and factory automation are other candidates against which the research methodology and the strategic focus theory might be tested. We are confident that the results of the research would be confirmed in investigations of such industries because firms participating in them have internal development environments and face external competitive pressures similar to the firms in the product-area clusters included in the present research. At the same time, we have strong reservations about extending the research results to other industries that are not strongly affected by rapid technological change because of the telling affect that such change has on the shape and outcomes of new product decisions.
The size of the firm is a second element in defining the scope of the research. We are again confident that the research results apply to small and medium-sized technology-based firms as defined above. A strength of the sample design was its diversity in terms of the performance measure. The largest company had achieved approximately $160 million in 1984 sales. While it is not appropriate to state that the research domain was only "small" technology-based firms, the research did not encompass "large" firms. There were several motivations behind this aspect of the sample design. In the innovation literature, independent technological entrepreneurship has been distinguished from internal corporate venturing in large companies (Roberts 1968). There are fundamental characteristics shown by small and medium-sized firms that may be viewed as preconditions for the results of our research and that are not found in large companies. These preconditions include operational independence and a direct linkage between the product-generating entity's technology and market decisions and its ability to implement these decisions. This linkage allows new product decisions to have direct impact on the entity's performance. In the large corporation, however, one department may make a product that is marketed by another department or subsidiary, or similarly, create the specifications for a new product that are then implemented by another engineering group or subsidiary. The synergy that may exist between disparate entities in large corporations may therefore interfere with the measurement of the relationship between the degree of strategic focus and performance.

A second factor in limiting the scope of the sample design to small and medium-sized firms was pragmatic. Requiring an in-depth investigation of each commercial product released by the firm, the research methodology was not
appropriate for large diversified companies such as IBM or Digital Equipment Corporation. Alternative approaches, such as singling out individual product successes and failures (Cooper 1979) or using company reports (Rumelt 1972), were both inadequate tools for studying in-depth new product strategy at the product sequence level. Further, the larger the company, the more difficult it is definitively to place the firm in a particular product cluster, given the diverse product lines offered by most large technology-based companies. We do not preclude the applicability of the strategic focus theory to the analysis of diversification patterns in large companies, nor is it suggested that new product strategy cannot be studied in an historical and empirical manner in such firms, especially at the divisional or strategic business unit. In fact, Roberts and Berry (1985) applied a variant of the author's research model to the study of business entry strategies at EG&G. However, a more suitable methodology must be devised before a strategic focus research effort is undertaken in large companies.

A third and equally fundamental consideration for the domain of research is that of causality. We have shown that a significant relationship exists between strategic focus in new product strategy and performance. In comparing these two variables, it is tempting to make the the implicit and logical assumption that particular patterns of new product strategy contribute to the firm's rate of growth, where a focused new product strategy leads to high performance, and an unfocused strategy to poorer performance. It could be hypothesized, however, that in certain cases past performance might itself affect new product decisions. The most direct example is that of a firm that develops a product in a specific core technology area and fails commercially with the product. Because of the threat of business foreclosure, the firm is forced to enter into a different, unrelated core
technology for its next product. Of course, this is not the only possible decision that such a firm could make. An alternative course of action might be to repackage and otherwise reposition its existing product technology to a different set of market applications. Still, the threat of an inverted causality between new product strategy and performance exists. The author believes, however, that in the twenty-six cases he studied this did not occur. The firms in this group that entered into new core technologies and market application areas appear to the author to have done so because of new perceived market opportunities rather than for reasons of financial duress.

Further research of new product strategy in technology-based firms that employs the author's research design may wish to consider additional conceptual development to the Product Innovation Model. Specifically, two potential variables that might be added to the market applications dimension became apparent in the course of our investigations. The first of these is the degree of existing competition within a new customer group that has been entered by the firm. The second is the growth potential of markets both before and after they are entered. The techniques developed by Porter (1980) are applicable to establishing measures and hypotheses for both issues. However, growth potential and levels of competition are difficult to measure precisely because small companies often do not gather market share data. Nonetheless, the utility of competitive analysis for the study of new product strategy is readily clear by looking at two of the clusters in our own sample, terminals and printers. Both industry segments have been dramatically affected by price competition from overseas suppliers. Measurement of market growth and market share could also be used to address the issue of reverse causality described above. In addition, a third dimension might be added to the
Product Innovation Model that reflects the managerial style and procedures employed to develop the technology and marketing programs for new products.

Taking into consideration limitations arising from the scope of the research and these potential improvements, we have nonetheless shown that new product strategy may be examined empirically. The concept of strategic focus is central to product decision-making and, by extension, to diversification strategy. It was suggested earlier in this chapter that previous researchers had challenged the diversification concept as a precept of growth strategy and market planning. However, no one had substantiated that challenge with empirical evidence at the level of new product strategy. Acknowledging the particular set of firms included in the research, and the modest size of the sample, the conceptual framework, methodology, and analyses of this research have created a foundation for conclusively providing that evidence. We have observed a significant relationship between low levels of combined technological and market applications change and performance. The technology-based firms that had concentrated on single core technologies, aggressively upgrading these technologies with new generations of component technology, and which had also been targeted in their marketing programs were the strongest performers in the sample. On the other hand, firms that had developed multiple core technologies and had substantial diversity in the customer groups, product functions, and distribution channels for their products were the poor performers. Technological focus was contrasted with market applications focus, and diversity in the latter dimension was found to be accompanied by a higher penalty in terms of performance.

In challenging the conventions of corporate strategy during his time
period, Ansoff (1965) argued effectively that methods of financial analysis were both insufficient and potentially damaging as the sole techniques for decision-making in areas of corporate growth and business diversification. This research makes an equivalent argument. Management theories that promote widespread diversity in product technologies and marketplaces ignore the requirements of technological excellence and focus in marketing that are necessary for success in today's technology-based sectors.
Bibliography


P. Lawrence and J. Lorsch, Organization and Environment, Division of Research,


S. Myers and D.G. Marquis, Successful Industrial Innovation, National Science


S. Wheelwright and S. Makridakis, "Qualitative Approaches to Forecasting", in M.L. Tushman and W.L. Moore (eds.), Readings in the Management of Innovations,
Pitman, Boston, 1982.

Appendix A

PRODUCT DATA
Appendix A

PRODUCT DATA

PRODUCT DATA
CASE 1

1  Technology :  2 - Passenger Airlines Applications software: communications element
    Market Appl:  - For a large computer: high tech transfer from former employer; sold to former employer

2  Technology :  3 - Built own terminals (new core), built previous communications software
    Market Appl:  4 - New usage: banking network appl; new group: thrift institutions; new channel: new direct sales force

3  Technology :  1 - 12" version of terminal
    Market Appl:  2 - New use: complete PAR for airlines; existing end-user: airlines; same channel: direct sales

4  Technology :  1 - Dumb 9" terminal product
    Market Appl:  1 - Same

5  Technology :  1 - Dumb 12" terminal product
    Market Appl:  1 - Same

6  Technology :  3 - Communications controller, 8088-based; new core combined with PARS system
    Market Appl:  2 - New use: multi-user clustered applications networked to mainframes

7  Technology :  2 - Floppy disk controller to complete workstation: new core but was purchased and enhanced
    Market Appl:  1 - Same

8  Technology :  2 - New communications protocol: 3270 emulation
    Market Appl:  1 - Same
Technology: 2 - Major new packaging, restyling of terminal products
Market Appl: 1 - Same

Technology: 2 - Extensive multi-user version of PARS product - up to 40 devices
Market Appl: 1 - Same
PRODUCT DATA
CASE 2

1 Technology: 2 - Credit authorization system, for department stores; time-share software system
Market Appl: - For a large department store chain; direct sales

2 Technology: 2 - Check authorization system: new applications software development; also time-share service
Market Appl: 3 - New group: grocery store chain; new usage: check (versus credit) validation

3 Technology: 3 - Transaction terminals (new core) combined with credit authorization system
Market Appl: 3 - New function: on-site credit checking; new group: sold to banks

4 Technology: 1 - Improved local intelligence in transaction terminals
Market Appl: 1 - Same (for banks and retail dept stores)

5 Technology: 1 - Added safe deposit box below terminal station to make a "Shopper's Bank"
Market Appl: 2 - New usage: cash and check deposits in retail environments

6 Technology: 2 - Added a "swipe" credit card reader to check authorization terminals; bought it and integrated.
Market Appl: 1 - Same

7 Technology: 2 - Added cash dispenser to retail banking unit; major development
Market Appl: 2 - New usage: giving retail shopper's cash on-site in a store

8 Technology: 3 - Developed electronic funds transfer software (new core), linking banks to supermarkets
Market Appl: 3 - New usage: full EFT services; new group: supermarket chains

9 Technology: 2 - Time and Attendance applications package, for supermarkets and retail stores
Market Appl: 2 - Same group and channels; new usage: In store personnel control
PRODUCT DATA
CASE 3

1 Technology: 3 - Single-board graphics imaging terminal (Data General compatible)
Market Appl: Usage: image display, used first for cat scanners; group: systems integrators; channel: VARs

2 Technology: 1 - Added color capability; some new boards and firmware
Market Appl: 1 - Same

3 Technology: 2 - Added display controller, local processing intelligence
Market Appl: 1 - Same

4 Technology: 1 - Repackaged display terminal
Market Appl: 1 - Same

5 Technology: 2 - Major upgrade of previous product; new design, ergonomics, etc
Market Appl: 2 - Same function: imaging; new group: CAD/CAM; still VARs

6 Technology: 3 - Added graphics database software to make a full CAD system
Market Appl: 3 - New group: integrated circuit manufacturers; built new direct sales force

7 Technology: 1 - Lower cost graphics workstation: cost reductions
Market Appl: 1 - Went back to VARs and systems integrators

8 Technology: 1 - Color version of previous product
Market Appl: 1 - Same

9 Technology: 2 - Turnkey system for solids modeling: CAD applications; (not a new core - major upgrade of previous database software)
Market Appl: 2 - New usage: solds modeling; same customers: CAD customers; both VARs and direct channels

10 Technology: 2 - Turnkey Medical Imaging system: major applications software development
Market Appl: 2 - New usage: ultrasound and cat-scanning display station; sold to systems integrators through direct

11 Technology: 2 - Seismic software system, new applications modeling software
Market Appl: 2 - New group: oil companies; usage: basic modeling, sold through VARs

12 Technology: 1 - Added more three-dimensional graphics display capability to terminals
Market Appl: 1 - Same (upgrade for all previous customers)
PRODUCT DATA
CASE 4

