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# Strategic Implications of R&D Investment on Dynamic Business Systems

George F. Farrimond Jr.  
*Portland State University*

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STRATEGIC IMPLICATIONS OF R&D INVESTMENT  
ON DYNAMIC BUSINESS SYSTEMS

by

GEORGE F. FARRIMOND, JR.

A dissertation submitted in partial fulfillment of  
the requirements for the degree of

DOCTOR OF PHILOSOPHY  
in  
SYSTEMS SCIENCE

Portland State University

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TO THE OFFICE OF GRADUATE STUDIES:

The members of the Committee approve the dissertation  
of George F. Farrimond presented July 10, 1989.

  
\_\_\_\_\_  
Chair

  
\_\_\_\_\_  
Walter G. Ellis


  
\_\_\_\_\_  
Kenneth M. Jenkins

  
\_\_\_\_\_  
George G. Lendaris

  
\_\_\_\_\_  
Richard M. Straw

  
\_\_\_\_\_  
Barry F. Anderson

APPROVED:

  
\_\_\_\_\_  
Martin Zwick, School of Systems Science

  
\_\_\_\_\_  
C. William Savery, Interim Vice Provost for Graduate  
Studies and Research

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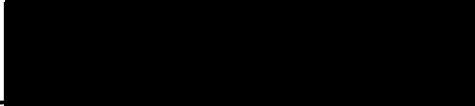
  
Lewis N. Goslin, Chair

  
W

  
Kenneth M. Jenkins

  
George G. Lendaris

  
Richard M. Straw

  
Barry F. Anderson

The United States' ability to compete in many international markets has been based on competitive advantage in high-technology products. Until recently, these industries had a favorable trade balance but in 1987, it slipped to deficit of \$0.6 billion.

Management of research and development programs is one of the most important elements in remaining competitive. Therefore, this research study of 291 high-technology firms was undertaken to determine if: (1) a positive relationship exists between the amount of investment in research and development (R&D) and a firm's success in sales, net income, or market share, (2) excessive investment in R&D would decrease profitability, (3) there exists a "critical mass" of R&D spending for a firm to remain competitive.

The results of this study indicate that while R&D is an important factor in high-technology industries, it is not the driving force in the success of a firm. Successful management requires a more systemic approach which considers many factors including research and development.

There was no evidence found that excessive investment decreases profits and no indication that a "critical mass" of R&D was required for a high-technology firm.

This study found lag times from R&D investment to the time of impact on sales, net income and market share. The

lag times did not have significant correlations in most cases but appeared to be in agreement with the opinions of industry experts surveyed in field interviews.

It was also found that the leading high-technology firms budget R&D by a percent of sales or prior years budget method. This approach may be very detrimental to effective management of research programs since it may reduce funding for at a time when it should be increased in order to develop new products and technologies.

The results indicate that start-up firms can compete effectively with mature firms. Leading start-up companies generally spend more as a percent of sales on R&D than mature firms but appear to be as effective in managing their research effort.

The results of this study has implications for stakeholders of high-technology industries in understanding some important elements in the management of successful R&D programs.

## CHAPTER I

### INTRODUCTION

The objectives of this study were to determine: if a positive relationship exists between R&D investment and improved sales, net income, and market share performance; if insufficient R&D investment would have a negative impact on net income, ROI and market share; and if there was a threshold level of R&D investment required to remain competitive in high-technology industries.

The results indicate that while R&D is an important factor in high-technology industries, it is not the driving force in success for a firm. Successful management requires a systemic approach which considers many factors including research and development.

No evidence was found that insufficient R&D investment would decrease sales, ROI or market share. In many cases firms with little investment in R&D were performing well in a niche of a high-technology industry.

Lastly, no evidence was found that a threshold level of R&D investment was required for a firm to remain competitive.

## STATEMENT OF THE PROBLEM

Companies in a high-technology environment are pressured to constantly improve the state-of-the-art of their products in order to stay competitive. Incremental product improvements and successful introduction of new products are primary responsibilities of corporate R&D programs. Corporate survival in international markets may depend on the results achieved by government and commercial research programs.

This project examines the effects of Research and Development (R&D) funding decisions made by 291 firms competing in high-technology industries. It compares the Return on Investment (ROI) performance of companies in the first quartile and fourth quartile firms, of their industry, and develops conclusions concerning the impact of R&D expenditures.

## BACKGROUND INFORMATION

The United States' ability to compete in many industrial international markets is based on competitive advantage in high-technology products. In the years since 1975, the U.S. has experienced escalating trade deficits that have rapidly increased to a phenomenal \$108.8 billion deficit for 1988 [U.S. Government Printing Office, 1989:36].

High-technology industries had been the bright spot in



an otherwise dismal export record for the U.S. since the export surplus in that sector grew from \$3.1 billion in 1965 to \$23.6 billion in 1981. But by 1984, the high technology surplus slipped to \$6.1 billion and by 1987, became a deficit of \$0.6 billion [Hatter, 1985:5] [U.S. Department of Commerce, International Trade Commission, 1984:13-16] [U.S. Department of Commerce, International Trade Commission:14-17] [U.S. Department of Commerce, International Trade Commission:15-17] [U.S. Department of Commerce, International Trade Commission:17-20].

This change in the trade balance has suggested that a weakness is emerging in the technological performance of the U.S. industrial system. This problem will increase in intensity as other countries develop high technology capability and penetrate markets presently dominated by U.S. industry [Buffa, 1984:9-13] [Hatter, 1985:1-11] [Piekartz, 1983:210-214], [Presidents Commission Vol. I, 1985:16-23], [Presidents Commission Vol. II, 1985:173-184].

"Japan and West Germany, the two countries that have competed most successfully against U.S. manufacturing industries, both devote a significantly greater share of their GNP to civilian R&D" [Congressional Budget Office, 1984:xv]. Although the U.S. as a whole spends slightly more than other countries for R&D, nearly half of the total is funded by the Federal Government, and within

that, defense and space programs account for about two-thirds. In funding for commercial innovation, America is behind West Germany and Japan in the percent of the GNP which is devoted to non-defense research and development. Table I lists Non-Defense R&D as a percent of GNP from 1960 to 1987.

TABLE I

## NON-DEFENSE R&amp;D AS A PERCENT OF GNP

<u>Year</u>	<u>West Germany</u>	<u>Japan</u>	<u>United States</u>
1960	.90	1.25	1.10
1964	1.40	1.50	1.28
1968	1.75	1.58	1.45
1972	1.95	1.80	1.41
1976	2.00	1.90	1.48
1980	2.38	2.10	1.65
1984	2.40	2.06	1.80
1985	2.50	2.80	1.90
1986	2.60	2.80	1.80
1987	2.80	2.90	1.70

Source: President's Commission on Industrial Competitiveness [Presidents Commission Vol. II, 1985:22] and the National Science Foundation [National Science Foundation, 1988:6]

The level of spending for R&D affects high-technology products more than other products since high-technology products are typically developed during the process of exploring new technological frontiers. Increased R&D investment may be required to remain competitive.

In 1978, the National Science Foundation stated that during the previous decade, R&D as a fraction of GNP in the U.S. had decreased 20%, basic research had declined

24%, and industrial investment in basic research as a percent of sales had declined 32%. While 80% of the patents issued by the U.S. Patent Office in 1965 originated in the U.S., by 1977, the percentage originating in the U.S. had decreased to 63% [Mechlin, 1980:93].

High technology industries are important to commercial markets and continued economic progress for the U.S. The U.S. Department of Commerce reported that during the period from 1929 to 1969, "technological innovation was responsible for 45% of the nation's economic growth" [Mechlin, 1980:93]. In December of 1981, the Department of Commerce was directed to study the competitive position of high-technology industries in the United States. This effort resulted in the following key findings [U.S. Department of Commerce, 1983:iii]:

1. "High-technology industries are vital to the U.S. economy since their growth rate has been double that for total industry and they provide most technological advances for the entire economy".
2. "National security depends on the technology intensive industries."
3. "The United States must depend heavily on the area of its greatest strength which is advanced technology".
4. The U.S. position in the international market for high-technology industries "has declined from a position of dominance to one of being strongly challenged" and as indicated on page one, the U.S. became a net importer in 1987.

5. "An array of factors influence U.S. versus foreign advances in technology. The most important of these across all industries are:

- a. The overall state of the domestic economy
- b. Cost and supply of capital
- c. Relative R&D efforts
- d. The transfer of technology
- e. Availability of scientists and technicians
- f. Explicit foreign industrial policies targeting the technology-intensive sectors for development".

6. "Foreign government industrial programs promote high-technology development."

7. "The major technological challenge to the United States is from Japan" which has targeted certain industries and may expand its influence to other economic areas.

Other literature also provides evidence of the decline in U.S. high technology market position, of increased foreign competition, and of weakness in management of research strategy in America. For example, the Japanese now dominate the electronics markets for radio, television, and video recorders which were all American innovations (there are virtually no VCRs manufactured in the U.S.); the Russians are spending more for R&D than the U.S.; and "it seems as if the U.S. is relying more on existing technologies by shifting technology applications while relying less on radical innovations" [Abernathy, 1982:36]. West Germany now leads in capital goods and machine tool production and the Japanese have higher automobile productivity rates which give them cost advantages of from \$1200 to \$1600 per automobile [Abernathy, 1982:34-38].

Also, the Japanese are now challenging American market

dominance in computers, semiconductors, and robotics and European competitors are competing for aerospace markets which have been dominated by American firms. Boulton stated that "the economic strength and vitality of the U.S. economy will depend in the future on its willingness to save and invest, to remove regulations that unduly stifle competition, to stimulate technological progress, and to increase productivity" [Boulton, 1984:82-87, 110].

The economic importance of the high-technology sector can also be shown by other factors. First, the rate of growth of real output in high technology industries from 1970 to 1980 was seven percent, more than double the three percent rate for all U.S. business. Second, the rate of inflation over the decade of the 1970's averaged 2.5% for high-technology while the rate was 7% for all businesses. Third, the high-technology sectors had maintained a trade surplus until 1987 during which time they achieved productivity increases averaging over six times the rate for all U.S. business. Also, there are significant benefits in the transfer of high-technology research and development innovations to the non-manufacturing sector as evidenced by the estimate that as much as 50% of the value of the R&D effort may benefit industries that are not considered to be high-technology [U.S. Department of Commerce, 1983:3-4].

There are additional factors which bear on the success

of the high-technology sector, and these relate to the competitive posture of management in the U.S. One is the manner in which we evaluate management and financial investments. Since 1960, it has been popular to evaluate investments in the United States based on their Return on Investment (ROI). This type of evaluation has led to short term analysis and investment policies [Mechlin, 1980:94-95]. Other countries such as Japan, West Germany, and France have developed longer range strategies and significantly increased their total R&D funding in the past two decades. This has enhanced their technological capability at a time when the U.S. has experienced declining interest in research for the long term [Congressional Budget Office, 1984:xv].

Another is the difficulty that American management seems to have in linking long-range research planning with strategic management objectives. Weil and Cangemi reported that respondents to their survey had formal long-range planning systems whose time-horizon averaged 6.5 years, and this is in a context where the average time to develop new (high technology) products from concept to the market took an average time of 9.0 years [Weil, 1983:32-38].

In high technology industries, product life cycles may be significantly shorter than those experienced in the past. Fraker found some evidence of this in the

electronics industries. She stated that "at the heart of the current need for change is the fact that product life cycles are getting shorter" [Fraker, 1982:62].

The data from the interviews for this study indicate that business executives, with the exception of the aircraft industry, feel that their product life cycles typically range from one to seven years with an average of four.

In the current international market environment, organizational systems that have been identified as high-technology or technology intensive are the key to economic survival for U.S. industries. They must become adaptive systems that can react to the environmental turbulence, establish effective technological strategies, and enter markets where they can compete [Frohman, 1981:59-67].

If the United States is to maintain a competitive market posture, it is essential that the relationship of R&D investment to long range planning be understood, that effective performance measurement systems be implemented for managers and corporations, and that scarce resources be managed more effectively.

#### ORGANIZATIONS AS SYSTEMS

This section explains the perspective of organizations as systems, the importance of the research and development (R&D) subsystem, defines strategic management and the

process of strategic planning, and relates the activity of the R&D subsystem to the commercial innovation process.

Organizations have long been recognized as systems by noted authors. Barnard was one of the first when, in 1938, he defined organizations as "cooperative systems" in his classic The Functions of the Executive [Barnard, 1938:4-7]. Barnard states that "the survival of an organization depends upon the maintenance of an equilibrium of complex character in a continuously fluctuating environment of physical, biological, and social materials, elements, and forces, which calls for readjustment of processes internal to the organization" [Barnard, 1938:6].

Organizations are open systems because they depend on inputs of energy, material, information, capital, and personnel from the environment. They organize and transform inputs into output of goods and services for society. Organizations attempt to have stability and they develop feedback systems which permit effective reaction to changing conditions. Katz and Kahn listed the following characteristics for open systems: Importation of Energy; Throughput; Output; Cycles of Events; Negative Entropy; Information Input; Negative Feedback and the Coding Process; Steady State and Dynamic Homeostasis; Differentiation; and Equifinality [Katz, 1966:23-30].



In addition, businesses have the four characteristics of "partially self-controlled systems" as described by Ackoff [Chen, 1980:29].

- a. Content: people and equipment.
- b. Structure: physical and mental organization.
- c. Communication: information and effectiveness.
- d. Decision Making: setting objectives and directing action.

To be effective in the high technology markets, firms must be organized into efficient and effective dynamic systems. Drucker has stated that it "is the task of this generation of management to make the institutions of the society of organizations, beginning with the business enterprise, perform for society and economy; for the community; and for the individual alike" [Drucker, 1973:807].

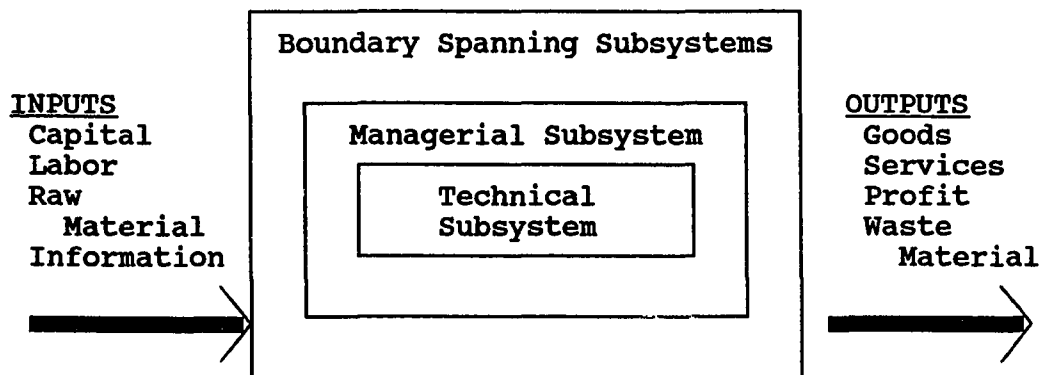
#### Research and Development (R&D) as a Subsystem

The R&D segment of a high-technology firm is a subsystem since it has all the attributes described by systems authors such as Ashby, Parsons, and von Bertalanffy [Ashby, 1961:48, 246] [Parsons, 1961:35] [von Bertalanffy, 1968:69-75]. The objectives of the R&D subsystem are to support the existing business and develop new products which in turn will maintain or expand the market for the organization.

Basic research, applied research, and development all present opportunities to develop cost advantages through

R&D spending. Benefits of scale, learning, and interrelationships can be achieved to provide competitive advantage [Porter, 1985:184].

Thompson provides an excellent perspective from which to understand the relationship of the primary subsystems of a high technology firm. This type of business has a technical subsystem surrounded and protected by the managerial and boundary spanning subsystems as shown in Figure 1 [Thompson, 1967:70-79].



**Figure 1.** The Organization With Subsystems.  
[Kreitner, 1980:159]

The R&D subsystem is part of the Technical Subsystem and has primary responsibility for basic and applied research. To function effectively, it must have strong relationships with the other critical subsystems in the corporation such as marketing, accounting and manufacturing.

Proper balance and coordination between the functional elements of an organization is essential to the stability

of the organization. In practice, balancing of functional elements is often extremely difficult to accomplish. Wind reported that [Wind, 1982:482]:

- a. Marketing and R&D often have conflicts over the "resources, plans, and responsibilities."
- b. There are organizational, professional, and human activities that tend to create cultural separateness between R&D and marketing.
- c. Interaction and collaboration are significant elements of success in innovative process.

Wolff stated that [63 p. 9]:

- a. "The manufacturing/R&D interface is healthy only when technology transfer occurs in both directions."
- b. "The transfer to manufacturing is only complete when the process in question is on-stream and reliably operating to produce a specification product that's being sold at a profit."
- c. "The transfer back to R&D is complete when R&D is able to improve the performance of its mission of providing technology for the firms benefit."

The R&D subsystem must take the initiative in developing linkages with the operational entities in the corporation. According to Westwood, "any research laboratory that fails to keep close touch with its customers, namely its plants, and possibly their customers, is headed for oblivion" [Wolff, 1985:9-11].