1 Technology: 2 - Infra-red touch terminal for manufacturing environments
Market Appl: - Sold to steel-mills; direct sales; for process control

2 Technology: 2 - Major enhancement to infra-red terminal
Market Appl: 3 - New Group: computer manufacturers for systems integration; new channel - OEMs

3 Technology: 4 - Family of plug-in scientific, electronics ROMS - 8088 compatible for voice synthesis
Market Appl: 4 - New function: custom engineering systems development; new group: E.E. "hackers"; new channel: mail order
PRODUCT DATA
CASE 5

1 Technology: 3 - First hand held terminal, "folded" printed circuit boards, using CMOS and dot-matrix
Market Appl: - Created a new market; did not sell many - "ahead of its time"

2 Technology: 3 - Major redesign or hand-held terminal, added LED display; new related core
Market Appl: 3 - New function: industrial process control; new group: manufacturers; same direct sales

3 Technology: 1 - Added two-line display
Market Appl: 1 - Same

4 Technology: 1 - Less expensive version; used "idiot lights", not LED
Market Appl: 2 - New usage: quality control (versus process control); same manufacturers and direct sales

5 Technology: 2 - 4 line display, scrolling capability with new RCA chip; substantial engineering
Market Appl: 1 - Same

6 Technology: 1 - two-line display version of previous product
Market Appl: 1 - Same

7 Technology: 2 - New generation of hand held terminals, used Motorola 6801; new "Starburst" Display
Market Appl: 1 - Same (still for process control in manufacturing environments)

8 Technology: 1 - Two-line version of previous product
Market Appl: 1 - Same

9 Technology: 3 - Developed "membrane" keyboard on unit; new related core (encountered many operational problems)
Market Appl: 2 - New function: applied to specific types of process control applications

10 Technology: 2 - Sealed, waterproof, shock-resistant terminal
Market Appl: 3 - New group: military agencies; new usage: outside, weapons control; same direct sales

11 Technology: 1 - Minor upgrade of previous product
Market Appl: 2 - Quasi-military equipment control: new set of customers

12 Technology: 2 - Repackaged previous products, added high intensity displays
Market Appl: 2 - New usage: night time equipment monitoring; new group: aerospace
Technology: 2 - A "mounted" version of small terminals
Market Appl: 3 - New function: "station-to-station" process monitoring; new group: different set of manufacturing users

Technology: 2 - Battery-powered unit, a major development effort, with LCD display
Market Appl: 3 - New function: mobile service applications (monitor Coke machines); new customers: computer disk manufactures, vending machine suppliers

Technology: 1 - Repackaged terminal
Market Appl: 2 - New function: data acquisition from machinery; same customers: manufacturing customers
PRODUCT DATA
CASE 6

1 Technology: 2 - Dumb terminal, with user-changed emulations to work with different computers
Market Appl: 1 - General computer usage: multiple emulation made it an instant winner

2 Technology: 2 - Added DEC VT-100 emulation and 132 line display
Market Appl: 1 - Same, using distributors

3 Technology: 1 - Implemented ANSI standard emulation
Market Appl: 2 - New channel: marketed through and OEM computer company

4 Technology: 1 - Customized terminal for Burroughs
Market Appl: 2 - New group: the OEMs specific market niche

5 Technology: 1 - Added DG emulation
Market Appl: 2 - New group: another market niche inside general computer market

6 Technology: 1 - Upgrade of ANSI terminal product
Market Appl: 1 - Same

7 Technology: 1 - Redesign of housing for earlier terminals
Market Appl: 1 - Same

8 Technology: 2 - New generation of terminals; this became a big seller;
Market Appl: 2 - Generally through same distributors, but did some direct sales to large organizations - a new channel

9 Technology: 1 - Added Hazeltine emulation
Market Appl: 2 - New group: sold for new market niche

10 Technology: 1 - Upgrade of Burroughs product
Market Appl: 1 - Used its distributors, lost Burroughs as an OEM

11 Technology: 2 - Added graphics mode to alpha-numeric terminals, emulating Tektronix 4014
Market Appl: 3 - New function: graphics processing; new group: scientific and engineering graphics users

12 Technology: 1 - Added existing ANSI and Vt-100 emulation to previous product
Market Appl: 1 - Same (In 1984-85, this company proceeded to diversify extensively into microcomputer market)
PRODUCT DATA
CASE 7

1 Technology: 1 - Bought and improved a terminal already used for lottery applications
Market Appl: - Marketed to state-wide lottery systems; direct sales

2 Technology: 2 - Added high speed communications; new housing; new cpu
Market Appl: 1 - Same - lotteries

4 Technology: 2 - Full in-house redesign; added Optical Marker Reader and fast printer bought from outside
Market Appl: 2 - New group: foreign lottery systems (very different than American)

5 Technology: 3 - Built their own high speed printer - new related core
Market Appl: 1 - Same

6 Technology: 2 - Added a new optical reader (bought from the outside), polished up the entire terminal station
Market Appl: 1 - Same
1. Technology: 4 - Among the first programmable microcomputer terminals
   Market Appl: 4 - Sold for general usage: banks, military applications; direct sales

2. Technology: 2 - Added 8-bit CPU, new internals and outside packaging
   Market Appl: 3 - New group: a large casino chain; new channel: OEM

3. Technology: 1 - Improvements to workstation
   Market Appl: 2 - Same function: general data entry station; new group: communications and computer companies

4. Technology: 1 - Less expensive version of previous product
   Market Appl: 1 - Same (mainly for communication company)

5. Technology: 1 - Word Processing Station for European OEM; outside source for software
   Market Appl: 1 - Same (OEMs before)

6. Technology: 2 - Added floppy diskettes and foreign language keyboards
   Market Appl: 1 - Same as previous product

7. Technology: 2 - Bought a new operating system for multi-user usage and integrated it
   Market Appl: 2 - New function: workstation for software developers; sold through OEMs

8. Technology: 3 - Developed word processing software in-house - new core - used on workstation
   Market Appl: 1 - Same

9. Technology: 2 - Major repackaging - many new components
   Market Appl: 2 - Same usage - software development; new channels; VARs

10. Technology: 1 - Added peripherals - bought from the outside
    Market Appl: 1 - Same

11. Technology: 1 - Inexpensive model of previous product
    Market Appl: 1 - Same

12. Technology: 3 - A "personal computer" - built a graphics console: the new core - and used z-80 chip; license applications software
    Market Appl: 3 - A new usage: personal computer usage; new group: hobbyists; same channel: OEMs and VARs
PRODUCT DATA
CASE 9

1 Technology : 2 - New high resolution terminal, OEMed Dec minicomputers, first text editing software
Market Appl: 2 - Large magazine company (funded development), small clustered systems for composition

2 Technology : 2 - Expanded multi-processing network and enhanced editing software
Market Appl: 2 - New group: targeted newspapers; same direct sales and usage

3 Technology : 2 - Classified advertizing package
Market Appl: 1 - New usage inside existing customer base (newspapers)

4 Technology : 3 - Developed proprietary text-database, networked systems software (new related core)
Market Appl: 1 - Same (Major competition emerged in marketplace at this time)

5 Technology : 1 - Refined previous system for magazine applications
Market Appl: 1 - Same (had already sold to magazine publishers)

6 Technology : 2 - Implemented distributed processing to solve I/O bottlenecks on main computer
Market Appl: 1 - Same

7 Technology : 1 - Refined previous system for magazines
Market Appl: 1 - Same

8 Technology : 1 - Refined editing software for in-house corporate publishing applications
Market Appl: 2 - New group: Fortune 500 corporations - beginning of market diversification that was to prove unsuccessful

9 Technology : 1 - Repackaged technology for government marketplace
Market Appl: 3 - Continued diversification; new group: government; new channel: D.C. Sales Reps

10 Technology : 1 - Repackaged technology for law office applications
Market Appl: 2 - New group: large law firms

11 Technology : 1 - Refined previous newspaper system, to provide less costly system
Market Appl: 1 - Refocused back on newspapers, aimed at medium-sized companies - this product was very successful

12 Technology : 3 - Pagination/Graphics Composition system - made their own 68000-based display - new related core
Market Appl: 1 - Same - This was a "hot" product; state of the art software and high res. terminals
Technology: 2 - Video-text, cable-based news service application; combined with advertising package
Market Appl: 2 - New function - remote information acquisition through cable networks
PRODUCT DATA
CASE 10

1 Technology: 3 - High resolution graphics terminal; among the first
Market Appl:  - Academic users; graphics applications; direct sales

2 Technology: 2 - Major upgrade of terminal
Market Appl:  1 - Same

3 Technology: 4 - Graphics tablet
Market Appl:  4 - For CAD workstations; engineers as users; OEM CAD company

4 Technology: 2 - Text Editor (software and z-80 computer), new core techs but licensed and enhanced
Market Appl:  4 - New usage, editing; new customers, offices; new channel
 - new Sales Force

5 Technology: 1 - Upgrade of text editor - multi-user version
Market Appl:  2 - New usage: multi-user editing

6 Technology: 2 - Implement new 16-bit chip set, purchased from National Semi for Editor
Market Appl:  2 - New channel: OEM

7 Technology: 1 - New version of 16-bit editing station
Market Appl:  1 - Same

8 Technology: 1 - Minor revision of software - newspaper text composition
Market Appl:  4 - New usage: newspaper copy; new customers: newspapers; new sales channels

9 Technology: 2 - Add composition applications software
Market Appl:  3 - New users: publishing niche; new channel: graphics supply houses

10 Technology: 2 - Developed wire service reporting package
Market Appl:  2 - New usage: information gathering for newspapers

11 Technology: 2 - Developed communications package
Market Appl:  2 - New usage: intercomputer telecommunications

12 Technology: 1 - Developed classified advertising package
Market Appl:  2 - New usage for advertising function
PRODUCT DATA  
CASE 11

1  Technology :  4 - State of the art, multi-user typesetting system; emulating IBM 11/30 (that's history!)  
Market Appl:  - Newspapers and publishers, direct sales

2  Technology :  2 - Wire Service package, to capture news items from wire services  
Market Appl:  2 - Same customers, new functional use

3  Technology :  3 - New generation of typesetting machine; new core - made high res. terminals; OEMed an image scanner  
Market Appl:  1 - Same (Company was acquired, and totally merged. End of data)
PRODUCT DATA
CASE 12

1. Technology: 3 - One of the first graphics terminals
   Market Appl: 3 - Confused in market; no clear group; general graphics use; direct sales

2. Technology: 2 - Upgraded graphics terminal; reimplemented vector-raster display
   Market Appl: 3 - New customers: universities; new use: graphics in engineering and scientific research

3. Technology: 3 - New core - added a set of software development tools, e.g. languages
   Market Appl: 3 - New group: software developers, industrial process control; new usage: graphics based software development

4. Technology: 1 - Repackaged previous product
   Market Appl: 1 - Same

5. Technology: 1 - Retrenched hardware, removed complexity and cost
   Market Appl: 3 - New market focus: systems integrators; new distribution: large OEM

6. Technology: 2 - New graphics terminal, major redevelopment for smaller, cheaper unit
   Market Appl: 1 - Same

7. Technology: 3 - PhotoComposition system, using graphics terminal; developed text editing software
   Market Appl: 4 - New group: corporate publishing depts; new function: typesetting; new channel: made sales reps network
PRODUCT DATA
CASE 13

1 Technology: 3 - Among the first "digital cameras" – an image scanner
Market Appl: - Military application

2 Technology: 2 - Major enhancement of scanner
Market Appl: 3 - New group: commercial users; same function; new channel: direct to large corporations

3 Technology: 2 - Major upgrade to scanner
Market Appl: 2 - New channel: shifted to OEM sales (as a component to other photocomposition systems companies)

4 Technology: 3 - A complete imaging system; combined scanner with color preview terminal workstation, the new core
Market Appl: 4 - New group: publishers; new function: complete photocomposition; New channels: new direct sales force and reps
PRODUCT DATA
CASE 14

1 Technology: 4 - Color computer imaging system
Market Appl: - Textile manufacturers; textile design; direct sales

2 Technology: 2 - Map making system; new applications software
Market Appl: 3 - New usage - cartography; new group - military

3 Technology: 1 - Floor Covering Design system - for large client - minor applications software work
Market Appl: 1 - Same (highly similar to textile application)

4 Technology: 1 - Upgrade of map-making system
Market Appl: 1 - Same

5 Technology: 3 - New generation of imaging system: new core - process, change color and images software algorithms; also OEMed HP computer, laser printer, terminals
Market Appl: 3 - New usage - magazine, advertizing photocomposition - production; new Group - publishers

6 Technology: 1 - Upgrade of number 4
Market Appl: 2 - Extended to printed circuit board designers - new group

7 Technology: 2 - Added an new high resolution display "imager", substantial microcode work
Market Appl: 1 - Same

8 Technology: 2 - Object oriented graphics composition software, merging graphics and text
Market Appl: 2 - For designers of magazine layouts - not production: new usage

9 Technology: 2 - Major upgrade of printed circuit board design system
Market Appl: 1 - Same

10 Technology: 1 - OEMed and integrated image scanner for magazine, publisher system
Market Appl: 1 - Same
<table>
<thead>
<tr>
<th>Case</th>
<th>Technology</th>
<th>Market Appl</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3 - Computer gambling machine</td>
<td>Las Vegas casinos, gambling and hotel management, direct sales</td>
</tr>
<tr>
<td>2</td>
<td>3 - First dot-matrix printer; used at first with gambling machine.</td>
<td>4 - New users: minicomputer users; general purpose printing; OEMs</td>
</tr>
<tr>
<td>3</td>
<td>1 - Refined first printer</td>
<td>Same</td>
</tr>
<tr>
<td>4</td>
<td>2 - Redesigned printer for cost reduction</td>
<td>Same</td>
</tr>
<tr>
<td>5</td>
<td>1 - Refined previous model</td>
<td>Same</td>
</tr>
<tr>
<td>6</td>
<td>2 - Higher speed, matrix line printer (two printing heads)</td>
<td>Same</td>
</tr>
<tr>
<td>7</td>
<td>2 - Acquired a high speed line printer and enhanced it</td>
<td>2 - Same applications; new channel of independent sales reps.</td>
</tr>
<tr>
<td>8</td>
<td>2 - New generation of dot matrix printers</td>
<td>Same</td>
</tr>
<tr>
<td>9</td>
<td>1 - Refined dot-matrix, very low cost version</td>
<td>2 - New users: first dot matrix for personal computer owners</td>
</tr>
<tr>
<td>10</td>
<td>2 - Major redesign of desktop dot-matrix printer</td>
<td>Same applications, still OEM and representatives</td>
</tr>
<tr>
<td>11</td>
<td>1 - Quick upgrade to smaller, less expensive dot-matrix printer</td>
<td>Same: only OEMs, microcomputer usage</td>
</tr>
<tr>
<td>12</td>
<td>2 - New desktop version Num 10 with faster and paper handling</td>
<td>Same</td>
</tr>
<tr>
<td>13</td>
<td>2 - Added color capability to dot-matrix line</td>
<td>2 - New basic function: color graphics presentation printing</td>
</tr>
<tr>
<td>14</td>
<td>1 - Refinements and repackaging of desktop line</td>
<td>Same</td>
</tr>
<tr>
<td>15</td>
<td>1 - Acquired and refined very low cost printer</td>
<td>Same</td>
</tr>
</tbody>
</table>
Technology: 1 - Acquired another, even cheaper printer and refined it
Market Appl: 1 - Same

Technology: 2 - A band line printer: a new key technology, but acquired and enhanced.
Market Appl: 2 - New users: DP shops, still OEMs.

Technology: 1 - Paper handler and sheet feeder; peripheral technology development
Market Appl: 1 - Sold with existing printers
<table>
<thead>
<tr>
<th></th>
<th>Technology</th>
<th>Market Appl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3 - Complex ink-jet color printer</td>
<td>Made for a large OEM</td>
</tr>
<tr>
<td>2</td>
<td>2 - Developed multiple computer interfaces</td>
<td>2 - New channels: systems integrators and reps</td>
</tr>
<tr>
<td></td>
<td>Technology</td>
<td>Market Appl</td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Technology: 2 - Intelligent terminal</td>
<td>Market Appl: German OEM</td>
</tr>
<tr>
<td>2</td>
<td>Technology: 4 - Word Processing software</td>
<td>Market Appl: 3 - US OEM, Whole new function, new end user customer group</td>
</tr>
<tr>
<td>3</td>
<td>Technology: 4 - Printer (12/7)</td>
<td>Market Appl: 3 - OEM, new function, new end-user group</td>
</tr>
<tr>
<td>4</td>
<td>Technology: 2 - Added command language to printer</td>
<td>Market Appl: 3 - Distributors, systems integrators (end user group), same function</td>
</tr>
<tr>
<td>5</td>
<td>Technology: 2 - Fix up of no. 4 (s/700)</td>
<td>Market Appl: 2 - Distributors (same), printing (same function), Fortune 500 customers</td>
</tr>
<tr>
<td>6</td>
<td>Technology: 1 - Added font packages to printers</td>
<td>Market Appl: 1 - Same customers</td>
</tr>
</tbody>
</table>
PRODUCT DATA
CASE 18

1 Technology: 1 - Drum printer
Market Appl: - Direct sales, government applications

2 Technology: 3 - Linked chain technology - new technology combined with existing printer expertise.
Market Appl: 3 - OEMs (new sales force), commercial DP shops

3 Technology: 1 - Faster speed
Market Appl: 1 - OEMs

4 Technology: 1 - Even faster speed
Market Appl: 1 - OEMs

5 Technology: 3 - New band printer technology - again, combined with existing technology.
Market Appl: 1 - OEMs

6 Technology: 1 - Higher speed version
Market Appl: 1 - OEMs

7 Technology: 1 - Yet higher speed
Market Appl: 1 - OEMs
Technology : 2 - Dot-matrix printer, 1 year development
Market Appl: - Wide PC-users application, distributors

2 Technology : 2 - Major improvements to the printer
Market Appl: 1 - Same

3 Technology : 1 - minor improvements
Market Appl: 1 - Same

4 Technology : 1 - re-packaging
Market Appl: 2 - Added sales reps and retail stores

5 Technology : 2 - Refinement of previous product
Market Appl: 2 - Turnkey systems houses added to channels

6 Technology : 1 - Less expensive version
Market Appl: 2 - New channel : mail order

7 Technology : 2 - Added 132 column printing
Market Appl: 1 - Same

8 Technology : 2 - Added color capability
Market Appl: 3 - New channels, large OEMs, new functionality (color), same users

9 Technology : 2 - 132 columns color printer
Market Appl: 1 - same

10 Technology : 1 - Faster speed of No. 5
Market Appl: 1 - same

11 Technology : 2 - Custom made to OEM specs, color printer
Market Appl: 1 - Same

12 Technology : 2 - Color printer, again for OEM specifications
Market Appl: 1 - Same

13 Technology : 1 - New generation of printers, new packaging
Market Appl: 1 - Strong move to OEM marketplace

14 Technology : 1 - IBM compatibility
Market Appl: 2 - New user group : IBM PC users

15 Technology : 2 - faster speed
Market Appl: 1 - same

16 Technology : 1 - IBM compatibility
Market Appl: 1 - same OEMs
PRODUCT DATA
CASE 20

1 Technology: 3 - Spreadsheet package, only Visicalc was out then
Market Appl: - Minicomputer VARs; users: minicomputer group; financial modeling

2 Technology: 1 - Bug fixes
Market Appl: 1 - Same

3 Technology: 2 - Major enhancement, new development team
Market Appl: 1 - same

4 Technology: 1 - Ported to new hardware
Market Appl: 1 - Same

5 Technology: 1 - Port to new hardware
Market Appl: 2 - New channel: OEM; same end-users and functionality

6 Technology: 2 - Major work for a new release
Market Appl: 1 - A new manufacturer, but OEMs already existed

7 Technology: 2 - Port to new hardware
Market Appl: 2 - New channel: distributor, a software publisher

8 Technology: 1 - Minor mod's, another hardware port
Market Appl: 2 - Added more manufacturer, OEMs

9 Technology: 2 - Port to new hardware
Market Appl: 1 - Same

10 Technology: 2 - Major enhancement
Market Appl: 2 - New end-user group: small business

11 Technology: 3 - Add new key technologies: graphics and some dbms, packaged with ss
Market Appl: 1 - same

12 Technology: 2 - Port to new hardware base
Market Appl: 2 - New channel: direct sales to large corporations
<table>
<thead>
<tr>
<th></th>
<th>Technology</th>
<th>Market Appl:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3 - Presentation graphics package: none really existed for micro's</td>
<td>Hardware OEMs; users: business and education; function: graphics</td>
</tr>
<tr>
<td>2</td>
<td>1 - Ported to new computer</td>
<td>2 - New channel: distributor (for Apple); same usage and customers</td>
</tr>
<tr>
<td>3</td>
<td>2 - New user interface, and hardware port</td>
<td>1 - Same</td>
</tr>
<tr>
<td>4</td>
<td>1 - Minor work for a new port</td>
<td>1 - Same</td>
</tr>
<tr>
<td>5</td>
<td>2 - New revision and ports</td>
<td>1 - Same</td>
</tr>
<tr>
<td>6</td>
<td>1 - New features and peripherals support</td>
<td>1 - Same</td>
</tr>
</tbody>
</table>
PRODUCT DATA
CASE 22