#### R&D's Relationship To Strategic Management

Prior to World War II, most businesses were small and there was little interest in long-range planning. It was felt that business could only react to the day-to-day

market forces due to erratic business cycles and managers at all levels could adequately handle any long-range planning which might be required. After the war, economic conditions stabilized and the rate of technological progress rapidly increased, business firms grew in size and complexity, and the environment of business rapidly changed [Steiner, 1963:2-3]. These forces, compelled "companies to introduce comprehensive planning programs" and establish staff planning functions in the 1950's and 1960's [Steiner, 1969:15].

In the 1960's, companies began to develop and stress the concept of corporate strategy to react to the increasingly complex environment at that time. Strategic management evolved as a systemic approach in the 1970's as the need for longer range and more comprehensive planning was recognized. It has been defined as "the process of managing the total organization and developing its distinctive competencies" and as "the study of the functions and responsibilities of those who lead and manage purposeful organizations. It is devoted to the problems of the total organizations as seen by top managers and key executives. It is concerned with the process and problems of determining the purpose of the organization, and the ends it hopes to achieve, and then committing critical resources to the accomplishment of those ends" [Boulton, 1984:12].

The process of strategic planning begins with senior management who provide guidance concerning the long-term direction of the firm over a 10 to 20 year time frame. For most firms, effective strategies evolve "from an iterative process in which the organization probes the future, experiments, and learns from a series of partial (incremental) commitments rather than through global formulations of total strategies" [Quinn, 1980:58]. Senior executives consciously go through the process of formal planning and understand that they must "manage the several-year, iterative, political, consensus-building process that is necessary to convert their broad visions into an effective new strategy" [Quinn, 1980:192].

From the strategic plan, the corporation typically develops a five-year plan which includes consideration of mission, objectives, policies, resources, and assumptions for the appropriate time frame [Cannon, 1984:20-22]. Two significant elements in the long-range plan for high technology firms will be the type of research programs and the resources to be devoted to R&D for both current and future products.

Funding for new product development is essential to high technology firms but is often neglected due to the focus on products that are currently generating significant cash flows. The type of budgeting process used may not meet the long range needs of the firm. Firms often allocate

funds for research based on a percentage of sales dollars of current products or the same dollar amount each year. This type of budgeting may run counter to the real needs of the corporation and actually reduce research budgets at a time when it is critical for the firm to acquire new technologies and products.

The need for continual funding of R&D is indicated in the findings of Abernathy and Utterback. They stated that innovation for major new products typically originates in response to an emerging or existing need while innovation for high-volume products is "typically incremental in nature". They also found that "major systems innovations have been followed by countless minor products and systems improvements" [Tushman, 1988:28-29].

Allio and Sheehan identified eight categories of R&D which require funding and vary in intensity during the life cycle of a technology. They are [Allio, 1984:14-20]:

- a. Exploratory research.
- b. New products-existing markets.
- c. Product extension.
- d. Process improvement.
- e. Raw material substitution.
- f. Regulatory response.
- g. Energy saving.
- h. Diversification.

Each of these categories must be reviewed and receive funding according to corporate requirements. R&D expenditures must be allocated carefully and support corporate strategy since "no corporation ... can maintain a program that comprehends all technologies" [Allio,

1984:14-20]. To respond adequately, the corporation must fund R&D above a threshold level in selected activities and concentrate the research effort on its core technologies. A core technology is defined by Allio and Sheehan as [Allio, 1984:14-20]:

- a. Critical to maintaining competitive position in a particular business, (or having the potential to displace an important existing technology) or,
- b. Providing significant technological underpinning for several corporate businesses.

Difficult policy decisions must be made concerning funding of R&D projects long before the conventional Product Life Cycle begins. The normal pattern of resource commitment begins with the research function and then shifts to project management, production, and then marketing. According to Boulton, the basic research expenditures begin years before the product introduction that is shown on the traditional Product Life Cycle charts. Investment recovery is not achieved until the product maturity phase [Boulton, 1984:185-186].

In summary, the strategic plan must consider the entire product development and marketing process. Feedback to the R&D subsystem must be provided by the corporation's planning and policy elements to provide sufficient direction to develop satisfactory products for the consumer [Cetron, 1969:43]. Incremental improvement of product quality and function is critical to success in the market.

### The Function of R&D in Commercial Innovation

The commercial innovation process begins with planning at the strategic level and continues with periodic review at the operational level where technology has been developed into market products. The process can be viewed as a sequence of stages as shown in Table II [Quinn, 1980:20].

TABLE II

#### NEW PRODUCT DEVELOPMENT STAGES

Business Strategy  
 New Products Strategy  
 New Products Strategic Plan  
 Focused Idea Generation  
 Concept Development  
 Business Analysis  
 Prototype Development  
 Testing  
 Commercialization

Source: Crawford

If a new concept has promise, prototype development can begin. After extensive testing and evaluation, the product can be prepared for market introduction. During all the phases, the R&D subsystem must be working to improve the product and coordinate with the other functions [Crawford, 1983:38].

Initially, the risk to the firm is a function of the required investment and the probability of failure. If development requires considerable capital and the product is a new market or type of venture, the risk is very high. The risk to the firm also increases if product development



continues for products that will eventually fail in the market. To achieve the desired benefits to the firm, there must be effective and efficient transfer of the technology from the laboratory to the customer.

The examples of successful technology transfer reported in the literature indicate that extensive effort is required to insure that critical linkages are made early [Cannon, 1984:20-22], [Frosch, 1984:11-14], [Thomas, 1984:15-19]. The high-technology firm must, effectively and rapidly, move new technology from basic research to product applications.

Porter provides seven "analytical" steps in formulating technological strategy "in order to turn technology into a competitive weapon." They are: [Porter, 1985:198-200]

1. "Identify all the distinct technologies and subtechnologies in the value chain."
2. "Identify potentially relevant technologies in other industries or under scientific development."
3. "Determine the likely path of change of key technologies."
4. "Determine which technologies and potential technological changes are most significant for competitive advantage and industry structure."
5. "Assess a firm's relative capabilities in important technologies and the cost of making improvements"
6. "Select a technology strategy, encompassing all important technologies, that reinforces the firm's overall competitive strategy."

In summary, it is important for American management to recognize the significance of the entire strategic planning

process and commit sufficient resources to the R&D subsystem. In the 1970's, management appeared to focus on the short-term payoff or ROI while the industrial systems of other nations focused on increased productivity and long-range benefits. The result in the U.S. was a loss of markets, competitiveness, and jobs to other countries. A continuation of this trend will result in further loss of high-technology markets and result in a change in the standard of living for Americans.

#### SIGNIFICANCE OF THIS RESEARCH PROJECT

This research project is significant to the stakeholders concerned with the high technology industries including executives, R&D management, stockholders, financial institutions, labor, government agencies, and American society. The following paragraphs describe some of the considerations for each:

The executives are concerned with the profitability, stability, market share, strategic direction, and long-range survival of the firm. Their primary responsibility is to insure that the corporate system provides the maximum benefits to society while using scarce resources to the best advantage. They provide the leadership and set the direction that the firm will take in the long run. For high-technology firms, the use and direction of R&D investment will set the corporate direction for many years

to come.

R&D managers are concerned with budgets, policy, and resource management. The budgets on which their organizations depend for survival are subject to the decisions and policies of top management. Sufficient expenditures allow for effective R&D programs while under funding may merely waste scarce resources. Management must have a sound basis on which to determine R&D budgets. Budget decisions made with rationale's such as a percentage of sales may not be sufficient in the high technology environment. A broader systems perspective which considers the requirements of the entire corporation is required.

Stockholders want to receive the maximum return on their investment and, usually, desire a long term period of stability for the firm. Speculators would want the firm to achieve the maximum rate of growth as rapidly as possible while minimizing risk.

Financial institutions are interested in the firm's stability and its ability to adjust to environmental turbulence. In particular, investor's decisions to risk funds will depend on estimates of the firm's ability to repay borrowed funds.

Labor is concerned with the firm's ability to maintain jobs, adjust to change, meet the payroll, and remain competitive in order to provide worthwhile careers for the work force.

Government agencies are involved in many aspects of business such as regulation, safety, productivity, and protective tariffs. Of particular importance at this time (1989), are competition from foreign industries and the productivity of American business. Both of these factors are significantly affected by the amount and application of R&D funds.

Society is concerned, among other things, with employment, pollution, safety, and use of resources. Businesses today cannot operate without concern for the impact on society. Results of the decisions must have desired impacts and any undesired outcomes must have the negative factors minimized. Scarce resources must be used properly to get the most benefits for the maximum number of people. Many of these considerations can be impacted by developments from R&D programs.

For each of the concerned parties, this research should provide some information of value. Executives will be able to see the impact of the past patterns of R&D investment; research managers should have an additional basis for budget development; stockholders should be able to observe the successful patterns of high-technology R&D; the resulting data will assist financial institutions with their analysis of applicable companies; other interested groups will be able to observe the results of different patterns of R&D investment. The perspective of each group will be different

and often their objectives will be in opposition but the effect of research and development has a significant impact on the lives of all people in society as it provides improved medical treatment, new information systems, better communication, larger yields from farms, etc. If we can improve the effectiveness and efficiency of research programs perhaps we can improve the economic systems and improve the quality of life for all countries.

#### RESEARCH APPROACH

##### Information Utilized

This research project began by extraction of historical financial data concerning sales, income, R&D expenditures, and related financial data for 347 firms in 34 industries from Standard & Poor's 1983 Compustat II data base [Standard and Poors, 1981, 1983:p. 1 section 3]. The data was modified by deleting some firms, adding companies from the Electronics 100, and assigning the remaining companies into 18 industries. Companies were removed from the data base if they did not release sufficient R&D data to conduct an analysis, did not have R&D data, did not conduct R&D, were not in high technology industries, or were holding companies. These changes are discussed in Chapter III.

The industries and companies were selected using the U.S. Department of Commerce definition of high-technology industries and products. The data for the companies listed

under the appropriate Standard Industrial Classifications in the data base was then extracted [U.S. Department of Commerce, 1983:33-37], [Standard and Poors, 1981, 1983].

#### Information Sources

The Standard & Poor's Compustat II data base was the primary source for the data. Where errors or omissions were identified, the data was amended with information from annual reports, Securities and Exchange Commission 10K's, Moody's Industrial Manual, Value Line, or data directly from the corporation. The Compustat data was extracted by Standard Industrial Classification (SIC) which included all companies listed in each industrial classification. No transfers of companies to other classifications were made at the time of extraction. Companies were included in similar groupings for the analysis to provide a better comparison of like corporations. Where a company was clearly not a high-technology corporation as defined by the U.S. Department of Commerce, it was dropped from the study. Also, if data was not available for at least five years, the company was not included. In some cases, the data received directly from the company did not clarify the data or provide missing elements. An examination of the 10K's for many of the smaller corporations revealed that many are not complying with the Security and Exchange Commissions requirement to report research and development expenses in their 10K's. For a complete list of companies used in this study see

## Appendix A.

Particular attention was focused on the data since 1974 because R&D expenses reported prior to that time were handled in a non-standardized manner. The Securities and Exchange Commission has required, since 1974, that R&D data be included in the Form 10K. According to Accounting Standard #2, R&D is "all costs associated with the search for and discovery of new knowledge that may be useful in developing new products, services, processes, or techniques, or that might significantly improve existing products or processes" [Business Week, 1976:43-44]. These costs include design, construction, testing of prototypes, cost of pilot facilities, and similar costs that involve technological aspects of process and product development. Specifically excluded are costs associated with "routine product improvements, market research, test marketing, seasonal style changes, quality control, and engineering follow-through in production. Also excluded are legal costs related to patents and the costs associated with their sale or licensing" [Business Week, 1976:62]. The company 10-K's, 10-Q's, annual and quarterly reports, news releases, and general reports to the stockholders are source documents for data in the Compustat data base. "The 10-K is used to finalize the company on the annual file." [Standard and Poors, 1982:p. 1 of Section 6].

### Data Based Procedures

Once the research data was extracted from the Compustat data base, it was entered into a spreadsheet format (Lotus 1-2-3) to compute data such as market share, profit share, R&D share, rate of change in sales, R&D investment, and profit relationships. Additional files were developed and processed using Systat, a microcomputer version of statistical routines programmed for mainframes. Point Five software programs were used to develop the lag data.

The following statistical processing was completed:

- a. Canonical Correlation Analyses
- b. Factor Analysis of corporate data.
- c. Cluster Analysis of corporate and industry data.
- d. Basic Statistics: tabulation, frequency plots, mean, standard deviations of the variables.
- e. Single and Multiple Regression analysis of selected variables including sales, profits, R&D expense, market share, and R&D share.
- f. Times Series lag analysis for corporate data.
- g. Covariance Analysis for industries.
- h. Analysis of Start-up company data.

The data was used to develop the correlation tables, graphic displays, the Strategic Planning Model, and the conclusions for the study.

The final phase of the study focused on field interviews with selected executives who have responsibility for R&D in



the corporate environment to discuss the high-technology environment, product life cycles, and receive expert opinion.

#### HYPOTHESES

High-technology industries have an "industrial norm" or level of R&D investment which is required to maintain sufficient profit levels and market share. R&D investment below this "industrial norm" will result in unstable conditions for the corporation. Significantly larger investment levels will reduce profits to the point that other turbulence may be encountered.

There were three hypotheses posited:

1. Investment in Research and Development is positively correlated with increases in Sales, Net Income, ROI, and Market Share.
2. Insufficient levels of investment in Research and Development will result in negative impacts on Net Income, ROI, and Market Share.
3. A threshold level of investment in Research and Development is required to remain competitive in the dynamic environment of high-technology industries.

#### LIMITATIONS AND KEY ASSUMPTIONS

1. The study did not address all industries or companies.
2. The study focused on high-technology firms and their respective industries which were included in the 1983

Compustat II data base.

3. The research was primarily for U.S. companies and industries and only included foreign companies that were in the Compustat II data base.

4. The study focused on data since 1974 but included all available data in the twenty year time span of the data base. Due to the accounting procedures used in the 1960's and a lack of standardization, the data is more complete and appeared to be of better quality in the later years.

5. The data from the Compustat data base was assumed to be correct except for obvious errors which were corrected as necessary.

#### CONTRIBUTION OF THE RESEARCH

The contribution of this research project is a set of guidelines for consideration by management in regard to R&D investment. The conclusions from the data did not indicate the R&D is the major driving force in the management of high-technology firms but the results should be of value in the strategic management decisions process. The conclusions from the related literature provide information of interest to current international competitors. The data suggests the probable average time delay required to achieve a return on the investment and the length of time required for R&D investment to have an impact on sales, net income, and market share.

In summary, the study provides some information of value concerning the effect of past decisions made on R&D investment at the corporate level and considerations for future strategic decisions concerning the level of R&D funding.

## CHAPTER II

### REVIEW OF RELATED LITERATURE

#### RESEARCH AND DEVELOPMENT AND STRATEGIC MANAGEMENT

Chapter II summarizes the literature relevant to this research study. The chapter consists of the following: An introduction discussing strategy and long range planning, a discussion of the relationship of R&D to strategic planning, a discussion of the relationship of R&D to other business functions, A brief summary of previous studies related to the impact of R&D on sales, profitability, and market share, a summary of the interviews conducted with corporate officials, and definitions of key terms used in this study.

#### Introduction

Strategy has evolved from the competitive nature of many of the endeavors of mankind. Without the need to counter an adversary's actions, to consider scarce resources, or to coordinate actions, there would be little need for strategic planning. Although business is not warfare, there are many common features. For example, the objective for both sides is generally a long term period of stability where all can prosper, but occasionally,

environmental turbulence will destroy the equilibrium and result in conflict. The side taking action can readily be observed, but the strategy is rarely visible. An ancient general, Sun Tsu said, "All men can see the tactics whereby I conquer, but what none can see is the strategy out of which victory is evolved" [Albert, 1983:1-5].

In the 1960's, Stanford Research Institute, Arthur D. Little and others developed some of the first comprehensive long-range planning models [Albert, 1983:1-13]. These projects focused attention on strategic planning and organizations began to establish staff positions in planning and development. By the 1970's, most large organizations had strategic planning departments which developed long-range plans and programs [Albert, 1983:6-8]. By the 1980's, the business environment required that high-technology firms carefully plan the strategic aspects of their businesses including R&D, which is one of the most critical elements [Albert, 1983:3-13, 14, 15] [Craig, 1982:101-112].

#### R&D's Relationship to Strategic Planning

Definitions of Strategic Planning by management authorities include the following: Sherman states that: "Strategic planning is a process whereby corporate objectives for the future are identified in response to perceived opportunities and threats and whereby activities are selected and resources are allocated to meet these

objectives" [Sherman, 1982:6]. Drucker defines strategic planning as "the continuous process of making present entrepreneurial decisions systematically and with the greatest knowledge of their futurity; organizing the efforts needed to carry out these decisions; and measuring the results of these decisions against the expectations through organized systematic feedback" [Drucker, 1973:125].

Although the individual corporation's reasons for strategic planning may vary due to environmental or internal factors, it is essential in the competitive markets of today. Camillus has identified five accepted purposes for strategic planning [Camillus, 1980:13-15]:

- a. To increase the creativity in managing the organization.
- b. As a means to determine long-term objective and a means to accomplish them.
- c. To define a framework or strategic context from which operating plans and budgets can be developed.
- d. As a vehicle for communication between hierarchical levels in the organization.
- e. As a means of developing managerial skills and perspectives in organizations.

The basis for effective planning must begin with the key question: "Where are we today and where are we going?" [Sherman, 1982:7], [Drucker, 1973:122]. This question provides a starting point from which to develop a comprehensive long-range plan. Consideration must be

given to factors which affect the organization at different metalevels. Camillus suggested that five broad levels be considered in the economy of the 1980's. They are: the organization, the community, the state, the nation, and the world [Camillus, 1980:23]. Planning consideration must be given to each of these levels as the corporate plans are developed. Eventually, each of the five factors will have an impact on the firm.

Ozbekin viewed the internal corporate planning system as a three-level system consisting of [Lorange, 1982:52]:

1. "a normative level where the dominant values of the corporation are defined".
2. "a strategic level where the objectives of the firm are defined and objectives ranked".
3. "an operational level where decisions are made to achieve the objectives".

An effective corporate planning system will provide the operational level of each of the major subsystems with detailed plans for the financial, capital, technical, and human resource aspects. One of the important outputs from the planning system is a balanced allocation of resources to all the operating elements. The Research and Development subsystem must be adequately considered in the planning stage in order that it will have the resources available to perform its intended function.

#### R&D's Relationship to the Other Business Functions

Lyons stated that "the long-range business plan is

really the integration of strategic, financial, capital, technical, and human resource plans" [Albert, 1983:3-12]. R&D planning must be integrated into the corporate programs to ensure that technical activities are funded, appropriate to the corporations line of business, and carried out effectively. Capital planning must include both tactical and strategic elements. The tactical effort will be centered around current programs which produce cash flow. Strategic funding allocations must also include sufficient R&D financial support to provide products, new products, and technologies for the longer term [Albert, 1983:3-13, 14, 15, 16, 17].

The cooperation and linkage of all the functions of a high-technology firm are essential to successful market performance. For example, marketing must relay the needs of the customer to the research function as early as possible. The manufacturing function must be integrated into the research program to insure that the process and product technology required for new products will be available. Wind stated that the Research and Marketing interface, required for technical innovation to be successful, must begin with idea generation and continue through manufacturing and sales to the customer [Wind, 1982:481-485].

The current need for rapid movement of product concepts to the market and shorter Product Life Cycles



makes it essential that the entire firm act as an integrated system. Success for the high-technology firm will depend on the extent of cooperation and teamwork achieved by all parts of the system throughout the product development process.

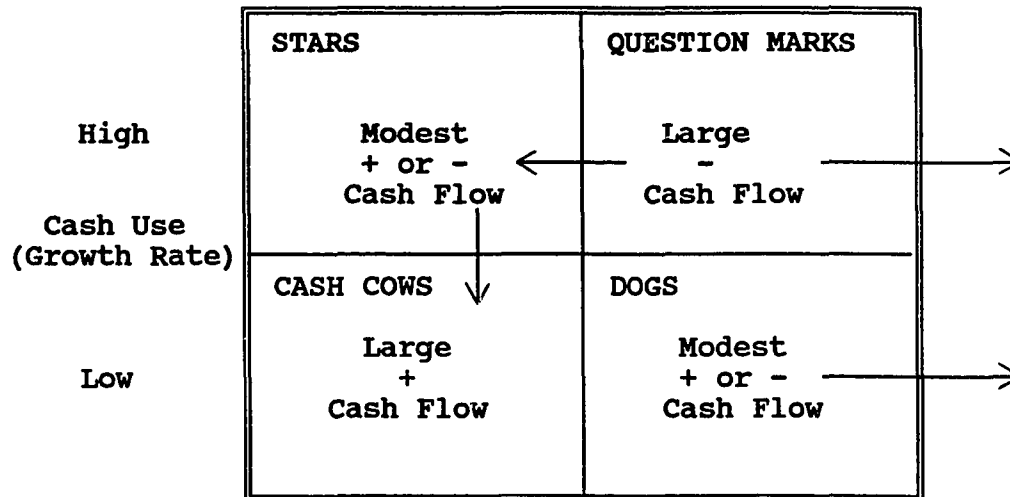
#### Previous Significant Studies

The following paragraphs briefly describe the major studies which are related to the impact of R&D on Return on Investment (ROI), profitability, and market share.

Boston Consulting Group (BCG) Concept. Literature concerning the Boston Consulting Group was reviewed because their approach stresses the importance of a firm's market growth rate and market share.

The BCG approach uses a competitive analysis of a firm's entire portfolio to assist in the development of a corporate strategic plan. BCG constructs a growth/market share matrix which plots the product market growth rate against the relative market share to determine where each of the company's products are in relation to these market factors. BCG also reviews the potential for multiproduct, multi-division corporations to shift resources to the most productive units and, therefore, improve corporate performance through integrated strategic planning. Additionally, products are categorized as Cash Cows, Dogs, Question Marks, and Stars as shown in Figure 2 [Harvard Business School, 1975:4]. Question marks will either

leave the system or become Stars. Stars will become Cash Cows and Dogs will also leave the system.



**Figure 2.** BCG Product Categories

From this analysis of a company's market position, decisions can be made on the strategic issues concerning each product.

After the portfolio has been developed, "a five-step competitive analysis may be carried out" consisting of the following steps [Harvard Business School, 1975:6-7]:

1. **Internal Balance:** Examination of the distribution of the products in the four quadrants.
2. **Trends:** Comparison of the current situation with earlier positions.
3. **Competitive Evaluation:** Charts for major competitors are developed and analyzed.
4. **Industry Position:** Analysis of the industry situation.
5. **Financial Balance:** Detailed cash flow

calculations.

In summary, the BCG approach "assumes a close relationship between cash generation and market share, a relationship based upon learning curve effects" [Harvard Business School, 1975:1-8]. BCG considers both the present situation and long term effects in an integrated approach to strategic planning [Hambrick, 1982:513-514] [Harvard Business School, 1975:1-8].

Profit Impact of Market Strategies (PIMS). The Profit Impact of Market Strategies (PIMS) program began in 1972 as a developmental project at the Harvard Business School (HBS). It was initially located at the Marketing Science Institute (MSI) which is a research organization affiliated with the HBS.

In February, 1975, the program was organized as an autonomous organization called The Strategic Planning Institute (SPI) which is still operating today. This change facilitated the evolution of the program beyond the academic stage to an operating system and allowed it to focus explicitly on the analysis of strategic business plans [The Strategic Planning Institute, 1980:5-8]. SPI had acquired the corporate operating data, for a three year time period from 1970 to 1972, from 57 major North American firms who owned "620 individual businesses" [Buzzell, 1975:105]. Each of the businesses was subdivided by division, product, or profit center. Based

on this data, an analysis of the firms' operations were performed.

Return on Investment (ROI) was measured by relating pre-tax operating profits to the sum of equity and long term debt because "this performance measure is most often used in strategic planning" [Buzzell, 1975:105]. The study found that "as market share increases, a business is likely to have a higher profit margin, a declining purchases to sales ratio, a decline in marketing costs as a percentage of sales, higher quality and higher priced products" [Buzzell, 1975:97]. "The average rate of return for business units with shares of more than 40% is two-and-a-half times the average for those with shares of 10% or less" [Buzzell, 1981:136]. The firms in the PIMS data base that had over 40% of their relative market share had an average ROI of 32.3% whereas firms with under 10% of their relative market share had an average ROI of 13.2% [Buzzell, 1981:137].

SPI, in 1974, also found that when market share was high, the highest level of ROI was achieved when R&D spending was above three percent of sales. When market share was low and R&D spending was high, it resulted in lower profits [Schoeffler, 1974:142].

SPI reported that the eventual lag from the time of the R&D investment to the time of impact on profits averaged a little more than four years based on 1978 data

and that a dollar spent on R&D returned an estimated \$3.08 [The Strategic Planning Institute, 1980:3].

"The results from the PIMS model suggest that investment intensity, relative market share, industry growth rate, life-cycle position, and marketing expense/sales ratios are the most significant of the 37 factors analyzed in affecting ROI and cash flow" [Kehoe, 1983:49].

R&D's Relationship with Profits and Sales.

Parasuraman and Zeren in 1982 researched the simultaneous and lagged correlation of R&D expenditures with profits and sales. This study used the Business Week magazine's Annual R&D Scoreboards for the years 1975 to 1980. The data source for Business Week was Standard and Poor's Compustat data base. The Annual R&D Scoreboards include only data for publicly held companies having annual sales of more than \$35 million that spend more than \$1 million on R&D or an amount equal to at least one percent of their sales.

Parasuraman stated that the correlations between R&D and profits are quite high and that there are "striking differences across industries" [Parasuraman, 1983:25]. A series of time lags was used that ranged from one to four years. For example, the following lagged effects of R&D investment related to profits was found:

Four year:	Metals and Mining
Three year:	None

Two year:           Appliances, Food and Beverages  
 One year:           Natural Resources and Miscellaneous  
                           Manufacturing

They also found the following lagged effect of R&D investment on sales:

Four year:           Automotive, Conglomerates, Instruments,  
                           Miscellaneous, Manufacturing, and  
                           Personal/Home Care Products

Three year:           Electrical/Electronics and Natural  
                           Resources

Two year:           Aerospace and Oil Service

One year:           Chemicals, Drugs, Food and Beverage,  
 and                    Metals and Mining.

Parasuraman and Zeren included in their study the companies for which there was a continuous set of data for the time frame in all types of industries, not just high-technology firms. This study is of significance since it utilizes data which was originally in the Compustat database and it examines the relationship of R&D investment to profit.

The Impact of New Product Strategies. Robert G. Cooper of McMaster University in Canada, conducted a study of 122 firms and determined that "new product programs that have a major impact on their firm's operations have a number of unique characteristics" [Cooper, 1983:252]. First, they "spend heavily on both R&D and new product market research (as a percent of sales)". Second, they "develop high risk products and undertake venturesome projects". Third, "they tend to view their new products efforts as offensive and as a leading edge of corporate

strategy". Fourth, they "have a decided technological orientation" [Cooper, 1983:252].

Cooper found that the "impact is not strongly correlated to variables describing a market orientation" [Cooper, 1983:252]. The three variables and the r values he found are listed below.

1. R&D spending as a percent of sales (r of .440).
2. Developing high risk products (r of .380).
3. Having a strong R&D orientation (r of .361).

Cooper developed three conclusions. First, new product development for industrial firms is satisfactory. Second, new product development is a multidimensional concept and third, that there is a relationship between synergy, focus, and newness of products [Cooper, 1983:254].

Effects of R&D on the Productivity Growth of Industries: An Exploratory Study. In 1974, Nestor E. Terleckyj conducted a productivity study of 33 manufacturing and non-manufacturing industries during the time period of 1948-1966.

Terleckyj reached the following conclusions [Terleckj, 1974:37-38]:

1. Company financed R&D had a positive effect on productivity growth with an estimated "rate of productivity return of 30% in manufacturing industries but there was not a similar correlation found in non-manufacturing industries".
2. "There is a strong correlation with productivity and the R&D content of the products they purchased."

3. Government financed R&D did not appear to improve the productivity of the industries who performed the R&D.

4. The impact of R&D was significantly stronger for the manufacturing industries than non-manufacturing industries.

One of Terleckyj suggestions was a study to extend the time frame beyond the year 1966. Significant changes in the reporting of R&D investment since 1974 would also indicate the need to focus on a more current time period [Terleckj, 1974:46].

R&D: What Link to Profits? Gilman and Miller compiled data for the 50 manufacturing corporations that spent the most for R&D in 1976 and made observations concerning the impact of research effort by these companies. Their statistical analysis revealed that no simple cause-and-effect relationship existed between R&D and profits but that there are underlying connections.

They found that a plot of income/sales (%) and research spending/sales (%) had a correlation of 0.45 with a regression line that indicated "that a one percent increase in relative research spending is related to a 0.65 percent increase in return on sales" [Gilman, 1978:25].

They also compared stock price/earnings and research spending/sales (%) to provide a future-related performance measure. The correlation for these factors was 0.59 with an r squared of 0.35 which indicated that 35% of the



variance in the P/E ratios of the sample was due to the differences in the strength of the research programs conducted by each company. They stated that the correlations were valid only where R&D spending was a "small" part of the gross income and that improvement in income could not be expected to continue beyond some "optimal" level of research spending [Gilman, 1978:23-26].

#### DEFINITIONS

##### High-technology

Definitions of high technology vary widely and are controversial. There is general agreement that there should be "above average concentrations of engineering and scientific skills and/or research and development expenditures" [Hatter, 1985:36].

The following are a few of the definitions of high technology [Hatter, 1985:37]:

- a. "High technology industries are generally those which usually spend at least 10% of their gross value added product on R&D and/or at least have 10% of their total employment consisting of scientists, engineers, and technicians".
- b. "R&D intensive goods are those associated with industries having 25 or more scientists and engineers engaged in R&D per 1000 employees and whose R&D funding amounts to at least 3.5% of net sales".
- c. "Products having an above average level of R&D intensity were classified as high technology".
- d. "Products having a significantly greater intensity of embodied R&D than other products were classified as high technology".

Therefore, industries listed as high-technology by the International Trade Administration, U.S. Department of Commerce, were used as the basis by which to extract data from the Compustat II Data Base. Lester A. Davis of the International Trade Commission "used input-output techniques to determine how much of the value of R&D embodied in the intermediate products should be included as an indirect addition to the R&D spent directly to produce the final product. Ratios of R&D to producer's shipments were used to produce total R&D requirements ratios. The value of the indirect R&D (R&D contributed by inputs) was then combined with the value of the direct R&D to find total R&D" [Hatter, 1985:32]. She then determined that the SIC groups in Table III constituted the high technology groups.

TABLE III  
HIGH TECHNOLOGY GROUPS

<u>High Technology Products</u>	<u>SIC Group</u>
1. Guided Missiles and Spacecraft	376
2. Communications Equipment and Electronic Components	365-367
3. Aircraft and Parts	372
4. Office, Computing, and Accounting Machines	357
5. Ordnance and Accessories	348
6. Drugs and Medicines	283
7. Industrial Inorganic Chemicals	281
8. Professional and Scientific Instruments	380
9. Engines, Turbines, and Parts	351
10. Plastic Materials and Synthetic Resins, Rubber, and Fibers	282

Source: U.S. Department of Commerce [Hatter, 1985:34-35]

#### Learning Curve

This is the phenomenon that for each time the quantity of items produced is doubled, the number of hours required to produce a unit decreases by a relatively constant rate. The techniques for using the learning curve were first developed in the aircraft industry prior to World War II. Since that time, it has been utilized by other industries [Brown, 1984:34-36].

#### Standard Industrial Classification (SIC)

The Executive Office of the President, Office of Management and Budget (OMB) develops industrial classifications. "The Standard Industrial Classification (SIC) is the statistical classification standard underlying all establishment-based Federal economic

statistics classified by industry". "The classification covers the entire field of economic activities and defines industries in accordance with the composition and structure of the economy" [Office of Management and Budget, 1987:3]. The SIC is used by the U.S. government, state agencies, trade associations, businesses, and others. It is used to collect data, develop statistics, report data, and publish data by industry.

Table IV lists the two digit industrial classifications used in this study:

TABLE IV

## SIC MAJOR GROUPS

<u>Industry</u>	<u>SIC Major Group</u>
Chemicals & Allied Products	28
Industrial & Commercial Machinery & Computer Equipment	35
Electronic & other Electrical Equipment & Components except Computer Equipment	36
Transportation Equipment	37
Measuring, Analyzing, & Controlling Instruments; Photographic, Medical, & Optical Goods; Watches & Clocks	38

Source: Office of Management & Budget (OMB)

## CHAPTER III

### DESCRIPTION OF RESEARCH METHODOLOGY

This chapter describes the research methodology, and includes the following: the nature and source of the data, collection and analysis of the data, the statistical treatment of the data, and a discussion and presentation of a Strategic Planning Model for a Research and Development subsystem in a high technology firm.

#### THE NATURE AND SOURCE OF DATA

The source of the original data for the study was Standard and Poor's Compustat II Data Base. This data base consists of a number of files covering financial data for several thousand companies listed on the New York, American, and Over-the-Counter Stock Exchanges. Standard and Poor's states that "for most companies, data is available for at least 10 years," and "in some cases, data is also available for as many as 20 years" [Standard and Poors, 1981, 1983:p. 1 sec. 3].

The total Compustat industrial files contain: The Primary Industrial File of approximately 900 companies; The Supplementary Industrial File of approximately 900 companies; The Tertiary Industrial File of approximately

900 companies; and the Over-the-Counter File of approximately 850 companies. Of this total of approximately 3550 companies, 347 firms in the high-technology classifications of the U.S. Department of Commerce Standard Industrial Classification (SIC) were extracted from the computer tape at the University of Oregon.

The number of firms was reduced from 347 to 267 because some of the firms listed were not high-technology firms based on any of the definitions of a high technology firm, others were holding companies, a few did not report R&D expenditures in their financial data and therefore, could not be included in this study.

Twenty four firms from the Electronics Business 100, listed in Appendix B, were added to the data base to bring the total number of firms in the study to 291. Appendix A provides a complete list of the companies used in this study.