1 Technology: 3 - New database technology
Market Appl: -

2 Technology: 2 - Acquired DBMS technology, then worked on it
Market Appl: 1 - Same

3 Technology: 3 - On-line, interactive query technology (highly novel at the time)
Market Appl: 1 - Same

4 Technology: 2 - Data dictionary facility added to database
Market Appl: 2 - Same

5 Technology: 1 - Enhancements made to overall database
Market Appl: 1 - Same

6 Technology: 1 - Additional features added to query processor
Market Appl: 1 - Same

7 Technology: 2 - Major redesign of database product
Market Appl: 1 - Same

8 Technology: 3 - Teleprocessing software, combined with database, for transaction systems
Market Appl: 2 - New functionality: telecommunications

9 Technology: 2 - Enhancement of no 7
Market Appl: 1 - Same

10 Technology: 2 - Redesign and enhancement of query processor
Market Appl: 1 - Same

11 Technology: 1 - Expanded data Dictionary module
Market Appl: 1 - Same

12 Technology: 2 - Major enhancement: added distributed, file handling to DBMS
Market Appl: 2 - New functionality: distributed database, multi-machine applications

13 Technology: 2 - New release of query processor
Market Appl: 1 - Same

14 Technology: 1 - Improvements to the data dictionary, e.g. recovery and logging
Market Appl: 1 - Same

15 Technology: 2 - Major enhancement to teleprocessing module
Market Appl: 1 - Same

16 Technology: 3 - 4GL query language for development, new generation of query language
Market Appl: 1 - Same

17 Technology: 2 - Major enhancement to distributed DBMS module
Market Appl: 1 - Same

18 Technology: 2 - New features added to query processor
Market Appl: 1 - Same

19 Technology: 1 - Expansion of data dictionary
Market Appl: 1 - Same

20 Technology: 1 - Improved telecommunications processor
Market Appl: 1 - Same

21 Technology: 3 - Developed End-user applications, a new technology, on
top of DBMS
Market Appl: 3 - New end-users; manufacturing application for
functionality

22 Technology: 2 - Enhanced an acquired outside technology; an executive
decision support system
Market Appl: 2 - Functionality: executive financial decision-making

23 Technology: 2 - Added relational database design to DBMS
Market Appl: 1 - Same

24 Technology: 1 - New version of query processor
Market Appl: 1 - Same

25 Technology: 1 - Additional data dictionary features
Market Appl: 1 - Same

26 Technology: 2 - Major enhancement to telecommunications: new
protocols
Market Appl: 1 - Same

27 Technology: 2 - Major enhancements to 4GL applications development
language
Market Appl: 1 - Same

28 Technology: 2 - Added new end-user applications, in financial area
Market Appl: 1 - Same

29 Technology: 3 - An integrated microcomputer product: added
Spreadsheet and graphics to DBMS
Market Appl: 2 - Function: microcomputer applications; group: same
corporate users

30 Technology: 2 - PC-mainframe communications; extension of its
teleprocessing software
Market Appl: 1 - For linking No. 29 with mainframe DBMS product
PRODUCT DATA
CASE 23

1 Technology: 3 - Among the first relational DBMS for the UNIX market
Market Appl: 3 - Direct end-user sales

2 Technology: 2 - New release, major bug fixing, added relational views
and dated relations
Market Appl: 2 - New channels: distributors

3 Technology: 4 - A new "shell" for UNIX, sold separately from DBMS
Market Appl: 3 - New functionality: applications front-ending; new
channels: OEMs; same group (developers)
1 Technology: 3 - data access method and DBMS techniques novel at the time
   Market Appl: Direct sales; Applications developments; Other developers

2 Technology: 2 - Major enhancement to first product
   Market Appl: 1 - same

3 Technology: 1 - Improvements to DBMS
   Market Appl: 1 - Same

4 Technology: 2 - Major design changes to DBMS
   Market Appl: 1 - same

5 Technology: 1 - New features to software
   Market Appl: 1 - Same

6 Technology: 2 - Major enhancements to DBMS
   Market Appl: 1 - Same

7 Technology: 1 - Improvements to DBMS
   Market Appl: 1 - Same

8 Technology: 2 - Major enhancements, new features
   Market Appl: 1 - Same

9 Technology: 4 - Real time process control for alarm monitoring
   Market Appl: 4 - New Users: building security engineers; new function: process control; new channels: dealer network

10 Technology: 2 - Revisions to DBMS and port to new hardware
    Market Appl: 1 - Same

11 Technology: 1 - Extension of No. 9, an access control system
    Market Appl: 1 - Same

12 Technology: 1 - Minor improvements to DBMS
    Market Appl: 1 - Same

13 Technology: 1 - DBMS improvements
    Market Appl: 1 - Same

14 Technology: 3 - Computer design and produced to monitor remote data collection devices for alarm and access products
    Market Appl: 1 - Same

15 Technology: 1 - Minor revisions to DBMS
    Market Appl: 1 - Same
PRODUCT DATA
CASE 25

1 Technology: 3 - PL/I compiler, a new implementation to meet new ANSI standard
Market Appl: - Computer OEMs and large corporations (direct sales)

2 Technology: 2 - Made Fortran 77
Market Appl: 2 - New group: scientists and engineers

3 Technology: 2 - Pascal compiler
Market Appl: 2 - Academic end-users

4 Technology: 2 - RPG-II compiler
Market Appl: 2 - New users: business applications

8 Technology: 4 - A National-Semi 32000 based Computer, including a UNIX port
Market Appl: 4 - New Application: systems integration; new users: integration houses plus OEMs

5 Technology: 2 - C compiler
Market Appl: 2 - UNIX software developers

6 Technology: 2 - Cobol compiler
Market Appl: 2 - A new set of business applications (much broader than RPGII)

7 Technology: 2 - Basic compiler
Market Appl: 1 - Educational markets
PRODUCT DATA
CASE 26

1
Technology: 2 - Ported Unix Operating System to PDP-11 with Real
Time data acquisition extensions
Market Appl: - Scientists, academics; general UNIX usage and
experiments; direct sales

2
Technology: 2 - Major enhancement, with upgrade Version 7 UNIX
Market Appl: 2 - New users: first commercial users

3
Technology: 2 - First UNIX Port to Intel 8088 architecture
Market Appl: 3 - New users; microcomputer market; new channel:
distributors; still for software development

4
Technology: 1 - Licensed an existing database system, ported it to own
UNIX
Market Appl: 1 - Same; birth of integrated UNIX applications concept

5
Technology: 2 - Licensed a word processor and ported it to UNIX
Market Appl: 2 - New usage: end-user text editing; same customers and
channels

6
Technology: 2 - New Release of UNIX for PCs, major bug fixing
Market Appl: 1 - Same

7
Technology: 1 - Implemented Kanjii language Shell to UNIX
Market Appl: 3 - New users: software Developers in Japanese market;
new channel: Japanese subsidiary

8
Technology: 2 - Licensed another DBMS, major recoding and new
features
Market Appl: 2 - New users: target DBMS software niche; mainly direct
sales

9
Technology: 2 - UNIX OS ported to DEC microcomputers
Market Appl: 2 - New channel: Large OEM agreement with DEC

10
Technology: 3 - Developed a spreadsheet and graphics, (new core
technologies), to DBMS
Market Appl: 1 - Same
Appendix B

SALES DATA
### Appendix B

**SALES DATA**

SALES DATA: In Millions of Dollars  
**CASE 1**

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal_Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>78</td>
<td>1</td>
<td>0.13</td>
</tr>
<tr>
<td>1</td>
<td>79</td>
<td>2</td>
<td>0.33</td>
</tr>
<tr>
<td>1</td>
<td>80</td>
<td>3</td>
<td>0.61</td>
</tr>
<tr>
<td>1</td>
<td>81</td>
<td>4</td>
<td>3.00</td>
</tr>
<tr>
<td>1</td>
<td>82</td>
<td>5</td>
<td>3.10</td>
</tr>
<tr>
<td>1</td>
<td>83</td>
<td>6</td>
<td>5.00</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars
CASE 2

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal_Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>69</td>
<td>1</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
<td>2</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>71</td>
<td>3</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>72</td>
<td>4</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>73</td>
<td>5</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>74</td>
<td>6</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>75</td>
<td>7</td>
<td>4.0</td>
</tr>
<tr>
<td>2</td>
<td>76</td>
<td>8</td>
<td>5.0</td>
</tr>
<tr>
<td>2</td>
<td>77</td>
<td>9</td>
<td>6.0</td>
</tr>
<tr>
<td>2</td>
<td>78</td>
<td>10</td>
<td>7.0</td>
</tr>
<tr>
<td>2</td>
<td>79</td>
<td>11</td>
<td>3.8</td>
</tr>
<tr>
<td>2</td>
<td>80</td>
<td>12</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>81</td>
<td>13</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>82</td>
<td>14</td>
<td>3.0</td>
</tr>
<tr>
<td>2</td>
<td>83</td>
<td>15</td>
<td>3.0</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars
CASE 3

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal_Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>74</td>
<td>1</td>
<td>0.0</td>
</tr>
<tr>
<td>3</td>
<td>75</td>
<td>2</td>
<td>0.0</td>
</tr>
<tr>
<td>3</td>
<td>76</td>
<td>3</td>
<td>0.2</td>
</tr>
<tr>
<td>3</td>
<td>77</td>
<td>4</td>
<td>0.4</td>
</tr>
<tr>
<td>3</td>
<td>78</td>
<td>5</td>
<td>0.9</td>
</tr>
<tr>
<td>3</td>
<td>79</td>
<td>6</td>
<td>1.9</td>
</tr>
<tr>
<td>3</td>
<td>80</td>
<td>7</td>
<td>4.4</td>
</tr>
<tr>
<td>3</td>
<td>81</td>
<td>8</td>
<td>14.5</td>
</tr>
<tr>
<td>3</td>
<td>82</td>
<td>9</td>
<td>28.6</td>
</tr>
<tr>
<td>3</td>
<td>83</td>
<td>10</td>
<td>25.7</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars
CASE 4

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>79</td>
<td>1</td>
<td>0.00</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
<td>2</td>
<td>0.16</td>
</tr>
<tr>
<td>4</td>
<td>81</td>
<td>3</td>
<td>0.30</td>
</tr>
<tr>
<td>4</td>
<td>82</td>
<td>4</td>
<td>0.40</td>
</tr>
<tr>
<td>4</td>
<td>83</td>
<td>5</td>
<td>0.50</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars
CASE 5

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal_Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>74</td>
<td>1</td>
<td>0.00</td>
</tr>
<tr>
<td>5</td>
<td>75</td>
<td>2</td>
<td>0.25</td>
</tr>
<tr>
<td>5</td>
<td>76</td>
<td>3</td>
<td>0.32</td>
</tr>
<tr>
<td>5</td>
<td>77</td>
<td>4</td>
<td>0.48</td>
</tr>
<tr>
<td>5</td>
<td>78</td>
<td>5</td>
<td>0.79</td>
</tr>
<tr>
<td>5</td>
<td>79</td>
<td>6</td>
<td>0.81</td>
</tr>
<tr>
<td>5</td>
<td>80</td>
<td>7</td>
<td>1.50</td>
</tr>
<tr>
<td>5</td>
<td>81</td>
<td>8</td>
<td>1.60</td>
</tr>
<tr>
<td>5</td>
<td>82</td>
<td>9</td>
<td>2.15</td>
</tr>
<tr>
<td>5</td>
<td>83</td>
<td>10</td>
<td>3.20</td>
</tr>
<tr>
<td>5</td>
<td>84</td>
<td>11</td>
<td>3.00</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars
CASE 6

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal_Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>78</td>
<td>1</td>
<td>0.00</td>
</tr>
<tr>
<td>6</td>
<td>79</td>
<td>2</td>
<td>0.74</td>
</tr>
<tr>
<td>6</td>
<td>80</td>
<td>3</td>
<td>7.53</td>
</tr>
<tr>
<td>6</td>
<td>81</td>
<td>4</td>
<td>18.04</td>
</tr>
<tr>
<td>6</td>
<td>82</td>
<td>5</td>
<td>25.81</td>
</tr>
<tr>
<td>6</td>
<td>83</td>
<td>6</td>
<td>47.00</td>
</tr>
<tr>
<td>Case</td>
<td>Fiscal_Year</td>
<td>Age</td>
<td>Sales</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>-----</td>
<td>---------</td>
</tr>
<tr>
<td>7</td>
<td>76</td>
<td>1</td>
<td>0.00</td>
</tr>
<tr>
<td>7</td>
<td>77</td>
<td>2</td>
<td>16.40</td>
</tr>
<tr>
<td>7</td>
<td>78</td>
<td>3</td>
<td>5.50</td>
</tr>
<tr>
<td>7</td>
<td>79</td>
<td>4</td>
<td>4.20</td>
</tr>
<tr>
<td>7</td>
<td>80</td>
<td>5</td>
<td>2.40</td>
</tr>
<tr>
<td>7</td>
<td>81</td>
<td>6</td>
<td>2.30</td>
</tr>
<tr>
<td>7</td>
<td>82</td>
<td>7</td>
<td>17.50</td>
</tr>
<tr>
<td>7</td>
<td>83</td>
<td>8</td>
<td>25.57</td>
</tr>
<tr>
<td>7</td>
<td>84</td>
<td>9</td>
<td>26.50</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars

CASE 8

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal_Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>68</td>
<td>1</td>
<td>0.0</td>
</tr>
<tr>
<td>8</td>
<td>69</td>
<td>2</td>
<td>1.6</td>
</tr>
<tr>
<td>8</td>
<td>70</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>8</td>
<td>71</td>
<td>4</td>
<td>3.5</td>
</tr>
<tr>
<td>8</td>
<td>72</td>
<td>5</td>
<td>0.0</td>
</tr>
<tr>
<td>8</td>
<td>73</td>
<td>6</td>
<td>0.0</td>
</tr>
<tr>
<td>8</td>
<td>74</td>
<td>7</td>
<td>0.0</td>
</tr>
<tr>
<td>8</td>
<td>75</td>
<td>8</td>
<td>0.0</td>
</tr>
<tr>
<td>8</td>
<td>76</td>
<td>9</td>
<td>2.6</td>
</tr>
<tr>
<td>8</td>
<td>77</td>
<td>10</td>
<td>7.6</td>
</tr>
<tr>
<td>8</td>
<td>78</td>
<td>11</td>
<td>13.0</td>
</tr>
<tr>
<td>8</td>
<td>79</td>
<td>12</td>
<td>22.7</td>
</tr>
<tr>
<td>8</td>
<td>80</td>
<td>13</td>
<td>26.5</td>
</tr>
<tr>
<td>8</td>
<td>81</td>
<td>14</td>
<td>29.6</td>
</tr>
<tr>
<td>8</td>
<td>82</td>
<td>15</td>
<td>28.5</td>
</tr>
<tr>
<td>8</td>
<td>83</td>
<td>16</td>
<td>16.5</td>
</tr>
<tr>
<td>Case</td>
<td>Fiscal_Year</td>
<td>Age</td>
<td>Sales</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>-----</td>
<td>-------</td>
</tr>
<tr>
<td>9</td>
<td>74</td>
<td>1</td>
<td>0.0</td>
</tr>
<tr>
<td>9</td>
<td>75</td>
<td>2</td>
<td>2.0</td>
</tr>
<tr>
<td>9</td>
<td>76</td>
<td>3</td>
<td>6.0</td>
</tr>
<tr>
<td>9</td>
<td>77</td>
<td>4</td>
<td>8.0</td>
</tr>
<tr>
<td>9</td>
<td>78</td>
<td>5</td>
<td>12.0</td>
</tr>
<tr>
<td>9</td>
<td>79</td>
<td>6</td>
<td>25.0</td>
</tr>
<tr>
<td>9</td>
<td>80</td>
<td>7</td>
<td>40.0</td>
</tr>
<tr>
<td>9</td>
<td>81</td>
<td>8</td>
<td>55.0</td>
</tr>
<tr>
<td>9</td>
<td>82</td>
<td>9</td>
<td>83.0</td>
</tr>
<tr>
<td>9</td>
<td>83</td>
<td>10</td>
<td>83.0</td>
</tr>
<tr>
<td>Case</td>
<td>Fiscal_Year</td>
<td>Age</td>
<td>Sales</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>-----</td>
<td>-------</td>
</tr>
<tr>
<td>10</td>
<td>69</td>
<td>1</td>
<td>0.0</td>
</tr>
<tr>
<td>10</td>
<td>70</td>
<td>2</td>
<td>0.0</td>
</tr>
<tr>
<td>10</td>
<td>71</td>
<td>3</td>
<td>1.0</td>
</tr>
<tr>
<td>10</td>
<td>72</td>
<td>4</td>
<td>2.0</td>
</tr>
<tr>
<td>10</td>
<td>73</td>
<td>5</td>
<td>3.0</td>
</tr>
<tr>
<td>10</td>
<td>74</td>
<td>6</td>
<td>3.0</td>
</tr>
<tr>
<td>10</td>
<td>75</td>
<td>7</td>
<td>4.0</td>
</tr>
<tr>
<td>10</td>
<td>76</td>
<td>8</td>
<td>5.0</td>
</tr>
<tr>
<td>10</td>
<td>77</td>
<td>9</td>
<td>6.0</td>
</tr>
<tr>
<td>10</td>
<td>78</td>
<td>10</td>
<td>7.0</td>
</tr>
<tr>
<td>10</td>
<td>79</td>
<td>11</td>
<td>3.8</td>
</tr>
<tr>
<td>10</td>
<td>80</td>
<td>12</td>
<td>3.0</td>
</tr>
<tr>
<td>10</td>
<td>81</td>
<td>13</td>
<td>3.0</td>
</tr>
<tr>
<td>10</td>
<td>82</td>
<td>14</td>
<td>3.0</td>
</tr>
<tr>
<td>10</td>
<td>83</td>
<td>15</td>
<td>3.0</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars
CASE 11

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>71</td>
<td>1</td>
<td>0.0</td>
</tr>
<tr>
<td>11</td>
<td>72</td>
<td>2</td>
<td>2.0</td>
</tr>
<tr>
<td>11</td>
<td>73</td>
<td>3</td>
<td>5.0</td>
</tr>
<tr>
<td>11</td>
<td>74</td>
<td>4</td>
<td>7.0</td>
</tr>
</tbody>
</table>
**SALES DATA : In Millions of Dollars**

**CASE 12**

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal_Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>69</td>
<td>1</td>
<td>0.00</td>
</tr>
<tr>
<td>12</td>
<td>70</td>
<td>2</td>
<td>0.50</td>
</tr>
<tr>
<td>12</td>
<td>71</td>
<td>3</td>
<td>1.06</td>
</tr>
<tr>
<td>12</td>
<td>72</td>
<td>4</td>
<td>1.59</td>
</tr>
<tr>
<td>12</td>
<td>73</td>
<td>5</td>
<td>2.11</td>
</tr>
<tr>
<td>12</td>
<td>74</td>
<td>6</td>
<td>2.95</td>
</tr>
<tr>
<td>12</td>
<td>75</td>
<td>7</td>
<td>3.33</td>
</tr>
<tr>
<td>12</td>
<td>76</td>
<td>8</td>
<td>4.12</td>
</tr>
<tr>
<td>12</td>
<td>77</td>
<td>9</td>
<td>4.69</td>
</tr>
<tr>
<td>12</td>
<td>78</td>
<td>10</td>
<td>5.83</td>
</tr>
<tr>
<td>12</td>
<td>79</td>
<td>11</td>
<td>7.51</td>
</tr>
<tr>
<td>12</td>
<td>80</td>
<td>12</td>
<td>8.12</td>
</tr>
<tr>
<td>12</td>
<td>81</td>
<td>13</td>
<td>7.50</td>
</tr>
<tr>
<td>12</td>
<td>82</td>
<td>14</td>
<td>7.63</td>
</tr>
<tr>
<td>12</td>
<td>83</td>
<td>15</td>
<td>5.36</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars
CASE 13