#### COLLECTION AND ANALYSIS OF DATA

After the data for the high-technology firms was extracted, a program was written in the COBOL computer language to read the computer tape on a Harris 500 Computer at Southern Oregon State College. Files were then converted into a format which was readable by IBM XT computers.

The Compustat data base had financial data from 1964 to 1982 but it varied in completeness for each company. For some companies, the files had complete data for 19 years. For other companies, the number of years of data varied from five to 19 years. Quite often the number of years of available data was different for each of the financial items. In some cases, there were gaps in the coverage of the financial data for several years. The information was spot checked for accuracy and found to be accurate except in a few cases.

For the 24 firms that were added to the data base, at least five years of data was obtained and if possible, the information was entered for all years since 1975.

Data was gathered to complete the missing information and correct inaccuracies in the data using Annual Reports, 10k's, Value Line, Moody's Industrial Manuals, Standard and Poor's Stock Reports, letters from the corporations, and other corporate reports. Since this research activity took longer than expected, two additional years of information, 1983 and 1984, were added to the files.

The data items in Table V were extracted to use in the computations of financial variables:

TABLE V

## DATA ITEMS EXTRACTED

<u>Compustat Data Item Number</u>	<u>Description</u>
4	Current Assets
5	Current Liabilities
9	Long Term Debt
11	Common Equity
12	Sales (Net)
13	Operating Income before Depreciation
14	Depreciation and Amortization
15	Interest Expense
16	Income Taxes
18	Income before Extraordinary Items & Discontinued Operations
19	Preferred Dividends
41	Cost of Goods Sold
46	Research and Development
49	Minority Interest
117	Sales (Restated)
118	Income before Extraordinary Items & Discontinued Operations (Restated)
120	Assets (Total) (Restated)
121	Working Capital (Restated)
122	Pretax Income (Restated)

The two variables shown in Table VI were extracted but could not be used due to incomplete data in the Compustat file, and could not be completed via other sources.

TABLE VI

## VARIABLES NOT USED

<u>Compustat Data Item Number</u>	<u>Description</u>
45	Advertising Expense
29	Number of Employees

The sales, R&D, and net income data for the companies within a Standard Industrial Classification were totaled



to provide industry totals for Sales, Net Income, Research and Development (See Table VII).

TABLE VII  
INDUSTRY VARIABLES

<u>Variable Name</u>	<u>Description</u>
G	Industry Sales
H	Industry Research and Development
I	Industry Net Income

Table VIII lists the specific variables utilized in the study for each firm. Variables P through X were computed on an IBM XT computer using Lotus 1-2-3. Appendix D contains descriptions of the software utilized.

TABLE VIII  
VARIABLES USED FOR EACH FIRM

<u>Variable Name</u>	<u>Description</u>
J	Common Equity
K	Net Income
L	Research and Development(R&D)
M	Assets (Total)
N	Operating Income
O	Sales
P	Return on Investment
Q	R&D as a Percent of Sales
R	Return on Total Assets
S	Return on Common Equity
T	Market Share
U	R&D Share
V	Net Income Share
W	Annual Percent Change in Sales
X	Annual Percent Change in R&D

The industry classification listed by Standard and Poor's for each company was reviewed and compared with

other listings of industrial classifications. Companies were moved to other SIC's as deemed appropriate. The changes resulted in the data being sorted and compiled for 18 industrial classifications (SIC).

#### STATISTICAL TREATMENT OF DATA

Four sets of files were developed. The first incorporated the entire data set available for each firm, which varied in the number of years of data available for each of the variables. The second was a rectangular matrix with the maximum years of data being restricted by the variable for which the least number of years were available. The third set contained averages of the last five years of data (1979 to 1984) and includes variables J through X for each firm. A fourth set included a single record for each firm, combining the most recent available data (1984) for most variables with the R&D expenditures and total assets for the prior year corresponding to the estimated lag between R&D investment and its effect on sales. Where a specific lag period for a firm was not identified, the industry (SIC) average for the classification was used.

#### Canonical Correlation Analysis

Canonical correlation analysis was used to study the interrelationships among multiple dependent variables and multiple independent variables. It is the most

generalized of the multivariate statistical techniques. The strength of the relationship between the variates is reflected by the canonical correlation [Hair, 1979:183].

Two sets of data were processed combining data for all 291 firms. The first was the five year averages, the second included lagged data for R&D dollar investment and total assets against 1984 income and sales data. When data were tested for normality, it was found that they were very strongly skewed. They were approximately normalized by converting to logarithms and then processed again. Canonical correlation analyses were performed between the logarithms of R&D dollars, R&D as a percent of sales, vs. the logarithms of net income, pretax income, and sales.

#### Single and Multiple Regressions

Single and Multiple Regressions were computed for all 291 companies and the 18 industries using the following models:

- a.  $\text{Sales} = \text{Constant} + \text{Research \& Development (R\&D)}$
- b.  $\text{Sales} = \text{Constant} + \text{R\&D} + \text{Assets (Total)}$
- c.  $\text{Net Income} = \text{Constant} + \text{R\&D}$
- d.  $\text{Net Income} = \text{Constant} + \text{R\&D} + \text{Assets (Total)}$
- e.  $\text{Market Share} = \text{Constant} + \text{R\&D}$
- f.  $\text{Market Share} = \text{Constant} + \text{R\&D} + \text{Assets (Total)}$
- g.  $\text{Market Share} = \text{Constant} + \text{R\&D \% of Sales}$
- h.  $\text{ROI} = \text{Constant} + \text{R\&D}$

i.  $ROI = \text{Constant} + R\&D + \text{Assets (Total)}$

j.  $ROI = \text{Constant} + R\&D \% \text{ of Sales}$

A similar set of regression models were compiled using a data set with R&D lagged by one year to determine the effect of establishing a budget for R&D based on the previous years sales.

A list of quartiled regressions compiled by industry can be found in Appendix G.

#### Time Series Analysis

Time Series Analysis was used to determine if there was any indication of a time delayed impact of R&D investment on sales, ROI, or market share. Data were developed for all companies in the study if there were enough years of data to develop a lag correlation. This data was statistically processed by using an IBM XT computer and Point Five software. The Series module of Systat was used to calculate the correlation of the lag values.

#### Covariance Analysis

Covariance Analysis was completed for industries which had enough companies included in their data to make the computations meaningful. Two and Four digit Standard Industrial Classification computations were completed. The results were computed using Point Five software and compared with similar runs from the Harris 500 computer to

verify accuracy. Total Assets (M) were held constant and covariance calculated for Sales (O), ROI (P), Market Share (T), and Net Income (K).

### Basic Statistics

Basic Statistics were compiled using Systat on an IBM XT (see Appendix D for a description of Systat) for the last five years of data (variables J-X) for all 291 companies.

The following basic statistics were used to rank the companies into quartiles used when running Single and Multiple Regression, Factor Analysis, Cluster Analysis, and Start-Up statistics:

Standard Deviation

Mean

Maximum

Minimum

### Analysis of Start-Up Companies

An Analysis of Start-Up Companies was made for firms in which the files had data from near the date of the establishment of the corporation. In other words, if the company started after 1964, it was considered as a Start-Up firm.

The start-up firm's data were compared to data for mature firm's in regard to their performance for variables J through U. The companies were ranked according to their

average ROI over the last five years of the data and then quartiled. The first and fourth quartiles of both the start-up and mature firms are listed in Appendix J.

#### Corporate Field Interviews

Thirteen interviews were conducted with corporate management personnel, who have research and development responsibility, to obtain expert opinion and correlate the findings of this research project with current field information. Appendix K is a sample of the questionnaire and a summary of the answers. The results of the interviews are discussed in Chapter IV.

#### STRATEGIC PLANNING MODEL

In the business environment of the 1980's, a high technology company will usually have customers with very diverse product needs and requirements. Therefore, there is a need for continual feedback from the customer and the functional areas of the corporation to corporate management. Often, high-technology firms must anticipate the future requirements of their customers.

Internally, the major functional areas of the firm must work as an effective and efficient system to remain competitive. Research and Development, Manufacturing, and Marketing must receive their primary direction from the strategic planning function. The firm must develop feedback channels, synchronize their operations, and

incrementally improve the performance of the corporation.

As a critical element in a high technology firm, the R&D subsystem has two primary functions. First, it needs to conduct Basic Research, if required by the mission of the firm, which will provide the technology and products of the future. Second, it must have a successful Applied Research operation which can support and update current products. For most corporations, the research effort will be concentrated on applied research. This results in incremental or minor changes in current technology of the firm.

Four levels of technological change were found by Meyer and Roberts. The first is a "minor improvement to the company's existing product technology". The second is "a major enhancement to an existing product technology". The third "occurs when a company develops an entirely new technology that is integrated with an existing company technology in the final product." The fourth level is new unrelated "core technologies that are not combined with existing product technology" [Meyer, 1988:9-10]. Therefore, most of the interface, coordination, and feedback will be between applied research units, corporate functional elements, and the customer.

These levels of technological change appear to be creating market pressures due to shorter product life cycles as discussed in current literature. Fraker

mentioned the evolution of the micro computer from the eight bit technology to 32 bit technology through four steps in only six years [Fraker, 1982:62] and Meyer found that "major enhancements tend to be sequenced in intervals of three to five years within specific product lines" [Meyer, 1988:9].

Spital and Lauenstein interviewed the CEOs of 10 high technology companies and found that their product life cycles "were typically in the 5-to-7 year range, and some CEOs stated that the life cycles were getting shorter because of accelerating rates of new product introduction" [McCarthy, 1987:315]. There "has been a dramatic reduction in product life cycles, forced by the pace of technological innovation and more aggressive marketing [Young, 1988:103].

These market forces which are influencing the product life cycle will require a more responsive type of corporation to react to these changes. The high-technology firm will require effective planning, communication, coordination, and feedback channels to meet this challenge.

The Strategic Planning Model, Figure 3 on page 61, developed for this research, illustrates the information flow and relationship of the Research and Development (R&D) subsystem of a typical high technology firm to the other elements of the corporation and the environment.



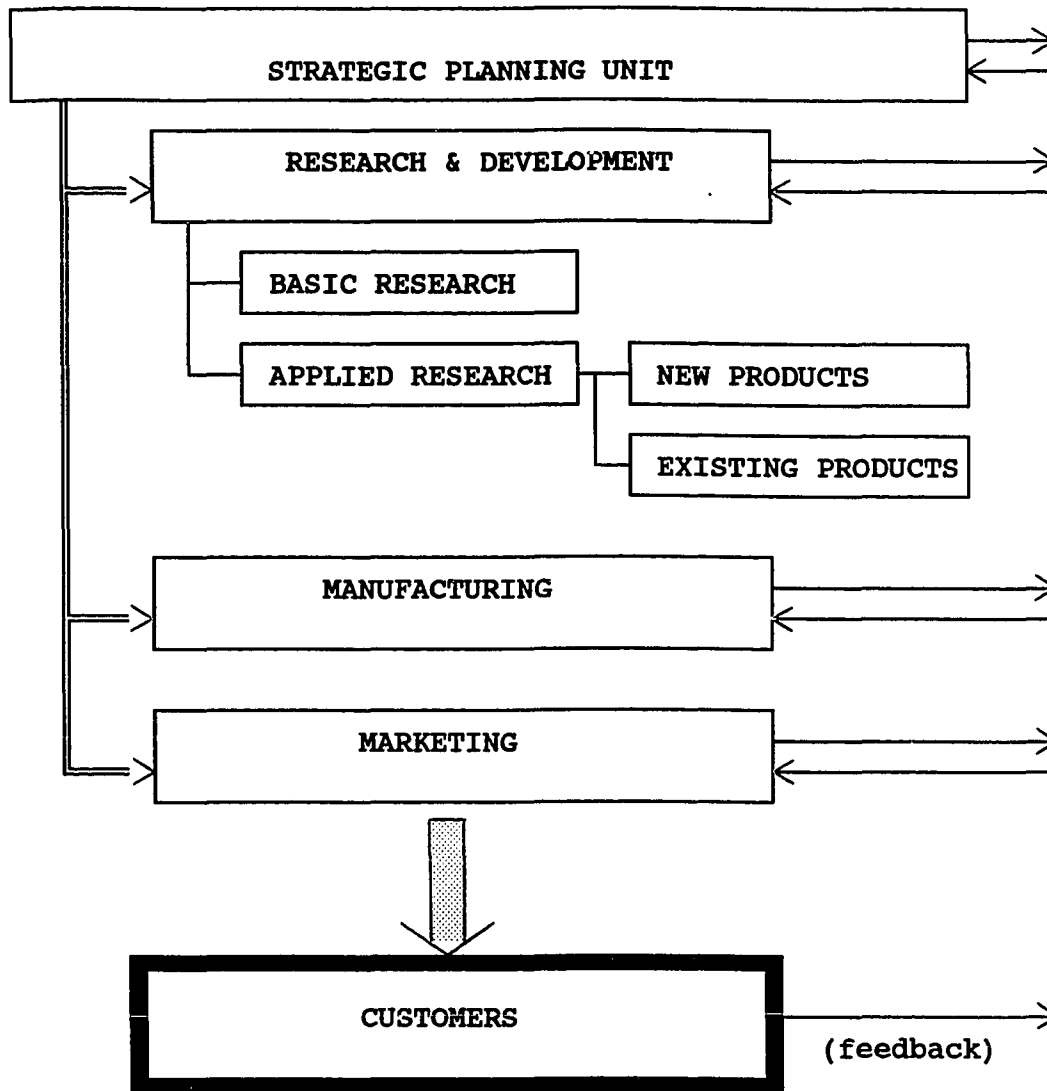
Of particular importance to the survival of American firms is feedback from the customer whose needs must be considered first and foremost, even before attention is focused on the actions of competitors. Attention to customer requirements will provide necessary information for the firm to react to market changes. This feedback will also provide direction and focus for effective planning for incremental change and rapid product improvement.

Coordination and cooperation among the functional elements of R&D, manufacturing, and marketing are essential elements for success in a high-technology firm. In the past, American firms have relied on major technological break-throughs for new products. In today's market environment, successful firms must give more attention to applied research and immediate response to customer preferences and requirements.

The strategic planning unit must use information from the market and internal functions to adequately develop plans and programs. The traditional short term focus of American management has not been successful. Companies must lengthen the planning time frame to provide strategic direction for the firm and provide a sound basis for the firm to react to customer needs.

In summary, the Strategic Planning Model was developed to illustrate the essential flows of information,

feedback, policy and direction, and products in a typical high-technology firm. It is intended to provide a perspective of the relationship of the subsystems related to the corporate planning function.



**Legend:**

== Policy/Direction from Management

■ This component is in the environment

... Products and Services

— Information Flow

**Figure 3. Strategic Planning Model.**

## CHAPTER IV

### RESEARCH RESULTS

This chapter discusses the results of the statistical processing of the data for both firms and industries. The primary correlations were between R&D factors, Sales, Net Income, ROI, and Market Share. The data were collected and processed by company. Tabulations were by industry in most cases and therefore, the findings are primarily focused on the industry results.

#### R&D RELATIONSHIPS FOR FIRMS AND INDUSTRIES

Three statistical techniques, factor analysis, cluster analysis, and stepwise regression, were used to determine which variables in the data set were related and should be used for the regression analysis. Canonical correlation analysis was further used to study the relationships in more detail. The results for each of these are discussed in the next sections.

#### Factor Analysis

The Factor Analysis module of Systat was used to compile data for the 18 industries and identify variables for the regression analysis. The results indicated that

the independent variables most often related to the dependent variables of sales, net income, market share, and ROI were as follows:

TABLE IX  
FACTOR ANALYSIS VARIABLE LIST

<u>DEPENDENT VARIABLE</u>	<u>INDEPENDENT VARIABLES</u>
SALES (O)	R&D INVESTMENT (L) & TOTAL ASSETS (M)
NET INCOME (K)	R&D INVESTMENT (L) & TOTAL ASSETS (M)
MARKET SHARE (T)	R&D INVESTMENT (L), TOTAL ASSETS (M) & R&D AS A PERCENT OF SALES (Q)
ROI (P)	R&D INVESTMENT (L), TOTAL ASSETS (M) & R&D AS A PERCENT OF SALES (Q)

#### Cluster Analysis

Cluster diagrams were developed by company and industry using the Cluster module of Systat and the files of the last five year averages for each firm. Tree diagrams were developed to allow visual comparison of the related variables.

An evaluation of the clusters for the corporate data, which contained the variables for Research and Development Dollars (L) and R&D as a Percent of Sales (Q) for each company, revealed that the typical set of variables related to Research and Development were common equity, net income, total assets, pretax income and sales.

When the results were quartiled using ROI as the ranking criteria, there were some differences between the quartiles and the industries.

The most notable exceptions to the general pattern

were Engines and Turbines SIC 3510 and Aircraft Parts SIC 3728, which had fewer variables related to the R&D Dollar Investment variable. This was probably the result of the influence of the large dollar amount of the government funded research in these industries. In summary, this set of cluster analysis verified the results of factor analysis and indicated that the same variables were closely related.

A second Cluster Analysis set was developed which clustered the companies within an industry. The results were quite different between the industries when the first and fourth quartile firms were compared. In some industries, the firms in the first quartile were very closely related while in other industries the first quartile firms were scattered throughout the industry cluster.