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal_Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>69</td>
<td>1</td>
<td>0.000</td>
</tr>
<tr>
<td>13</td>
<td>78</td>
<td>9</td>
<td>1.980</td>
</tr>
<tr>
<td>13</td>
<td>79</td>
<td>10</td>
<td>2.284</td>
</tr>
<tr>
<td>13</td>
<td>80</td>
<td>11</td>
<td>3.001</td>
</tr>
<tr>
<td>13</td>
<td>81</td>
<td>12</td>
<td>3.169</td>
</tr>
<tr>
<td>13</td>
<td>82</td>
<td>13</td>
<td>4.355</td>
</tr>
<tr>
<td>13</td>
<td>83</td>
<td>14</td>
<td>5.600</td>
</tr>
<tr>
<td>13</td>
<td>84</td>
<td>15</td>
<td>6.500</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars
CASE 14

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal_Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>71</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>14</td>
<td>72</td>
<td>2</td>
<td>2.0</td>
</tr>
<tr>
<td>14</td>
<td>73</td>
<td>3</td>
<td>3.0</td>
</tr>
<tr>
<td>14</td>
<td>74</td>
<td>4</td>
<td>4.0</td>
</tr>
<tr>
<td>14</td>
<td>75</td>
<td>5</td>
<td>5.3</td>
</tr>
<tr>
<td>14</td>
<td>76</td>
<td>6</td>
<td>7.4</td>
</tr>
<tr>
<td>14</td>
<td>77</td>
<td>7</td>
<td>7.7</td>
</tr>
<tr>
<td>14</td>
<td>78</td>
<td>8</td>
<td>8.8</td>
</tr>
<tr>
<td>14</td>
<td>79</td>
<td>9</td>
<td>14.0</td>
</tr>
<tr>
<td>14</td>
<td>80</td>
<td>10</td>
<td>23.8</td>
</tr>
<tr>
<td>14</td>
<td>81</td>
<td>11</td>
<td>34.8</td>
</tr>
<tr>
<td>14</td>
<td>82</td>
<td>12</td>
<td>50.5</td>
</tr>
<tr>
<td>14</td>
<td>83</td>
<td>13</td>
<td>71.0</td>
</tr>
<tr>
<td>14</td>
<td>84</td>
<td>14</td>
<td>104.0</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars
CASE 15

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>70</td>
<td>1</td>
<td>.093</td>
</tr>
<tr>
<td>15</td>
<td>71</td>
<td>2</td>
<td>.544</td>
</tr>
<tr>
<td>15</td>
<td>72</td>
<td>3</td>
<td>6.723</td>
</tr>
<tr>
<td>15</td>
<td>73</td>
<td>4</td>
<td>24.027</td>
</tr>
<tr>
<td>15</td>
<td>74</td>
<td>5</td>
<td>41.462</td>
</tr>
<tr>
<td>15</td>
<td>75</td>
<td>6</td>
<td>41.536</td>
</tr>
<tr>
<td>15</td>
<td>76</td>
<td>7</td>
<td>52.177</td>
</tr>
<tr>
<td>15</td>
<td>77</td>
<td>8</td>
<td>58.037</td>
</tr>
<tr>
<td>15</td>
<td>78</td>
<td>9</td>
<td>75.018</td>
</tr>
<tr>
<td>15</td>
<td>79</td>
<td>10</td>
<td>121.533</td>
</tr>
<tr>
<td>15</td>
<td>80</td>
<td>11</td>
<td>127.608</td>
</tr>
<tr>
<td>15</td>
<td>81</td>
<td>12</td>
<td>120.804</td>
</tr>
<tr>
<td>15</td>
<td>82</td>
<td>13</td>
<td>112.671</td>
</tr>
<tr>
<td>15</td>
<td>83</td>
<td>14</td>
<td>164.429</td>
</tr>
<tr>
<td>15</td>
<td>84</td>
<td>15</td>
<td>167.812</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars
CASE 16

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal_Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>81</td>
<td>1</td>
<td>0.0</td>
</tr>
<tr>
<td>16</td>
<td>82</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>16</td>
<td>83</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>16</td>
<td>84</td>
<td>4</td>
<td>4.0</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars

CASE 17

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal_Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>78</td>
<td>1</td>
<td>.50</td>
</tr>
<tr>
<td>17</td>
<td>79</td>
<td>2</td>
<td>1.40</td>
</tr>
<tr>
<td>17</td>
<td>80</td>
<td>3</td>
<td>2.68</td>
</tr>
<tr>
<td>17</td>
<td>81</td>
<td>4</td>
<td>1.79</td>
</tr>
<tr>
<td>17</td>
<td>82</td>
<td>5</td>
<td>3.66</td>
</tr>
<tr>
<td>17</td>
<td>83</td>
<td>6</td>
<td>3.29</td>
</tr>
<tr>
<td>17</td>
<td>84</td>
<td>7</td>
<td>1.75</td>
</tr>
<tr>
<td>Case</td>
<td>Fiscal Year</td>
<td>Age</td>
<td>Sales</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>-----</td>
<td>-------</td>
</tr>
<tr>
<td>18</td>
<td>69</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>18</td>
<td>70</td>
<td>2</td>
<td>2.03</td>
</tr>
<tr>
<td>18</td>
<td>71</td>
<td>3</td>
<td>3.92</td>
</tr>
<tr>
<td>18</td>
<td>72</td>
<td>4</td>
<td>6.44</td>
</tr>
<tr>
<td>18</td>
<td>73</td>
<td>5</td>
<td>9.10</td>
</tr>
<tr>
<td>18</td>
<td>74</td>
<td>6</td>
<td>8.68</td>
</tr>
<tr>
<td>18</td>
<td>75</td>
<td>7</td>
<td>14.44</td>
</tr>
<tr>
<td>18</td>
<td>76</td>
<td>8</td>
<td>16.51</td>
</tr>
<tr>
<td>18</td>
<td>77</td>
<td>9</td>
<td>20.44</td>
</tr>
<tr>
<td>18</td>
<td>78</td>
<td>10</td>
<td>29.37</td>
</tr>
<tr>
<td>18</td>
<td>79</td>
<td>11</td>
<td>35.65</td>
</tr>
<tr>
<td>18</td>
<td>80</td>
<td>12</td>
<td>31.08</td>
</tr>
<tr>
<td>18</td>
<td>81</td>
<td>13</td>
<td>27.23</td>
</tr>
<tr>
<td>18</td>
<td>82</td>
<td>14</td>
<td>21.45</td>
</tr>
<tr>
<td>18</td>
<td>83</td>
<td>15</td>
<td>26.00</td>
</tr>
<tr>
<td>18</td>
<td>84</td>
<td>16</td>
<td>28.00</td>
</tr>
<tr>
<td>Case</td>
<td>Fiscal_Year</td>
<td>Age</td>
<td>Sales</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>-----</td>
<td>-------</td>
</tr>
<tr>
<td>19</td>
<td>78</td>
<td>1</td>
<td>1.05</td>
</tr>
<tr>
<td>19</td>
<td>79</td>
<td>2</td>
<td>3.52</td>
</tr>
<tr>
<td>19</td>
<td>80</td>
<td>3</td>
<td>9.50</td>
</tr>
<tr>
<td>19</td>
<td>81</td>
<td>4</td>
<td>18.18</td>
</tr>
<tr>
<td>19</td>
<td>82</td>
<td>5</td>
<td>20.78</td>
</tr>
<tr>
<td>19</td>
<td>83</td>
<td>6</td>
<td>38.09</td>
</tr>
<tr>
<td>19</td>
<td>84</td>
<td>7</td>
<td>80.00</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars
CASE 20

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>81</td>
<td>1</td>
<td>0.670</td>
</tr>
<tr>
<td>20</td>
<td>82</td>
<td>2</td>
<td>1.100</td>
</tr>
<tr>
<td>20</td>
<td>83</td>
<td>3</td>
<td>3.400</td>
</tr>
<tr>
<td>20</td>
<td>84</td>
<td>4</td>
<td>4.100</td>
</tr>
</tbody>
</table>
### SALES DATA: In Millions of Dollars

**CASE 21**

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>81</td>
<td>1</td>
<td>.100</td>
</tr>
<tr>
<td>21</td>
<td>82</td>
<td>2</td>
<td>.400</td>
</tr>
<tr>
<td>21</td>
<td>83</td>
<td>3</td>
<td>1.400</td>
</tr>
<tr>
<td>21</td>
<td>84</td>
<td>4</td>
<td>2.250</td>
</tr>
<tr>
<td>Case</td>
<td>Fiscal Year</td>
<td>Age</td>
<td>Sales</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>-----</td>
<td>---------</td>
</tr>
<tr>
<td>22</td>
<td>68</td>
<td>1</td>
<td>.010</td>
</tr>
<tr>
<td>22</td>
<td>75</td>
<td>8</td>
<td>1.645</td>
</tr>
<tr>
<td>22</td>
<td>76</td>
<td>9</td>
<td>3.433</td>
</tr>
<tr>
<td>22</td>
<td>77</td>
<td>10</td>
<td>5.291</td>
</tr>
<tr>
<td>22</td>
<td>78</td>
<td>11</td>
<td>8.921</td>
</tr>
<tr>
<td>22</td>
<td>79</td>
<td>12</td>
<td>11.974</td>
</tr>
<tr>
<td>22</td>
<td>80</td>
<td>13</td>
<td>17.727</td>
</tr>
<tr>
<td>22</td>
<td>81</td>
<td>14</td>
<td>29.351</td>
</tr>
<tr>
<td>22</td>
<td>82</td>
<td>15</td>
<td>49.269</td>
</tr>
<tr>
<td>22</td>
<td>83</td>
<td>16</td>
<td>78.533</td>
</tr>
<tr>
<td>22</td>
<td>84</td>
<td>17</td>
<td>120.036</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars
CASE 23

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal_Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>81</td>
<td>1</td>
<td>.10</td>
</tr>
<tr>
<td>23</td>
<td>82</td>
<td>2</td>
<td>.20</td>
</tr>
<tr>
<td>23</td>
<td>83</td>
<td>3</td>
<td>.25</td>
</tr>
<tr>
<td>23</td>
<td>84</td>
<td>4</td>
<td>.15</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars
CASE 24

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>75</td>
<td>1</td>
<td>.712</td>
</tr>
<tr>
<td>24</td>
<td>76</td>
<td>2</td>
<td>1.192</td>
</tr>
<tr>
<td>24</td>
<td>77</td>
<td>3</td>
<td>.994</td>
</tr>
<tr>
<td>24</td>
<td>78</td>
<td>4</td>
<td>1.609</td>
</tr>
<tr>
<td>24</td>
<td>79</td>
<td>5</td>
<td>2.114</td>
</tr>
<tr>
<td>24</td>
<td>80</td>
<td>6</td>
<td>3.161</td>
</tr>
<tr>
<td>24</td>
<td>81</td>
<td>7</td>
<td>3.475</td>
</tr>
<tr>
<td>24</td>
<td>82</td>
<td>8</td>
<td>4.067</td>
</tr>
<tr>
<td>24</td>
<td>83</td>
<td>9</td>
<td>4.739</td>
</tr>
<tr>
<td>24</td>
<td>84</td>
<td>10</td>
<td>6.596</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars
CASE 25

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>76</td>
<td>1</td>
<td>.100</td>
</tr>
<tr>
<td>25</td>
<td>77</td>
<td>2</td>
<td>.200</td>
</tr>
<tr>
<td>25</td>
<td>78</td>
<td>3</td>
<td>.400</td>
</tr>
<tr>
<td>25</td>
<td>79</td>
<td>4</td>
<td>.600</td>
</tr>
<tr>
<td>25</td>
<td>80</td>
<td>5</td>
<td>.800</td>
</tr>
<tr>
<td>25</td>
<td>81</td>
<td>6</td>
<td>1.000</td>
</tr>
<tr>
<td>25</td>
<td>82</td>
<td>7</td>
<td>.600</td>
</tr>
<tr>
<td>25</td>
<td>83</td>
<td>7</td>
<td>.700</td>
</tr>
<tr>
<td>25</td>
<td>84</td>
<td>8</td>
<td>.200</td>
</tr>
</tbody>
</table>
SALES DATA: In Millions of Dollars
CASE 26

<table>
<thead>
<tr>
<th>Case</th>
<th>Fiscal_Year</th>
<th>Age</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>81</td>
<td>1</td>
<td>.125</td>
</tr>
<tr>
<td>26</td>
<td>82</td>
<td>2</td>
<td>.250</td>
</tr>
<tr>
<td>26</td>
<td>83</td>
<td>3</td>
<td>.500</td>
</tr>
<tr>
<td>26</td>
<td>84</td>
<td>4</td>
<td>1.500</td>
</tr>
</tbody>
</table>
Appendix C

EQUATIONS SETS
Appendix C

EQUATIONS SETS

Equation Set 1
Focal Point Calculations

\[
FP(T) = \frac{\sum_{i=2}^{N} |\Delta T_p,|}{N-1}
\]

\[
FP(M) = \frac{\sum_{i=2}^{N} |\Delta M_p,|}{N-1}
\]

\[
FP(TM) = \frac{\sum_{i=2}^{N} |\Delta T_p, \times \Delta M_p(i)|}{N-1}
\]

FP = Focal Point
T = Technology Dimension
M = Market Applications Dimension
TM = Combine Technological and Market Applications
Delta T = Level of Technological Newness
Delta M = Level of Market Applications Newness
N = Total Number of Products
p = A product
Equation Set 2
Variance Calculation

\[
V(T) = \frac{\sum_{i=2}^{N} |\Delta T_{p_i} - \Delta T_{p_{i-1}}|}{N-1}
\]

\[
V(M) = \frac{\sum_{i=2}^{N} |\Delta M_{p_i} - \Delta M_{p_{i-1}}|}{N-1}
\]

\[
V(TM) = \frac{\sum_{i=2}^{N} |\Delta T_{p_i} - \Delta T_{p_{i-1}}| \times |\Delta M_{p_i} - \Delta M_{p_{i-1}}|}{N-1}
\]

\text{V = Variance} \\
\text{T = Technology Dimension} \\
\text{M = Market Applications Dimension} \\
\text{TM = Combine Technological and Market Applications} \\
\text{Delta T = Level of Technological Newness} \\
\text{Delta M = Level of Market Applications Newness} \\
\text{N = Total Number of Products} \\
\text{p = A product}

Equation Set 3
Strategic Focus Calculations

\[
SF(T) = FP(T) \times \sqrt{V(T)}
\]

\[
SF(M) = FP(M) \times \sqrt{V(M)}
\]

\[
SF(TM) = FP(TM) \times \sqrt{V(TM)}
\]

\text{SF = Strategic Focus} \\
\text{T = Technological Dimension} \\
\text{M = Market Applications Dimension} \\
\text{TM = Combine Technological and Market Applications}
Equation Set 4
Innovation Intensity

\[ \Phi = \frac{N}{\text{Age} \ N} \sum_{i=2}^{\Delta T_{p_i}} \]

\[ \Psi (T) = \frac{\sum_{i=2}^{\Delta T_{p_i}}}{\text{Age}} \]

\( \Phi = \text{Average Product Releases} \)
\( \Psi = \text{Innovation Intensity} \)
\( T = \text{Technological Dimension} \)
\( p = \text{A Product} \)
\( N = \text{Number of Products current to 1984} \)
\( \text{Age} = \text{Age of Firm current to 1984 or Last Year of Business Operations} \)

Equation Set 5
Average Normalized Sales Calculation

\[ \text{ANS} = \frac{\sum_{j=\text{Start}}^{Y} \frac{\text{Sales}_j}{\text{Current} - \text{Start}}}{Y - \text{Start}} \]

\( \text{ANS} = \text{Average Normalized Sales} \)
\( \text{Start} = \text{Calendar Year of Company Startup} \)
\( \text{Sales} = \text{Annual Sales, Product-related revenues} \)
\( \text{Current} = \text{Current Calendar Year} \)
\( Y = \text{The Most Recent, 1984 or Last Year of Business Operations} \)
Equation Set 6
The Spearman Rank Coefficient

\[
\rho = 1 - \left[ 6 \times \frac{\sum_{i=1}^{N} (\text{Rank}_i(SF_{TM}) - \text{Rank}_i(P))^2}{N^3 - N} \right]
\]

\(\rho = \text{Spearman rank coefficient}\)
\(\text{Rank} = \text{Rank position}\)
\(\text{SF} = \text{Strategic Focus}\)
\(\text{TM} = \text{Combined Technological and Market Applications}\)
\(\text{P} = \text{Performance}\)
\(\text{N} = \text{Number of Companies in Test}\)

Equation Set 7
The Relationship Between Strategic Focus and Performance

\[y = A \times e^{-B \times x}\]

\(A = 8.970\)
\(B = .514\)
\(\text{range} = (0,8)\)
Appendix D

SPEARMAN RANK COEFFICIENT VALUES
Appendix D

SPEARMAN RANK COEFFICIENT VALUES

<table>
<thead>
<tr>
<th>N</th>
<th>.05</th>
<th>.01</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>.900</td>
<td>1.000</td>
</tr>
<tr>
<td>6</td>
<td>.829</td>
<td>.943</td>
</tr>
<tr>
<td>7</td>
<td>.714</td>
<td>.803</td>
</tr>
<tr>
<td>8</td>
<td>.643</td>
<td>.733</td>
</tr>
<tr>
<td>9</td>
<td>.600</td>
<td>.783</td>
</tr>
<tr>
<td>10</td>
<td>.561</td>
<td>.746</td>
</tr>
<tr>
<td>12</td>
<td>.506</td>
<td>.712</td>
</tr>
<tr>
<td>14</td>
<td>.456</td>
<td>.645</td>
</tr>
<tr>
<td>16</td>
<td>.425</td>
<td>.601</td>
</tr>
<tr>
<td>18</td>
<td>.399</td>
<td>.564</td>
</tr>
<tr>
<td>20</td>
<td>.377</td>
<td>.534</td>
</tr>
<tr>
<td>22</td>
<td>.350</td>
<td>.508</td>
</tr>
<tr>
<td>24</td>
<td>.343</td>
<td>.485</td>
</tr>
<tr>
<td>26</td>
<td>.329</td>
<td>.465</td>
</tr>
<tr>
<td>28</td>
<td>.317</td>
<td>.448</td>
</tr>
<tr>
<td>30</td>
<td>.306</td>
<td>.432</td>
</tr>
</tbody>
</table>

From S. Siegel, *Nonparametric Statistics For The Behavioral Sciences*, (1956)
Appendix E

DATA ANALYSIS PROGRAMS
Appendix E

DATA ANALYSIS PROGRAMS

The programs contained below are:

1. make product ranks, using the multiplicative method
2. make product ranks, using the additive method
3. make sales ranks, using normalized sales
4. make sales ranks, using unnormalized sales
5. make Spearman rank coefficient using outputs from product rank and sales rank programs above

These programs are written using standard UNIX shell script with datal programs of PRELUDE, a UNIX applications software package.
# Make product ranks for each company using Multiplicative Method
# Creates a table called "prodmeans"

tput clear
echo "What is the name of the names file?"
lecho "Names file-> \c"
read list
project id < $list > tmp$$
echo "Here is the index of companies."
cat tmp$$
echo "Want to use them all? \c"
read x
case $x in
  [Nn]*)
    vi tmp$$
    ;;
  *)
    ;;
esac
mv tmp$$ index

tput clear
echo "What is the product database"
lecho "Product database-> \c"
read database

echo "co ft fm ftm dispt dispmdispstm-- - - --------- ------- -------" > prodmeans
exec 3<&0
exec 4<index
exec 0<&4
read x
read x
read x
while [ "$x" ]
do {
  echo "Doing case $x"
  select "co == $x" < $database | |
  addcol ftm dispdm dispt disptm | |
  compute 'ftm = sprintf( "%.3f", (m * t)); |
  if (z > 0) dispt = t - oldt; |
  if (z > 0) dispdm = m - oldm; |
  if (z > 0) dispt = sqrt (dispt * dispt); |
  if (z > 0) dispdm = sqrt (dispdm * dispdm); |
  if (z > 0) disptm = dispt * dispdm; |
  z = 1; oldm = m; oldt = t ' > tmp1$$

  select "num != 1" < tmp1$$ | |
  project co t m ftm disp t dispt disptm | |
  rename t ft m fm | math -t mean | |
  tail +3 >> prodmeans
  read x
}
done

exec 0<&3

addcol st sm stm < prodmeans | |
compute " st = ft * dispt ; sm = fm * dispdm ; |
        stm = ftm * disptm " | |
trim ft F5.3 fm F5.3 ftm F5.3 dispt F1.4 dispdm F1.4 |
        disptm F2.4 st F5.3 sm F5.3 stm F5.3 | clean > tmp2$$
mv tmp2$$ prodmeans

y='who am i'
set $y
name=$1

put clear

echo "Here are the product means"
echo "PRODUCT MEANS : file prodmeans 'date' $name
   " > tmp3$$
cat prodmeans >> tmp3$$
mv tmp3$$ Means
cat Means