Industries in which first quartile firms are clustered are: Drugs, Engines and Turbines, Computers (Small), Computers (Peripherals), Radio and TV Receiving Sets, Telephone and Telegraph Apparatus, Radio and TV Transmitting Equipment, Semiconductors, Electronic Components (NEC), Aircraft, Surgical and Medical Instruments, and Photographic Equipment and Supplies.

Industries that were not clustered are: Chemicals, Computers (Large), Aircraft Parts and Auxiliary Equipment, Engineering Laboratory and Research Equipment, Measuring

and Controlling Instruments, and Electrical Measurement and Test Equipment. Appendix F summarizes the data by industry.

### Stepwise Regressions

Stepwise Regressions were computed to further assist in the selection of variables for the single and multiple regressions related to this study. It was found that in most cases, that R&D Dollar Investment (L) and Total Assets (M) were the independent variables that had the most importance for the regression models for dependent variables Sales (O), Net Income (K), and Market Share (T).

### Basic Statistics

The System for Statistics (Systat) STATS module was used to compile basic statistics for two sets of data. The first set used files which included all the data for each of the 291 firms. Variables J through V were calculated. The process calculated the following data items:

N of Cases = number of years of data for the variable.

Minimum = the minimum value found in that variable.

Maximum = the maximum value found in that variable.

Mean = mean of the data for the variable.

Standard Dev = standard deviation of the variable.

A second set of files consisting of the last five years of data, from 1980 to 1984, was processed. This

information was used to rank the corporations into quartiles based on ROI performance for the various statistical processes. The data for selected variables were sorted by ROI performance and quartiled by industry to provide statistics concerning the following data items:

TABLE X  
BASIC STATISTICS VARIABLES

<u>NAME</u>	<u>VARIABLE</u>
Common Equity in Dollars	J
Net Income	K
R&D Dollar Investment	L
Total Assets	M
Sales	O
ROI Percent	P
R&D as a Percent of Sales	Q
Market Share Percent	T

The summaries are provided in Appendix E, for the first and fourth quartiles of each industry except Engines and Turbines (SIC 3510) which is too small to quartile.

#### Single and Multiple Regression

A series of ten regression models were compiled for sales, net income, market share, and ROI. The first set used R&D Dollar Investment as the independent variable. The second set used R&D Dollar Investment and Total Assets as the independent variables. A third set of models was developed for market share and ROI using only R&D as a Percent of Sales as the independent variable.

The corporate data were sorted by ROI for each industry. The results were tabulated to provide a



comparison of the best and worst performing companies based on ROI for the last five years in each industrial classification. Industry averages of the  $r^2$  computations for the first and fourth quartiles of 17 of the 18 industries are shown in Appendix G. Since the Engines and Turbines industry (SIC 3510) had only five companies, the data for that industry was not quartiled.

Sales Regression Models. The  $r^2$  for the model Sales (O) = Constant (C) + R&D Dollar Investment (L), was above .70 in all but a few cases. This was expected, since many companies establish R&D budgets using a percent of sales calculation or prior budgets as a basis for funding. The Model Sales (O) = Constant + R&D Dollar Investment (L) + Total Assets (M), resulted in very high  $r^2$  values, typically over .90 with only a few below .80.

The average was higher for first quartile firms in both models but there was not a wide disparity between the averages of the two quartiles.

For the two sales models, all industries have high  $r^2$  results. For example, the large computer manufacturing firms, SIC 3573A, had the highest  $r^2$  values for these models in both the first and the fourth quartiles. This indicates that the large computer firms are very similar in the way they handle the R&D budgets and support to the R&D subsystem. The first quartile companies average 11.1 percent of sales for R&D and had an average ROI of 38.2

percent. The fourth quartile firms averaged 8.3 percent of sales for R&D and had an average ROI of 16.1 percent. The other industries have similar patterns for the sales models indicating that most firms relate their expenditures for research and development to their sales dollars.

Net Income Regression Models. The same models were computed for Net Income with very different results. The  $r^2$  varied widely within each industry, from .99 to below .10. This may indicate that current investment in research and development may decrease current net income in many cases.

The first two Net Income models had significantly different results in the quartiled data. The first quartile firms had much higher averages than the fourth quartile firms. This indicates that the firms with the best ROI performance have significantly closer relationships of net income with R&D investment and total assets. The results were the same for all industries.

Market Share Regression Models. Three models were compiled for market share. The additional model was  $\text{Market Share (T)} = \text{Constant (C)} + \text{R\&D as a Percent of Sales (Q)}$ . The  $r^2$  varied widely for firms in each industry and for each of the models. The results indicate that often there will be little, if any, relationship between current R&D investment and market share. It may

take years for the impact of R&D on market share to materialize.

Two of the three market share models had very similar results for first and fourth quartile firms. They were the Market Share = Constant + R&D Dollars and Market Share = Constant + R&D Dollars + Total Assets. Therefore, the average values are not significantly different and indicate that these variables are definitely related to the firms market share performance. The third model, Market Share = Constant + R&D as a Percent of Sales, had much lower values but similar results for the two quartiles. This indicates that the percent of sales dollars that is invested in research and development is not a significant factor to the firm's success in acquiring additional market share.

ROI Regression Models. The ROI model set added the ROI = Constant (C) + R&D as a Percent of Sales (Q) model. The R&D Dollar Investment (L) and R&D Dollar Investment (L) + Total Assets (M) models resulted in widely dispersed  $r^2$  averages which were relatively low compared to the sales models. The model with R&D as a Percent of Sales resulted in very low  $r^2$  computation in most cases indicating that the percent of sales invested in research and development is not an important factor in ROI projections.

Budget Allocations for Research and Development. An additional set of regressions were compiled for first quartile firms with R&D investment lagged by one year to investigate the impact of setting R&D budgets based on the previous years sales or the previous year's budget.

For this regression model the dependent variable was R&D investment (lagged by one year) and the independent variable was sales. The results indicate that of the 73 first quartile firms, 68 have  $r^2$  values over .800. Of the seven firms that had  $r^2$  values below .679, four had very large amounts of government funding for research and development, one was operating in a niche in aircraft parts, and one had sold all research facilities.

Therefore, first quartile firms either budget for research and development by using prior years budgets or allocate funds by a percent of sales calculation. This disagrees with the information from the corporate interviews since only four of thirteen companies indicated that they used one of these methods for budgeting for R&D.

Summary of the Regression Models. A review of the ten regression models based on the ROI quartile sort revealed the following:

1. The companies in the first quartile of ROI performance within their industries, had higher average  $r^2$  for all sales and net income models using R&D as an independent variable.

2. The results for the market share and ROI models for both first and fourth quartile firms were very different from the sales and net income models. Generally, the average  $r^2$  value dropped drastically and firms in the both quartiles had similar results. Therefore, there was little difference among firms in the first and fourth quartiles for the market share and ROI models.

3. The regression data confirm the very close relationship of research and development expenditures with sales and total assets. It indicates that first quartile firms have closer relationships between the same variables and net income than fourth quartile firms. The computations also indicates that the percentage of sales that is devoted to research and development is not important to a firm's performance. The amount of money invested in research and development and the amount of total assets to support the system are the significant factors.

4. Companies do budget for research and development by using either prior years budgets or a percent of sales calculation.

#### Time Series Analysis

Time series analysis was performed using Point Five software to determine if there were any time lagged correlations between the time of R&D investment and an impact on sales, net income, and market share.

Appendix H, provides the findings for each of the 291 firms sorted by industry. It provides the company name, the number of years of data available for each firm, and the number of years lag between R&D investment and its maximum correlation with an evident maximum for sales, net income, and market share. In some cases, the data did not indicate that there was a lag period.

The number of years of data available ranged from a minimum of five to a maximum of 21 years. Results varied among the firms and industries where there was a maximum lag of ten years and a minimum of four years. The longest average lag was in the Electronic Computing (mainframe), 3573A industry with 7.2 years for sales and 7.8 for net income. The shortest lags were in the Engines and Turbines (3510) and Photographic Equipment and Supplies (3861) industries which had 4.0 years of lag for market share. In nearly every case, there were differences in the number of years of lag for the three variables, sales, net income, and market share. Reasons for the variation of lag times for the variables cannot be explained by the data available in this study.

Lag Correlation. The Systat Series module was used to calculate the correlation values for the lag data. There were only 25 of 201 cases for sales, 26 of 219 cases for net income, and 17 of 218 cases for market share where the lag values were statistically significant. This was

probably due to the relatively small sample size for each company, the aggregated nature of dollar figures for R&D investment, and the fact that most companies budget the same way year after year.

Although very few were significant, it is felt that the lag times are valid. The data from the corporate interviews indicated that the average lag time was 4.53 years with a range of 1.5 to 7.5 years. In comparison, the average lag calculated for this study was 5.2 years with a range of 4.0 to 7.8 years.

In summary, the lag data did not have high correlations but seems to match the opinions of industry experts very closely. Table XI provides average lag values for all industries.

The length of the average lag indicates the importance of strategic planning for a time frame greater than the usual five years if a firm is going to maintain a strong competitive posture in their markets.

TABLE XI  
AVERAGE YEARS OF LAG BY INDUSTRY  
FROM R&D INVESTMENT TO IMPACT ON THE VARIABLE  
(FOR FIRMS THAT SHOW A LAG)

SIC NUMBER	INDUSTRY NAME	VARIABLE		
		O	K	T
		SALES	NET INCOME	MARKET SHARE
2800	Chemicals & Allied Products	5.933	5.400	5.600
2830	Drugs	6.714	5.786	5.154
3510	Engines & Turbines	5.800	5.000	4.000
3573A	Electronic Computing (Large Comp.)	7.200	7.833	5.111
3573B	Electronic Computing (Small Comp.)	5.182	5.077	4.571
3573C	Electronic Computing (Peripherals)	6.333	4.412	5.571
3651	Radio-TV Receiving Sets	6.533	5.375	4.933
3661	Telephone & Telegraph Apparatus	4.350	4.300	4.765
3662	Radio-TV Transmitting Equipment	5.083	5.286	5.154
3674	Semiconductors	5.273	4.929	4.067
3679	Electronic Components (NEC)	5.429	5.265	4.641
3721	Aircraft	5.714	5.000	4.250
3728	Aircraft Parts & Aux. Equipment	4.125	4.571	5.625
3811	Engineering Lab & Research Eq.	5.500	6.125	5.429
3820	Measuring & Control Inst.	6.083	6.091	4.100
3825	Electrical Measurement & Test Eq.	5.200	4.545	4.200
3841	Surgical & Medical Instruments	5.364	4.500	4.667
3861	Photographic Equipment & Supplies	5.700	4.800	4.000
Average For All Industries		5.640	5.239	4.769
Composite Average		5.216		



### Covariance Analysis

Covariance analysis was completed for the industries which had a sufficient number of companies to permit a meaningful computation. For this procedure, Total Assets was held constant in order to remove the impact of corporate size on the differences among the quartiles. Covariance was calculated for independent variables R&D Dollar Investment (L) and R&D as a Percent of Sales (Q) with dependent variables Sales (O), ROI(Q), and Market Share (T). Two sets of data were processed.

The first set was for the industries at the four digit level of Standard Industrial Classification (SIC). There were only 13 of the 18 industries that had a sufficient number of companies in their quartiles to run the analysis. Eight models were calculated using Point Five software. Four models used R&D Dollar Investment (L) as the independent variable and four used R&D as a Percent of Sales (Q) as the independent variable resulting in a total of 104 computations.

Table XII provides a summary of the results of the covariance tabulation with R&D Dollar Investment as the independent variable.

TABLE XII  
COVARIANCE  
INDEPENDENT VARIABLE R&D DOLLAR INVESTMENT  
(HOLDING TOTAL ASSETS CONSTANT - FOUR DIGIT SIC)

<u>SIC</u>	<u>Industry</u>	<u>Dependent Variable</u>
3573B	Electronic Computing (Small)	Sales
3573C	Electronic Computing (Peripheral)	Sales
	" "	ROI
	" "	Market Share
3661	Telephone & Telegraph	Net Income
	" "	Sales
	" "	Market Share
3674	Semiconductors	ROI
3679	Electronic Components	ROI
3820	Measuring & Control Inst.	Net Income
	" "	Sales

A review of Table XII reveals that there were only 11 cases of 104 in industries that had enough firms to quartile the data, where either R&D Dollar Investment had a significant impact on the Sales, ROI, Net Income and Market Share variables. This indicates that R&D Dollar Investment is very important to the industries listed in Table XII.

Table XIII indicates the industries where R&D as a Percent of Sales had an impact on the dependent variables listed.

TABLE XIII

COVARIANCE  
INDEPENDENT VARIABLE R&D AS A PERCENT OF SALES  
(HOLDING TOTAL ASSETS CONSTANT - FOUR DIGIT SIC)

<u>SIC</u>	<u>Industry</u>	<u>Dependent Variable</u>
2830	Drugs	Market Share
3651	Radio-TV Receiving Sets	ROI
3841	Surgical & Medical Inst.	ROI
	" " "	Market Share

The results indicate that R&D as a Percent of Sales has a significant impact on Market Share in Drugs and Surgical and Medical Instruments. It also has an impact on ROI in Radio-TV Receiving Sets and Surgical and Medical Instruments. Therefore, R&D as a Percent of Sales is not very important to the majority of industries in this study. The more important variable is the dollar amount of R&D investment.

The second set of data was processed using an aggregated group of industries at the two digit level of the SIC to provide a computational set with more companies in the data. This reduced the number of industries to five. They were Chemicals and Drugs, Computers, Electronics, Aircraft, and Instruments. The data were processed to determine the impact of the two R&D variables on Market Share and ROI.

The five cases where R&D Dollar Investment had a significant impact are shown in Table XIV.

TABLE XIV  
COVARIANCE  
INDEPENDENT VARIABLE R&D DOLLAR INVESTMENT  
(HOLDING TOTAL ASSETS CONSTANT - TWO DIGIT SIC)

<u>SIC</u>	<u>Industry</u>	<u>Dependent Variables</u>
28	Chemicals and Drugs	Market Share
35	Computers	Market Share
36	Electronics	ROI
	"	Market Share
38	Instruments	Market Share

The results indicate that R&D Dollar Investment has a significant impact on the Market Share in four of the five industries and on ROI in only one industry.

Table XV indicates the industries in which R&D as a Percent of Sales had an impact on the ROI and Market Share.

TABLE XV  
COVARIANCE  
INDEPENDENT VARIABLE R&D AS A PERCENT OF SALES  
(HOLDING TOTAL ASSETS CONSTANT - 2 DIGIT SIC)

<u>SIC</u>	<u>Industry</u>	<u>Dependent Variable</u>
36	Electronics	ROI
	"	Market Share

The results indicate that R&D as a Percent of Sales is only significant in the Electronics industry.

In summary, it appears that when Total Assets are held constant, the two R&D variables have an impact on sales, net income, ROI, and market share for some industries. The most significant of the variables is R&D Dollar

### Investment.

The industries in which the computations indicated that the amount of R&D investment had a significant impact on sales were Electronic Computing, Telephone and Telegraph Apparatus, and Measuring and Control Instruments. ROI was affected in Electronic Computing, Semiconductors and Electronic Components (NEC). Net income was affected in Telephone and Telegraph Apparatus and Measuring and Control Instruments.

At the two digit level of SIC, Market share is affected in the following industries: Chemicals and Drugs, Electronic Computing, Electronics, and Instruments.

### Canonical Correlation Analysis

The Multivariate General Linear Hypothesis module (MGLH) of Systat was used for statistical processing. The actual data for net income, R&D investment, total assets, pretax income and sales were used since they seemed to be the most useful data.

The two files processed were five year averages, and 1984 information with R&D and total assets lagged ahead of the other data. The data included all 291 companies except when cases were removed due to abnormal values.

Since the data were found to be non-normally distributed (strongly positively skewed), logarithms were used to approximately normalize them, although some strong skewness remained.

Canonical correlations used related (logarithms of) R&D dollars and total assets with the set of sales dollars, pretax income, and net income. All of these values are highly correlated with one another individually, and had similar coefficients of variation. The two canonical correlation coefficients on data for five year averages of all values among the 291 firms were .987 and .285. All univariate and multivariate test statistics (F, Wilks' Lambda Statistic, Pillai's and Hotellings-Lawley traces) are very highly significant ( $P < .001$ ) showing strong correlation among the sets of data.

Twenty one firms with the most extreme values were removed from the data. Using these single year (1984) data with lagged R&D and assets, corresponding to the presumed maximum influence of R&D on sales, the canonical correlations among the two sets of values (still using their logarithms to increase normality) are somewhat lower (.868 and .244) but still very highly significant ( $P < .001$ ) on all relevant tests.

Tests for the effect of lag (R&D) on these data against the dependant variables of sales, net income and pretax income after the lag period were all highly significant ( $P < .001$ ), as were the relevant multivariate statistics (F, Wilks' Lambda Statistic, Pillai's and Hotellings-Lawley traces). A test for the effect of total

assets showed all tests significant except the relationship of assets (lag years earlier) and 1984 pretax income. Again all multivariate tests were highly significant. Since these data are linked and related to each other based on the size of the firm, it is probable that they are in fact not a sound basis for examination of the impact of R&D on the success of the firm.