echo "Do you want a printout? \c"
read x
case $x in
  [Yy]*) lp -dlaser Means
;;
*; esac
sleep 2

tput clear
echo "PRODUCT MEANS SORTED BY TECHNOLOGY STRATEGIC FOCUS : file ST
date \$name
" > tmp4$$
echo PRODMEANS SORTED by ST

project co ft dispt st < prodmeans | \ sorttable -n st | \
number | \ rename number productrank | clean > ST
cat ST >> tmp4$$
cat tmp4$$
echo "Do you want a printout ? \c"
read x
case $x in
  [Yy]*)
    lp -dlaser tmp4$$
    ;;
  *)
    ;;
esac
sleep 2

tput clear
echo "PRODUCT MEANS SORTED BY MARKET STRATEGIC FOCUS : file SM
date \$name
" > tmp4$$
echo PRODMEANS SORTED by SM

project co fm dispn sm < prodmeans | \ sorttable -n sm | \
number | \ rename number productrank | clean > SM
cat SM >> tmp4$$
cat tmp4$$
echo "Do you want a printout ? \c"
read x
case $x in
  [Yy]*)
    lp -dlaser tmp4$$
    ;;
  *)
    ;;
esac
sleep 2
tput clear
echo "PRODUCT MEANS SORTED BY TECHNOLOGY-MARKET STRATEGIC FOCUS"
' date' $name
"
> tmp4$$
echo PRODMEANS SORTED by STM

project co ftm disptm stm < prodmeans | \ sorttable -n stm | \ number | \ rename number productrank | clean > STM
cat STM >> tmp4$$
cat tmp4$$
echo "Do you want a printout? \c"
read x
case $x in
  [Yy]*)
    lp -dlaser tmp4$$
    ;;
  *)
    ;;
esac
sleep 2

rm -f tmp*
PRODUCT RANKS USING ADDITIVE METHOD

# Make product ranks for each company, using Additive Method
# Creates a table called "prodmeans"

tput clear
echo "What is the name of the names file?"

lc
echo "Names file-> \c"
read list
project id < $list > tmp$$
echo "Here is the index of companies."
cat tmp$$
echo "Want to use them all? \c"
read x
case $x in
  [Nn]*)
    vi tmp$$
    ;;
  *)
    ;;
esac
mv tmp$$ index

# Continue with product database

# Add product database

tput clear
echo "What is the product database"

lc
echo "Product database-> \c"
read database

# Process product database

echo "co ft fm ftm dispt dispd disptm"
exec 3<&0
eexec 4<index
eexec 0<&4
read x
read x
read x
while [ "$x" ]
do {
    echo "Doing case $x"
    select "co == $x" < $database |
    addcol ftm dispm dispt dispkm |
    compute "ftm = sprintf( "%3.3f\", ( m * t )); |
        if (z > 0) dispt = t - oldt; |
        if (z > 0) dispm = m - oldm; |
        if (z > 0) dispt = sqrt ( dispt * dispt ); |
        if (z > 0) dispm = sqrt ( dispm * dispm ); |
        if (z > 0) dispkm = dispt + dispm ; |
    z = 1; oldm = m; oldt = t " > tmp1$$
    select "num != 1" < tmp1$$ |
    project co t m ftm dispm dispt dispkm |
    rename t ft m fm math -t mean |
    tail +3 >> prodmeans
    read x
}
done

exec 0<&3

addcol st sm stm < prodmeans |
compute "st = ft + sqrt ( dispt ) ; sm = fm + sqrt ( dispm ) ; |
     stm = ftm + sqrt ( dispkm ) " |
trim ft F5.3 fm F5.3 ftm F5.3 dispt F1.4 dispm F1.4 dispkm F2.4
mv tmp2$$ prodmeans

y='who am i'
set $y
name=$1

tput clear

echo "Here are the product means"
echo "PRODUCT MEANS : file prodmeans "
'e date' "$name
" > tmp3$$
cat prodmeans >> tmp3$$
mv tmp3$$ Means
cat Means

echo "Do you want a printout? \c"
read x
case $x in
    [Yy]*)
        lp -dlaser Means
    ;;

New Product Strategy
* ) ;;
sac
sleep 2

tput clear
echo "PRODUCT MEANS SORTED BY TECHNOLOGY STRATEGIC FOCUS : file ST
date" $name
" > tmp4$$
echo PRODMEANS SORTED by ST

project co ft dispt st < prodmeans | \ sorttable -n st | \
number | \ rename number productrank | clean > ST
cat ST >> tmp4$$
cat tmp4$$
echo "Do you want a printout ? \c"
read x
case $x in
  [Yy]*)
    lp -dlaser tmp4$$
    ;;
  *) ;;
esac
sleep 2

tput clear
echo "PRODUCT MEANS SORTED BY MARKET STRATEGIC FOCUS : file SM
date" $name
" > tmp4$$
echo PRODMEANS SORTED by SM

project co fm dispn sm < prodmeans | \ sorttable -n sm | \
number | \ rename number productrank | clean > SM
cat SM >> tmp4$$
cat tmp4$$
echo "Do you want a printout ? \c"
read x
case $x in
  [Yy]*)
    lp -dlaser tmp4$$
    ;;
  *) ;;
esac
sleep 2
tput clear
echo "PRODUCT MEANS SORTED BY TECHNOLOGY-MARKET STRATEGIC FOCUS
'date' $name
"
> tmp4$$
echo PRODMEANS SORTED by STM

project co fmt disptm stm < prodmeans |
sortable -n stm |
number |
rename number productrank | clean > STM
cat STM >> tmp4$$
cat tmp4$$
echo "Do you want a printout ? \c"
read x
case $x in
  [Yy]*)
    lp -dlaser tmp4$$
    ;;
  *) ;;
esac
sleep 2
rm -f tmp*
SALES RANKS USING NORMALIZED SALES

# Make a table called SALES that contained Average Normalized Sales
# for each company

tput clear
echo "What is the sales database"
le
echo "Sales database-> \c"
read database

echo "co growth
--  --------" > SALES

exec 3<&0
exec 4<index
exec 0<&4

read x
read x
read x

while test ! -z "x"
do {
    echo "Doing case x"
    select "co == x" $database | \n    addcol growth | \n    compute " if ( NR == 1 ) { start = year }; \n    growth = sales / ( year - start + 1 )" > tmp1$
    project co growth < tmp1$ | math -t mean | tail +3 >> SALES
    read x
}
done

exec 0<&3
trim growth F5.3 < SALES | clean > tmp2$
mv tmp2$ SALES

y=`who am i`
set $y
name=$1

tput clear
echo "Here are the sales means: file SALES"
echo "Salesmeans
date $name"
" > tmp3$$
cat SALES >> tr.3$$
cat tmp3$$
echo "Do you want a printout? \c"
read x
case $x in
  [Yy]*)
    lp -dlaser tmp3$$
  ;; *
]*) ;;
esac
sleep 2

tput clear
echo "GROWTH PERFORMANCE DATA: file SALESRANK
date $name"
" > tmp4$$
sortable -n -r growth < SALES | number | 
rename number salesrank | 
clean > SALESRANK
cat SALESRANK >> tmp4$$
cat tmp4$$
echo "Do you want a printout? \c"
read x
case $x in
  [Yy]*)
    lp -dlaser tmp4$$
  ;; *
]*) ;;
esac
sleep 2
rm -f tmp*
# Make a table called Sales that contains Unnormalized Average Sales
# for each company

tput clear
echo "What is the sales database"
lc
echo "Sales database-> \c"
read database
echo "co growth
-- ---------" > SALES

eexec 3<&0
eexec 4<index
eexec 0<&4

read x
read x
read x

while test ! -z "$x"
do {
echo "Doing case $x"
select "co == $x" $database | \
addcol growth | \
compute "growth == sales" > tmp1$
project co growth < tmp1$ | math -t mean | tail +3 >> SALES
read x
}
done

eexec 0<&3
trim growth F5.3 < SALES | clean > tmp2$
mv tmp2$ SALES

y='who am i'
set $y
name=$1

tput clear
echo "Here are the sales means : file SALES"
echo "Salesmeans
'date' $name" > tmp3$
cat SALES >> tmp3$
cat tmp3$
echo "Do you want a printout ? \c"
read x
case $x in
  [Yy]*)
    lp -dlaser tmp3$$
    ;;
  *) ;;
esac
sleep 2

tput clear
echo "GROWTH PERFORMANCE DATA: file SALESRANK
'date' $name

" > tmp4$$

sortable -n -r growth < SALES | number | \\rename number salesrank | \\clean > SALESRANK
cat SALESRANK >> tmp4$$
cat tmp4$$

echo "Do you want a printout ? \c"
read x
case $x in
  [Yy]*)
    lp -dlaser tmp4$$
    ;;
  *) ;;
esac
sleep 2

rm -f tmp*
SPEARMAN RANK COEFFICIENT

# Create Spearman rank coefficient
# Produces three files: SPEAR.T, SPEAR.M, SPEAR.TM
# Ranking Strategic focus for dimensions separately and combined

\num = 'SALES RANK'
\status = 'who am i'
set $\status$
\name = "$1$

tput clear
echo "What is the cluster ?\c"
read \cluster

for i in T M TM
do {
    tput clear
echo "Doing $i$ by $y$"
    project co productrank < $S\$i | sortable -n co > tmp1$$
    project co salesrank < $y | sortable -n co > tmp2$$

    rjoin tmp1$$ tmp2$$ > tmp3$$

    num = 'tail +3 tmp3$$ | wc -l'

    addcol -i co productrank salesrank diff residual < tmp3$$ | |
    compute "diff = productrank - salesrank ;
    residual = diff * diff" > tmp4$$

    echo "Spearman's Rank Coefficient Test for $i$
\$\cluster
\$\name 'date'
" > SPEAR.$i

    math -l -t -o residual total < tmp4$$ | clean >> SPEAR.$i
    junk=math -t -o residual total < tmp4$$ | |
    addcol -i spearrank residual | |
    compute "spearrank = 1 - (( 6 * residual ) / |
    (( $num * $num * $num ) - $num))" | |
    project -h spearrank'

    echo "
The Coefficient is : $junk" >> SPEAR.$i
cat SPEAR.$i
echo "Do you want a printout? \c"
read x
case $x in
    [Yy]*)
        lp -dlser SPEAR.$i
        ;;
    *)
        ;;
esac
sleep 2
rm -f tmp*
}
done