Therefore, another set of data was processed using R&D as a percent of sales as the independent variable and ROI, net income and pretax income as the dependent variables. These variables were selected because they are the indicators of results of the firms operations. This resulted in a very different outcome. The P was greater than .005 and the relevant multivariate statistics (F, Wilks' Lambda Statistic, Pillai's and Hotellings-Lawley traces) were high ( $P > .005$ ). Since these tests indicated that R&D was not significant, no further tests were justified and the testing was discontinued.

The results indicate that although R&D is an important factor in the operation of a high-technology firm, it is not a driving force or factor in the management of the firm. Rather, it is one of a number of factors that must be managed in a systemic manner in order to achieve success in the international markets of the 1980's. This will be discussed further in Chapter V.

### Analysis of Start-up Companies

The 291 companies were sorted into mature and Start-up companies. A firm was labeled as a Start-up if the data base contained financial information from near the establishment of the firm. That is, if the corporation began after 1964, it was considered to be a Start-up firm. The other firms in this study are referred to as Mature firms. The result was 207 firms in the Mature category and 84 firms in the Start-up category.

The averages for Start-up and Mature firms for variables J through T are shown in Appendix J. Based on a percentage of Common Equity and Total Assets, the size of the Start-up firms appears to be 8.6% and 7.2% respectively, of the size of the mature companies. The Start-up firms averaged a higher percentage of sales expended for R&D than mature firms. The Start-up firms have: Pretax Income at a much higher percentage, ROI that is comparable to the mature firms, but Net Income that is slightly lower. This may be caused by the additional tax write offs a mature firm may have. The Start-up firms apparently acquire Market Share more rapidly since their percentage of the market is relatively higher.

The Start-up and Mature firms were quartiled based on the ROI percentage in order to compare the performance of the firms in the first and fourth quartiles. The results of these computations are shown in Appendix J.



A review of the first quartile data shows that the first quartile Start-up firms are about 5.5 percent of the size of the average Mature firm based on common equity and total assets. The average ROI for both Start-up and Mature first quartile firms is nearly equal, at .371 and .349 respectively. The average R&D expenditures as a percentage of sales for Start-up firms was 7.2 percent, while it was 4.5 percent for Mature firms. The Start-up firms have a higher average percentage of the sales to assets, with sales being 174% of total assets while for Mature firms the percentage of sales to total assets was 123%.

A review of the two Sales regression models,  $\text{Sales} = \text{Constant} + \text{R\&D Dollar Investment}$  and  $\text{Sales} = \text{Constant} + \text{R\&D Dollar Investment} + \text{Total Assets}$ , for Start-up and Mature firms, reveals additional evidence that top performing companies in both categories have close linkage between their R&D programs, their sales performance, and their net income. Table XVI provides  $r^2$  data for the regression models of the first and fourth quartile Start-up and Mature firms.

TABLE XVI

START-UP AND MATURE FIRM  
SINGLE AND MULTIPLE REGRESSION  
FRACTION OF VARIANCE EXPLAINED BY THE REGRESSION ( $r^2$ )

MODEL	SALES = CONSTANT + R&D \$	SALES = CONSTANT + R&D \$ + TOTAL ASSETS	NET INCOME = CONSTANT + R&D \$	NET INCOME = CONSTANT + R&D \$ + TOTAL ASSETS
FIRST QUARTILE				
START-UP FIRMS	.778	.896	.672	.769
MATURE FIRMS	.875	.931	.729	.836
FOURTH QUARTILE				
START-UP FIRMS	.621	.893	.250	.487
MATURE FIRMS	.652	.815	.264	.408

As Table XVI shows, with the exception of the Start-up firms sales model, with independent variables research and development investment and total assets, there is a decrease in the  $r^2$  between the first and fourth quartiles for all models. This indicates that the firms with the best ROI, regardless of category, have closer linkage between their Research and Development programs and their sales and income performance.

Appendix J also outlines the findings that were observed in the fourth quartile among the Start-up and Mature firms. The average size of the Start-up firms was

about 12 percent of the size of the Mature firm based on common equity and total assets. The Start-up firms averaged an ROI of 3.1%, as opposed to 4.9% for the Mature firms. The average R&D as a percentage of Sales varies greatly between the Start-up firms and the Mature firms. The Start-up firms averaged 8.4 percent as compared to 4.5 percent for the Mature firms. A comparison of the ratio of sales to total assets indicates that the fourth quartile firms have sales of 108% of total assets.

In summary, Start-up firms appear to use their R&D programs as effectively as the well established firms. It appears that Start-up must invest a higher percentage of sales dollars in research to achieve higher level of performance in ROI and sales.

#### Corporate Field Interviews

Thirteen field interviews were conducted with firms included in this study. Since several respondents agreed to provide information if the source was not revealed, the identity of the firms or their SIC cannot be identified.

The key findings from the interviews are as follows:

1. Only three of the 13 respondents stated that their R&D budgets were based on a percent of sales calculation and one stated that the prior years budget was used. This disagrees with the results of the regression analysis which strongly suggests that nearly all first quartile firms budget research and development by one of these

methods.

2. The respondents felt that it took from one to ten years to achieve a payoff in sales, ROI, or market share from research and development. The average time was 4.5 years.

3. Eleven of the 13 respondents felt that research and development was of critical (6) or significant (5) importance to their business.

4. The average mix of Basic and Applied research was 17.2 and 82.8 percent respectively.

5. The primary source of R&D funding was from corporate assets (93%).

6. Six of the firms felt that foreign firms have an advantage over domestic firms.

7. Seven respondents felt that small firms were at a disadvantage in high-technology markets.

8. The time to recover their R&D investment ranged from one to ten years with an average of 4.2.

9. Five of the firms stated that they use a leader strategy while six stated that they lead for some products and follow for others. Only two firms stated that they are followers.

10. When asked who had the most influence on the direction of their R&D programs, eight firms ranked competitors as the most important and three ranked them second. Customers were ranked first by three firms,

second by two firms and fourth by one firm. Corporate requirements were ranked first by one firm, second by one, and third by three firms. Vendors were mentioned only once and they were ranked fourth. The results of this question indicate that American firms are not considering the customer as the most important factor in determining the direction for their research programs.

11. Five of the seven firms that indicated that they had basic research, stated that it takes ten years for that type of effort to initially reach the market. The other two firms did not respond to this part of the question.

12. All firms replied to the question concerning the time for applied research to reach the market. The answers ranged from one to five years with an average of 3.4 years.

13. All firms responded to the question about the length of their product life cycle. The answers varied from one to ten years with one exception which was an aircraft firm that stated that some product technology lasts for 30 years. The average product life cycle reported by the respondents was 6.6 years.

14. When asked what factor was the most important in determining success of their R&D programs, six of the 13 stated that budgets were the most important and five additional firms ranked budgets second. One other firm ranked budgets third. Management was ranked first three

times, second four times, and third once. Although technical staff was not a choice provided in the questionnaire, it was mentioned as the most important factor by four firms and as the second most important by two other firms. The importance of adequate budgets is indicated by the high ranking given by 12 of the 13 firms.

In summary, the interviews provided some insight into current opinions by corporate personnel. Of particular importance was the opinions that:

R&D budgets are not set by a percent of sales or prior budgets.

The time for payoff from R&D investment is very close to that found by the lag analysis in this study.

Product life cycles are important to planning and success and they are usually over five years.

#### SUMMARY

In this chapter the data for the 291 companies in 18 industries and the field interviews were analyzed. Factor and cluster analysis was used in conjunction with stepwise regression to determine variables to use in single and multiple regressions.

The results for the regression analysis indicate that R&D investment has a high positive relationship with sales and net income for firms in the first quartile when sorted by ROI. The relationship of R&D investment with market

share and ROI is very mixed even with first quartile firms and the results varied widely between companies and industries.

Lag correlations were developed to determine the time from R&D investment to the impact on sales, net income, and ROI. In most cases the lag values did not have significant correlations but it is felt that they are valid since the data was in agreement with the opinions of industry experts. The lag data provides a basis for an aggregate average by industry which may be used by management to compare corporate performance with other firms in their industry.

Covariance analysis was completed to investigate the effect of removing the impact of corporate size on the relationship between the independent variables of R&D dollar investment and R&D as a percent of sales on the dependent variables sales, ROI and market share. The results indicated that R&D dollar investment is significant in the industries noted in Tables XII-XVI. R&D as a percent of sales is significant to a few industries as noted in Table XIII and Table XV but it is not nearly as important as R&D dollar investment.

The results of the Canonical Correlation Analysis indicated that while R&D is an important factor in a high-technology firm, it is only one of the factors in the management of a successful firm.

A comparison was made of mature and start-up firms. It appears that when they are sorted into quartiles based on ROI, start-up firms perform as effectively as mature firms. They invest a higher percentage of sales in research but have smaller dollar budgets than mature firms.

The field interviews provided additional information concerning the importance of R&D to high-technology firms. Industry experts indicated that the lag time for their research programs was close to the times determined by the this study. They said that product life cycles generally range from one to eleven years and they attempt to recover their R&D investment within the first few years of the product life cycle. The only point of disagreement between this study and the answers given by the respondents was that only four of the thirteen stated they budget research based on a percent of sales calculation or prior budgets while the analysis indicated that nearly all firms used one of these methods.



## CHAPTER V

### SUMMARY AND CONCLUSIONS

This chapter presents a summary of the study, the conclusions, possible applications, limitations of the study, and suggestions for further research.

#### SUMMARY

##### Research Problem Addressed

This study was undertaken to determine if an analysis of the financial data available to the public could provide insights of interest to stakeholders in high-technology industries. An attempt was made to determine if a positive relationship exists between R&D investment and dependent variables of sales, net income, and market share. This study also attempted to determine the effect of insufficient R&D funding and whether a critical mass of R&D investment is required for a firm to remain competitive.

R&D investment was found to be an important factor in the management of a high-technology firm but it is not a dominant factor. The aggregated nature of the data reported in financial documents may not allow determination of specific conclusions concerning the

application of R&D investment. Also, the data did not reveal an effect of insufficient R&D expenditure on the firm. Additionally, there was no evidence of a critical mass of R&D investment. But, the study did reveal some insights for stakeholders.

First, this paper has provided executives with data which stresses the importance of R&D funding. It was found that most firms are following a percent of sales type of budgeting for research and development which may be counterproductive since R&D budgets might be reduced at the time of the greatest need for new product development. Lag times values and the evidence of shorter product life cycles should also be of interest and provide some assistance in setting guidelines for planning and budgeting. This study also provides information from which to make a comparison with the top performers in each industry.

For R&D managers there are some data which might assist them in justifying a change in the budgeting process in order to react to shorter life cycles, economic conditions and competitors actions. The information also provides the R&D subsystem with a basis to make some comparative analysis with other firms.

Stockholders and financial institutions can identify companies with the highest and lowest ROI performance. Also, there is information that would assist in an

evaluation of a corporate management.

Labor can use the information to assess the stability and profitability of the firm. They too, can evaluate the effectiveness of management's actions in regard to research spending.

Government agencies can assess elements of effectiveness in companies and industries. They can make comparisons with international competitors including a few foreign firms in this study.

For society, the data provides information concerning the effectiveness of research programs. Of particular concern is the performance of our high-technology industries. They need to return to a positive trade balance in order to protect our jobs and standard of living.

In summary, the information should be of interest to most of the stakeholders and provide a background from which to make some improvement in management of research programs.

#### CONCLUSIONS FROM THE DATA ANALYSES

The objective of this research project was to examine the high technology industries to determine some predictive elements of success in the application of research and development planning and funding. The data did not reveal that R&D is a driving force in the

operation of a high-technology firm. It is one of a number of important factors which must be considered by management in a competitive firm.

A systemic management approach is required which considers all factors in the corporations environment. Of course, R&D would be an important factor which requires careful consideration of research types and programs. Although this study did not find R&D a significant factor, perhaps a detailed study of the impact of basic and applied research would provide important insights.

Successful managers in our current competitive environment have a multitude of important factors to consider in operating the firm as an integrated system. They include the strengths and weaknesses of the firm, their products and their product life cycle, actions of competitors, customer needs and requirements, new technologies, and many other facets of their type of business.

The following paragraphs discuss some topics of interest that were found in processing of data.

A review of the data for first quartile firms in 18 industries provides some insights into operation of research programs by industry leaders.

Industry Leader Comparison

In regard to R&D funding there were differences in the spending patterns among industry leaders as shown in Table XVII.

TABLE XVII

INDUSTRY LEADER COMPARISON OF R&D SPENDING  
(FIRST QUARTILE - ROI SORT)

SIC	INDUSTRY	AVERAGE 1ST QUARTILE R&D SPENDING	QUARTILE LEADER'S R&D SPENDING
2800	Chemicals	\$179.6	\$250.4
2830	Drugs	\$134.8	\$139.4
3510	Engines & Turbines	\$39.0	\$5.4
3573A	Computers (Large)	\$1,156.7	\$85.7
3573B	Computers (Small)	\$29.2	\$22.1
3573C	Computers (Periph)	\$12.0	\$25.8
3651	Radio-TV Rec. Sets	\$123.2	\$88.4
3661	Tele./Telegraph App.	\$118.7	\$107.8
3662	Radio-TV Trans. Eq.	\$77.2	\$1.8
3674	Semiconductors	\$49.6	\$7.1
3679	Electronic Components	\$124.2	\$11.5
3721	Aircraft	\$122.5	\$85.8
3728	Aircraft Parts	\$421.7	\$0.7
3811	Eng. Lab. & Res. Eq.	\$6.0	\$1.8
3820	Measuring & Ctl. Inst.	\$406.6	\$299.5
3825	Elec. Meas./Test Inst.	\$49.9	\$4.9
3841	Surgical & Med. Inst.	\$7.0	\$1.5
3861	Photographic Eq.	\$401.1	\$515.1

Dollar figures are in millions

A review of Table XVII reveals that there are differences in the amounts for R&D spending in different industries. For some, like the computer industry, massive amounts of money are invested in research while in other industries a company may remain competitive with a relatively small research investment. Often the quartile

leader, based on ROI, is not spending even an average amount on research and development. Usually these firms have found a niche where they can operate very successfully such as in the Aircraft Parts industry where Aeronca spends very little on research but achieves a ROI of 33.6 percent. Another example is Briggs and Stratton in the Engines and Turbines industry. They spend very little for R&D but have an ROI of 27.8 percent.

Some of the leading companies are small when compared with the largest firms in their industry. For example, Amdahl in the Computer industry is very small in comparison with IBM but achieved a slightly higher ROI.

Management must determine the most effective strategy for their firm based on the strengths and weaknesses of their corporation.

Table XVIII provides a comparison of the percent of sales spent on R&D by the industry leaders. The Engines and Turbines, Radio-TV Transmission Equipment, and Aircraft Parts industries are notable exceptions to the general pattern. These industries all have companies which appear to be selling products in the mature stage of the product life cycle and do not require significant amounts of research and development. The industries with the highest average percent of sales spent on R&D are Computers (Large), Semiconductors, Computers (Small), Electrical Measurement and Test Instruments, Computers

(Peripherals), Radio-TV Transmitting Equipment and Drugs.

TABLE XVIII

INDUSTRY LEADER COMPARISON OF R&D PERCENT OF SALES  
(FIRST QUARTILE - ROI SORT)

SIC	INDUSTRY	AVERAGE 1ST QUARTILE R&D % SALES	QUARTILE LEADER'S R&D % SALES
2800	Chemicals	2.8%	3.0%
2830	Drugs	6.0%	3.2%
3510	Engines & Turbines	2.6%	0.1%
3573A	Computers (Large)	11.1%	15.4%
3573B	Computers (Small)	6.6%	4.9%
3573C	Computers (Periph)	6.5%	9.2%
3651	Radio-TV Rec. Sets	4.3%	5.5%
3661	Tele./Telegraph App.	3.3%	2.1%
3662	Radio-TV Trans. Eq.	6.4%	0.1%
3674	Semiconductors	7.9%	4.9%
3679	Electronic Components	3.8%	6.3%
3721	Aircraft	2.8%	2.5%
3728	Aircraft Parts	3.8%	1.6%
3811	Eng. Lab. & Res. Eq.	5.0%	2.8%
3820	Measuring & Ctl. Inst.	3.6%	5.0%
3825	Elec. Meas./Test Inst.	6.6%	4.4%
3841	Surgical & Med. Inst.	2.7%	2.1%
3861	Photographic Eq.	5.8%	6.2%

Table XIX provides a comparison of the average ROI and the industry leader's ROI. The industries where the leader had a notable exception from the average were Computers (Small), Computers (Peripherals), and Aircraft. The companies are Commodore International, Mohawk Data Sciences Corporation, and Martin Marietta Corporation.

TABLE XIX

INDUSTRY LEADER COMPARISON OF ROI  
(FIRST QUARTILE - ROI SORT)

SIC	INDUSTRY	AVERAGE 1ST QUARTILE ROI	QUARTILE LEADER'S ROI
2800	Chemicals	33.9%	39.4%
2830	Drugs	40.8%	57.5%
3510	Engines & Turbines	18.0%	27.8%
3573A	Computers (Large)	38.2%	43.9%
3573B	Computers (Small)	42.2%	92.8%
3573C	Computers (Periph)	47.8%	100.7%
3651	Radio-TV Rec. Sets	42.4%	54.0%
3661	Tele./Telegraph App.	28.6%	29.8%
3662	Radio-TV Trans. Eq.	28.8%	32.1%
3674	Semiconductors	25.7%	30.8%
3679	Electronic Components	33.5%	45.7%
3721	Aircraft	53.2%	83.0%
3728	Aircraft Parts	33.2%	33.6%
3811	Eng. Lab. & Res. Eq.	37.3%	51.0%
3820	Measuring & Ctl. Inst.	25.1%	26.7%
3825	Elec. Meas./Test Inst.	25.5%	28.9%
3841	Surgical & Med. Inst.	31.2%	33.7%
3861	Photographic Eq.	25.9%	29.0%

Commodore's success appears to be a combination of strong sales for new and old technology. They have continued to sell computers developed in the early 1980's while introducing new technology to match competitors. They also follow learning curve pricing strategy and begin lowering prices soon after product introduction. Martin Marietta has had outstanding success in aerospace and information systems and continues to perform well.

A word of caution is in order at this point. Mohawk Data has had good ROI performance but very poor net income for several years due to high overheads, debt, and problems in some operating divisions. Also, Xonics in



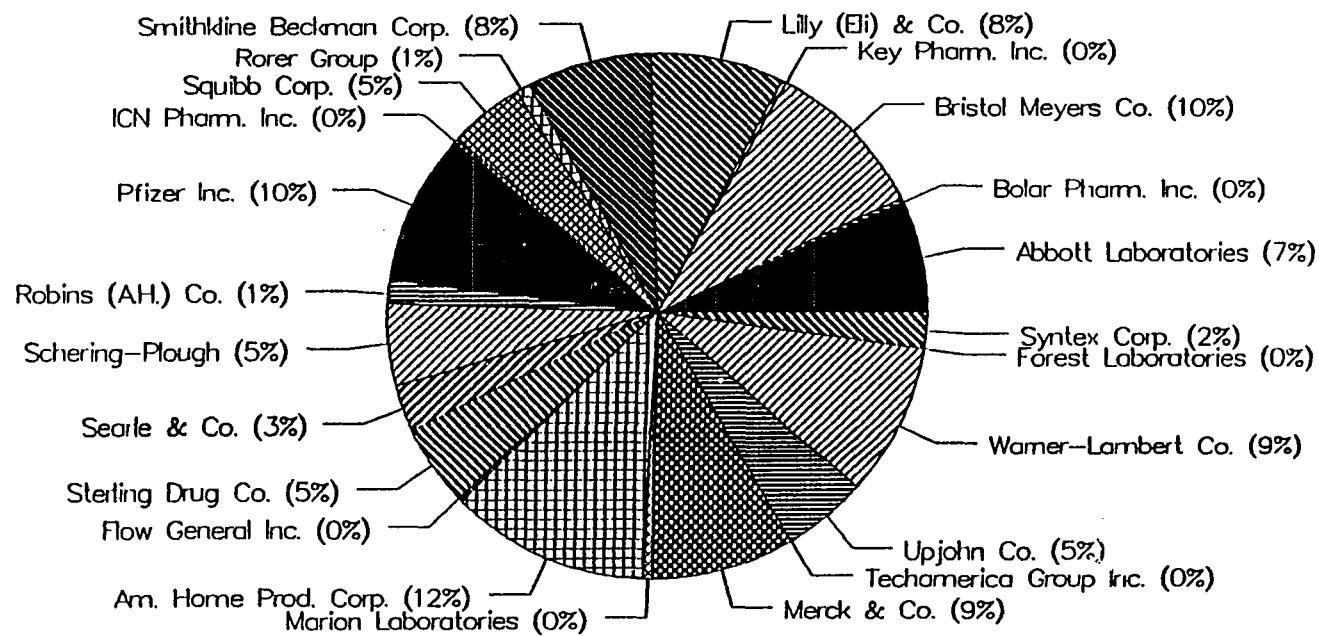
Surgical and Medical Instruments (3841) is the industry leader for ROI but they sold all research capability in 1984 and filed a Chapter 11 reorganization plan. Therefore, a stakeholder must investigate more than ROI as a criterion for evaluation.

### Regression Analysis

The regression analysis indicated that when Total Assets were added to R&D investment as an independent variable for models of Sales, Net Income, ROI, or Market Share, the correlation was usually improved. There was a close relationship between R&D dollar expenditures and Net Income. The relationship to ROI and Market Share was not as strong but there was a definite positive relationship. Of course, there are many other factors besides the amount of funding for research that are outside the scope of this study that enter into the corporate profit and market share performance. Nevertheless, the most important factor was the amount of the research effort in dollars.

In the Market Share models, the correlations with independent variables R&D and Total Assets were moderately strong for all industries. Market Share is often a difficult factor to use in an analysis because most markets are quite fragmented. For example, there are 24 companies in this study that were classified as being in the Drug industry, and they had market shares which varied

from 11.7 percent to .1 percent of the market as shown in Figure 4.



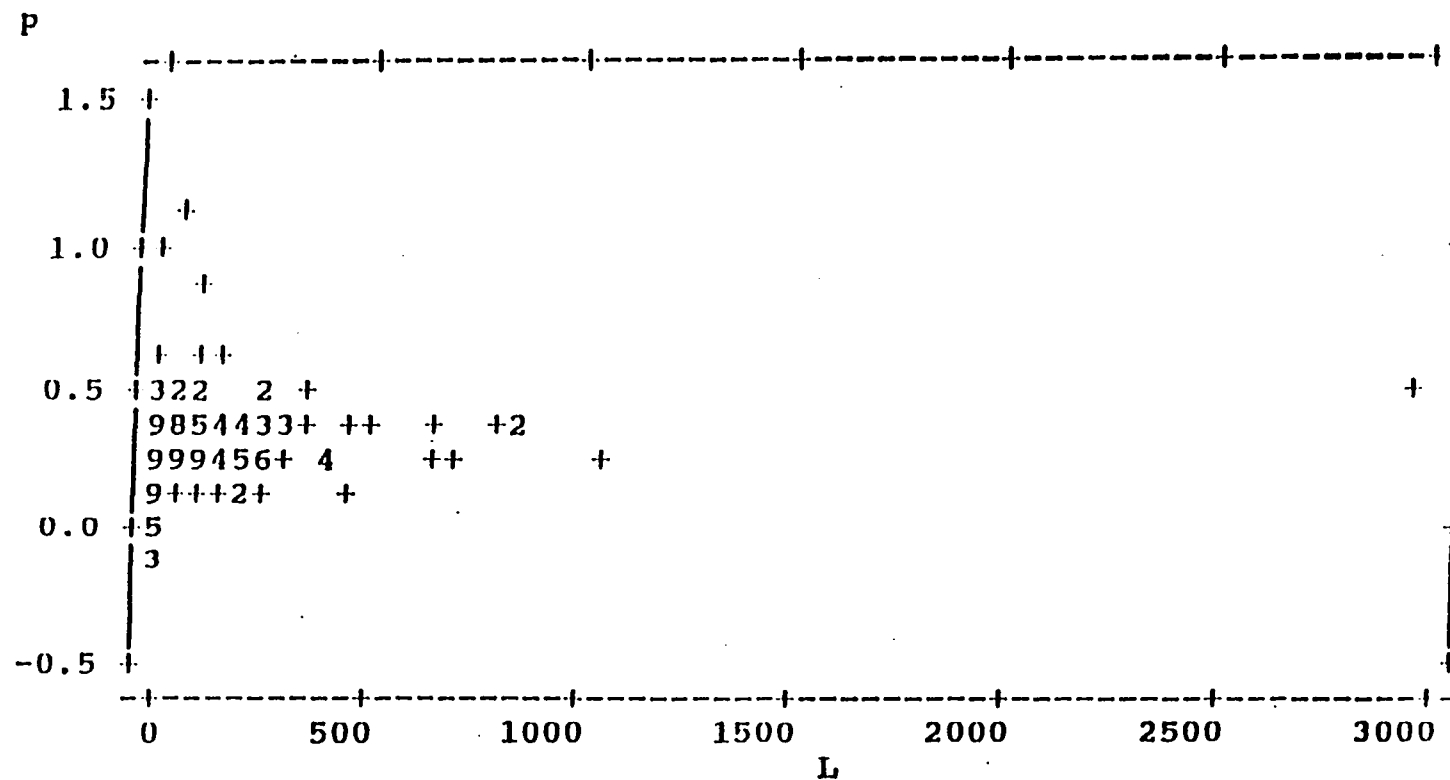
**Figure 4. Drugs SIC 2830 Market Share.**

The pie chart shows the fragmented nature of the drug industry. Although, not all industries are as divided, many are segmented by a large number of companies. In addition, there are also private firms (those not listed on the stock exchanges) in the markets. Because most of the firms have a relatively small part of their markets, the changes in their share are usually made very slowly in small increments.

#### Critical Mass

There was no evidence found that there is a "critical mass" of R&D investment that must be maintained for a firm to continue in a steady state, improve their market position, or increase profitability. Appendix L contains plots of ROI vs R&D investment for each of the 18 industries. Although the various plots have clusters, there does not appear to be any indication that an increase in R&D spending results in increased ROI.

Figure 5 is a graph of the ROI (P) and the R&D Dollar Investment (L) for the 291 firms in the study. It can readily be seen that although the data points are clustered, there is not a correlation or "critical mass".



### Lag Analysis

The study provided an indication of the time delay from the investment in research and development to the impact on sales, net income and market share. Most time lag factors were over five years. Therefore, for effective strategic management, a time frame of more than the customary long range plan of five years must be considered. Corporations that have longer lag times must take some action to shorten their lead times to be competitive.

Appendix H includes the time values for the leading firms in each industry for the dependent variables of sales, net income, and market share. This information permits a review of the firms with the best ROI performance in regard to their ability to move their technology from the laboratory to the market.

The results of the lag time analysis indicates that companies must focus their research programs on current and new product needs of the customers. Reaction time must be reviewed and modified as required to serve customers and react to the actions of their competitors.

### Start-up Firms

This study also revealed that Start-up firms can compete with the Mature firms and they can achieve satisfactory performance in net income and ROI. Start-up firms usually spend a greater portion of their sales

dollars for research than the established companies when developing new product lines. In summary, first quartile start-up firms compare favorably with first quartile mature firms.

#### CONCLUSIONS FROM RELATED LITERATURE

Current literature and corporate field interviews have provided important insights and implications for management. The following paragraphs briefly discuss some of the important topics.

##### Customer First

One of the elements in the success of the Japanese has been feedback from their customers and corporate willingness to provide consumers with innovative adaptations of existing products. They also follow a learning curve pricing strategy and continually lower prices to provide better market values [Abegglen, 1985:54-59]. The Japanese introduce a product into the market and then rapidly modify it based on customer feedback [Dertouzos, 1989:75].

The MIT Commission on Industrial Productivity found that successful companies in the United States "are making a concerted effort to develop closer ties to their customers." These ties allow them to react more rapidly to market requirements and provide differentiated products [Dertouzos, 1989:119-120]. Companies must learn to

provide products which cater to customer tastes and preferences [Friberg, 1989:88].

#### Incremental Applied Research

In the past, American firms have relied on major technological breakthroughs to provide new products. Our competitors have captured many markets by developing improvements to existing technology. The U.S. research deficiency appears to be in applied research for products and processes not in basic research [Smith, 1988:120-121].

The consumer electronics industry provides an example of Japanese innovation in upgrading technologies continuously. Using this strategy, they have dominated many market that had their beginnings in the United States [Business Week, 1989:22].

American firms must learn to "embrace product customization and production flexibility" to remain competitive [Dertouzos, 1989:133-134].

#### Organize National Direction

The United States needs a more concerted effort by the government to provide R&D direction. Companies may have to pool their research efforts to develop new techniques and products. Targeted goals for products and processes may be required to meet international competition [Smith, 1989:238-240]. Although some progress is being made "there's still no clear-cut policy," but "the federal



government is actively fostering ties between science and industry" [Business Week, 1989:40].

This relatively new direction was recommended by the President's Commission on Industrial Competitiveness and may be one of the most important elements to rejuvenating U.S. competitiveness [Dertouzos, 1989:306, 314-15].

#### Lengthen Planning Horizons

There are indications that it takes between five and ten years for technology to move from the laboratory to the market while American planning systems focus on a six to 12 month time frame [Business Week, 1989:157,172].

While successful planning programs must consider both long-term and short-term horizons, many American firms have lost markets because they focused on the near-term outcomes. To remain competitive, it is essential that we implement longer term planning systems similar to the Japanese approach. Financial factors such as the cost of capital and pressure to demonstrate short-term profits often overshadow the need to take action for long-term success [Dertouzos, 1989:53-66].

Investment in basic research is a very essential factor for American firms to achieve long-term success. Management must be willing to take the risks associated with programs which may not achieve a payoff for over five years. With improved government guidance and industry cooperation, our productive systems can remain strong and

competitive in the future [Dertouzos, 1989:144-145, 154-155]. "If you don't invest for the long term, there is no short term" [Dumaine, 1989:58].

#### Communication Between Functional Areas

"U.S. companies are being out-managed by their toughest competitors. The main reason may be structural."

The traditional organization hierarchy must be replaced by teamwork by R&D, marketing and manufacturing in order to improve competitive posture. The customary passing of technology from R&D to manufacturing to marketing should be replaced by a "fast cycle" approach which also allows all functions to rapidly react to consumer preferences [Business Week, 1989:106-107].

In many industries, such as Drugs (2830), a new product must move through a long cycle from R&D to the market and then to government approval of the product which requires extensive coordination and communication. Merck has been successful by using a champion or "shepherd" who stays with the new technology from the laboratory to the market in order to maintain continuity [Business Week, 1989:120].

On a broader scale, the Cuomo Commission "recommends that management and labor encourage greater communication between those engaged in R&D and those involved in production." They feel that it is essential to closely link the functional areas and improve the flow of

information among all corporate personnel in order to react to technological progress [Smith, 1988:181,241].

Products often fail due to a lack of information concerning the market or product. All contributors to the development process must be integrated as a system to provide a basis for effective planning and product success. Each functional area should develop their own complimentary strategies which contribute to the overall success of the firm [Harvard Business Review, 1989:113-125].

#### APPLICATIONS

High technology industries are a vital factor for our economic survival in international markets. In order to maintain, gain, or establish leadership in these markets, it is essential that corporations in the high technology sectors operate as effective integrated systems. This requires that particular attention be paid to the research and development of new and improved products.

The business environment is now a world economy where the U.S. firms must compete with foreign markets that may have many economic advantages such as government subsidies, less expensive labor, more abundant resources, and favorable tax laws.

The United States must exploit the technological advantage it has in high technology fields. Many of

these industries have had a favorable trade balances even in times when the United States economy as a whole suffered massive trade deficits. Many markets have been lost and others will be if action is not taken to keep the U.S. ahead in the technical fields where we have the advantage over other foreign markets.

American industries must use their R&D systems more effectively to develop commercial products that are on the leading edge of technology and which can compete with other high technology industries in countries like Japan and West Germany.

Such a restructuring will require some changes in the way we manage research programs. This study found that most companies tie their R&D budgets to a percentage of Sales or the prior year budgets. Apparently, this approach has been a well established method for some time. Figure 6 is a plot of the R&D Dollar Investment (L) and Sales (O) variables for all 291 companies in the study. It can be seen that there is a definite correlation between the two factors even when all firms are plotted. A regression line for this data set has a slope of .798 indicating that even when this is aggregated there is a very strong relationship.

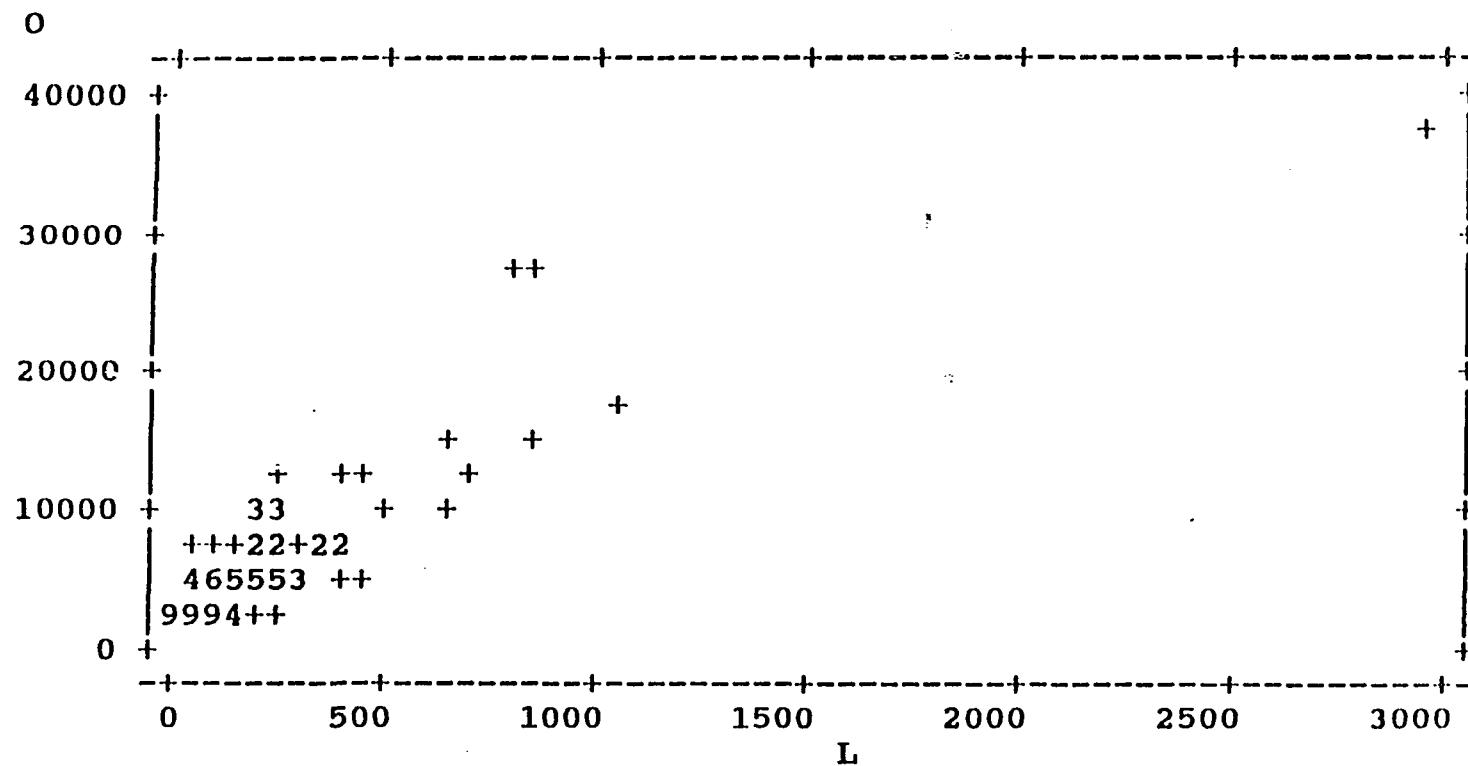


Figure 6. Sales vs R&D Dollar Investment.  
All firms in this study.

Legend: 0 = Sales  
L = R&D Dollar Investment  
+ = 10 or more data points, numbers are the number of data points

It may be essential that a new systems approach be utilized to decouple R&D budgets from the percent of Sales approach. That type of funding may be counter productive since budgets are reduced at a time when more funding is actually required.

Basic research is required many years before concepts transferred can be entered into applied research which will develop products to meet the needs of the customer. This must be done in a systemic manner with management utilizing a more strategic approach in development of corporate strategy and policy. Basic and applied research are essential and require adequate resources including personnel, equipment, materials, and capital.

Also supporting this argument is the time series lag correlations. They pointed out the need for long range planning. The average time period from R&D investment to payoff in sales, net income and market share was over five years and is beyond the normal planning time span used by management in most U.S. corporations.

Management must review their current product lines and anticipate the market needs and requirements. They must make strategic funding decisions for R&D many years prior to product requirements of the customer.

This study indicated that one of the most important factors in success for high technology firms is the amount of R&D investment that can be made. Start-up firms and

others that do not have the necessary resources to accumulate adequate funds may have to join with other firms to form a consortium for R&D. This approach may also be required for large projects and efforts that push the state-of-the-art significantly.

#### LIMITATIONS OF THE STUDY

This study did not address all industries in the high-technology classifications nor did it include all companies in any of the industries. It focused on companies that were listed in the Compustat II data base with some major firms added from the electronics industry.

This study did not include foreign firms unless they were listed in the Compustat II data base. A more complete research project would include all the major foreign firms for each industry. A system to convert foreign currency to realistic equivalent to domestic currency will be needed for the addition of foreign firms to this study.

The research focused more on the years since 1974 due to the availability of more data since that time. Also, the quality of the accounting for Research and Development expense data was improved when it was based on common definitions provided to corporations by the Security and Exchange Commission in 1974.

The data from the Compustat data base was generally

assumed to be correct. A sample of the data was cross checked and found to be relatively accurate. Where errors or omissions were found, they were corrected or completed as necessary. The Compustat file did not contain complete data and required an extensive amount of data search to complete missing items.

This study is limited because of the fact that there are other types of statistical techniques which were not utilized which might further clarify relationships and causality between variables. Additionally, the future trends in Research and Development investment may be significantly different than for the time period used in the study. For example, there presently exists a trend towards R&D consortiums, cooperative efforts between firms, and even organizations being formed to focus their efforts on R&D programs and high-technology fields.

Time is also a limitation. There is a massive amount of data available even for the 291 firms in the study. To cover all possible aspects or considerations, probably is beyond the scope of one or even a team of individuals to complete in a reasonable time.

Another shortcoming is the lack of information from private firms. Access to that data would perhaps change some of the deduced relationships between the variables.



### SUGGESTIONS FOR FURTHER RESEARCH

This study was exploratory in nature using a large data base of industries and companies. Therefore there are a number of additional or improved research projects that could be expanded beyond this study. A few of the most promising are suggested here:

1. A logical extension of this study would be to concentrate on one industry, such as computers, and obtain the data from a source such as the Q File. It has Annual Reports and 10k's since 1978 which could be used in order to have a more complete data set and include all or nearly all companies in an industry. This would avoid the problems with incomplete data and interpretations by another source such as the Compustat II data base.
2. An industry set of corporate data could be processed using a deflator to provide a more common base for the financial data. This approach would reduce the impact of inflation on the financial data.
3. A study which included all major foreign firms would provide a more complete data set in this time of international markets. This type of study would be important to the high-technology industries since they are presently engaged in a very dynamic and competitive international market with increased foreign competition.
4. A study of actual product life cycles and their relationship to R&D investment would be very helpful to

corporate management. Research of this type could examine the S curve incremental changes in a technology. This type of information could assist management in strategic planning for research and development. A comprehensive set of interviews with corporate executives would provide expert opinion and verification of quantitative analysis.

5. A study comparing firms that have excellent market performance compared with those that have failed or have significant financial problems might provide a more prescriptive perspective for management.

6. A study of R&D investment with the dollar amounts spent for basic and applied research as separate variables might provide more information concerning the optimum use of research and development funding. Although the information may be very difficult to obtain due to the aggregate nature of most accounting data released by public corporations, a study of this type might be extremely useful to American firms competing in international markets.

### Epilogue

Although all the objectives of this study have not been met, it has proved to be interesting and worthwhile. Perhaps it can provide a starting point for a more in-depth analysis of the dynamic high-technology environment.

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## APPENDIX A

### LIST OF COMPANIES INCLUDED IN THIS STUDY

A list of all 291 companies included in this study. The companies are listed by Standard Industrial Classification (SIC) and alphabetically.

Appendix B lists the 24 firms which were added from the Electronics Business 100 and are included in the 291 firms.

Appendix C lists the start-up firms identified in this study which are also included in the 291 firms.



FILE	SIC - 2800
NAME	CHEMICALS & ALLIED PRODUCTS
A018	Air Products & Chemicals Incorporated
A001	Allied Corporation
A002	American Cyanamid Company
A023	Celanese Corporation
A003	Dow Chemical
A004	Du Pont (E.I.)
A019	Essex Chemical Corporation
A005	FMC Corporation
A060	General Defense Corporation
A006	Grace (W.R.) & Company
A020	Great Lakes Chemical Corporation
A007	Hercules Incorporated
A008	Imperial Chemical Industry
A021	Learonal Incorporated
A009	Monsanto Company
A010	Morton Thiokol Incorporated
A012	Olin Corporation
A014	Pennwalt Corporation
A013	PPG Industries Incorporated
A024	Reichhold Chemical Incorporated
A015	Rohm & Haas Company
A016	Stauffer Chemical Company
A017	Union Carbide Corporation

FILE NAME	SIC - 2830 DRUGS
B025	Abbott Laboratories
B027	American Home Products Corporation
B028	Bolar Pharmaceutical Company Incorporated
B029	Bristol Meyers Company
B031	Flow General Incorporated
B032	Forest Laboratories Incorporated
B034	ICN Pharmaceuticals Incorporated
B036	Key Pharmaceuticals Incorporated
B037	Lilly (Eli) & Company
B038	Marion Laboratories
B039	Merck & Company
B040	Pfizer Incorporated
B041	Richardson-Vicks Incorporated
B042	Robins (A.H.) Company
B043	Rorer Group
B044	Schering-Plough
B045	Searle (G.D.) & Company
B047	Smithkline Beckman Corporation
B048	Squibb Corporation
B049	Sterling Drug Company
B050	Syntex Corporation
B051	Techamerica Group Incorporated
B053	Upjohn Company
B054	Warner-Lambert Company

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FILE	SIC -3510
NAME	ENGINES AND TURBINES

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C062	Briggs & Stratton
C063	Brunswick Corporation
C064	Cummins Engine
C065	Outboard Marine Corporation
C066	Teledyne Incorporated

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FILE	SIC - 3573A
NAME	ELECTRONIC COMPUTING EQUIPMENT

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D071	Amdahl Corporation
D076	Burroughs Corporation
D083	Control Data Corporation
D084	Cray Research
D085	Data General Corporation
D090	Digital Equipment Corporation
D096	Hewlett-Packard Company
D097	Honeywell Incorporated
D098	International Business Machines Corporation
D107	NCR Corporation
D113	Sperry Corporation

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FILE	SIC - 3573B
NAME	ELECTRONIC COMPUTING EQUIPMENT

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E073	Apple Computer Incorporated
E080	Commodore International Limited
E081	Computer Consoles
E082	Computervision Corporation
E086	Datapoint Corporation
E089	Diagnostic/Retrieval Systems
E091	Electronic Associates Incorporated
E093	Floating Point Systems Incorporated
E095	Gould Incorporated
E099	Intertec Data Systems Corporation
E101	Lundy Electronics & Systems
E103	Management Assistance
E104	Modular Computer Systems
E106	NBI Incorporated
E108	Prime Computer
E111	Reynolds & Reynolds
E112	Rolm Corporation
E119	Wang Laboratories

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FILE	SIC - 3573C
NAME	ELECTRONIC COMPUTING EQUIPMENT

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F072	Anderson Jacobson Incorporated
F074	Applied Magnetics Corporation
F078	Centronics Data Computer
F079	Cognitronics Corporation
F087	Dataproducts Corporation
F088	Dataram Corporation
F092	Electronic Memories & Mag.
F094	Genisco Technology
F102	MSI Data Corporation
F105	Mohawk Data Sciences
F110	Recognition Equipment Incorporated
F114	Storage Technology Corporation
F115	TEC Incorporated
F116	Telex Corporated
F117	Verbatim Corporation
F118	Vermont Research Incorporated
F120	Wespercorp

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FILE	SIC - 3651
NAME	RADIO-TV RECEIVING SETS (CONSUMER)

---

G131	Coleco Industries
G507	Corning Glass
G132	Craig Corporation
G146	Electrosound Group Incorporated
G133	Emerson Radio
G134	Esquire Radio & Electronics Incorporated
G137	Matsushita Electric Industrial
G519	Minnesota Mining & Manufacturing
G520	Nippon Electric Company
G521	North American Phillips
G138	Pioneer Electronic Corporation
G139	RCA Corporation
G140	Sony Corporation
G242	TDK Corporation
G144	Wells-Gardner Electronics
G145	Zenith Radio Corporation

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FILE	SIC - 3661
NAME	TELEPHONE & TELEGRAPH APPARATUS

---

H164	Aydin Corporation
H513	GTE
H150	Int'l Telephone & Telegraph
H151	Lynch Communication System
H152	Mitel Corporation
H180	Motorola Incorporated
H212	M/A-Com Incorporated
H153	Northern Telephone Limited
H181	Oak Industries Incorporated
H154	Plantronics Incorporated
H186	Plessey PLC
H155	Porta Systems Corporation
H190	Scientific-Atlanta Incorporated
H192	Sparton Corporated
H193	Stewart-Warner Corporated
H194	Sunair Electronics Incorporated
H158	Teleconcepts Corporation
H159	Telesciences Incorporated
H197	Texscan Corporation
H198	Timeplex Incorporated
H199	Torotel Incorporated
H160	Trans-Lux Corporation
H195	TRW Incorporated

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FILE	SIC - 3662
NAME	RADIO-TV TRANSMITTING EQUIPMENT

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I220	Adams Russell
I170	EDO Corporated
I169	E-Systems Incorporated
I149	General Datacomm Industries Incorporated
I173	Harris Corporation
I174	Hazeltine Corporation
I175	Instrument Systems Corporation
I179	Loral Corporation
I182	Paradyne Corporation
I188	Raytheon Company
I189	Sanders Associates Incorporated
I241	T Bar Incorporated
I196	Tech-Sym Corporated
I200	United Industrial Corporation
I202	Watkins-Johnson

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FILE	SIC - 3674
NAME	SEMICONDUCTORS & RELATED EQUIPMENT

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J207	Advanced Micro Devices
J208	Alpha Industries
J209	Analog Devices
J504	Applied Materials
J508	Eaton
J511	GCA
J210	INTEL Corporation
J211	Int'l Rectifier Corporation
J514	KLA
J515	Kulicke & Soffa
J517	LTX
J518	Materials Research
J213	National Semiconductor Corporation
J319	Teradyne Incorporated
J217	Texas Instrument Incorporated
J218	Unitrode Corporation
J205	Varian Associates Incorporation

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FILE	SIC - 3679
NAME	ELECTRONIC COMPONENTS (NEC)

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K121	Acme Electric Corporation
K122	Ametek Incorporated
K503	AMP
K161	Andrea Radio Corporation
K219	AVX Corporation
K123	Baldor Electric
K223	Burndy Corporation
K166	Canadian Maraconi Company
K248	Champion Spark Plug
K506	Cincinnati Milicron
K203	Clarostat Manufacturing Company Incorporated
K224	CTS Corporation
K168	Cubic Corporation
K228	EECO
K509	EG&G
K229	Electro Audio Dynamics
K128	Electronics Corp of America
K510	Emerson Electric
K171	Federal Signal Corporation
K512	General Electric
K204	General Instrument Corporation
K314	General Signal Corporation
K232	GTI Corporation
K135	Gulton Industries Incorporated
K316	Hipotronics Incorporated

FILE NAME	SIC - 3679 CONTINUED ELECTRONIC COMPONENTS (NEC)
K234	International Power Machines Corporation
K177	Knogo Corporation
K235	Kollmorgan Corporation
K236	Kyocera Corporation
K516	Litton Industries
K522	Nordson
K237	Nuclear Data
K183	Penril Corporation
K185	Pittway Corporation
K240	Rogers Corporation
K214	Semtech Corporation
K191	Servo Corporation of America
K524	Singer
K243	Thomas & Betts Corporation
K525	Tracor
K206	Varo Incorporated
K244	Veeco Instruments
K126	Vernitron Corporation
K528	Westinghouse

FILE NAME	SIC - 3721 AIRCRAFT
L258	Boeing Company
L259	Cessna Aircraft Company
L260	Fairchild Industries Incorporated
L261	Gates Learjet Corporation
L262	General Dynamics Corporation
L263	Grumman Corporation
L280	Lockheed Corporation
L281	Martin Marietta Corporation
L265	McDonnell Douglas Corporation
L266	Northrop Corporation
L282	Rockwell International Corporation
L267	Textron Incorporated

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FILE	SIC - 3728
NAME	AIRCRAFT PARTS & AUXILIARY EQUIPMENT

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M268	Aeronca Incorporated
M252	Curtiss Wright Corporation
M270	Lear Siegler Incorporated
M272	Moog Incorporated
M275	Sierracin Corporation
M276	Signal Companies
M254	Sundstrand Corporation
M277	TRE Corporation
M255	United Technologies Corporation

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FILE	SIC - 3811
NAME	ENGINEERING LAB & RESEARCH EQUIPMENT

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N284	Gerber Scientific Incorporated
N294	Instron Corporation
N298	Nicolet Instrument
N299	Perkin Elmer Corporation
N287	Sargent Welch Scientific
N288	Spectra Physics
N335	Sybron Corporation
N302	Vishay Intertechnology Incorporated
N290	Whitehall Corporation

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FILE	SIC - 3820
NAME	MEASURING & CONTROL INSTRUMENTS

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0291	Badger Meter Incorporated
0292	Bowmar Instrument Corporation
0312	Fluke (John) Manufacturing Company
0306	Foxboro Company
0295	Johnson Controls Incorporated
0297	Mark Controls
0308	Measurex Corporation
0301	Robertshaw Controls
0523	Schlumberger
0317	Sun Electric Corporation
0129	Tech Ops Incorporated
0303	Watsco Incorporated



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FILE	SIC - 3825
NAME	ELECTRICAL MEASUREMENT & TEST INSTRUMENTS

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P165	Barnes Engineering Company
P311	Cohu Incorporated
P167	Conrac Corporation
P293	Esterline Corporation
P305	Fischer & Porter Company
P315	Genrad Incorporated
P068	Mangood Corporation
P346	Talley Industries Incorporated
P318	Tektronix Incorporated
P278	Teleflex Incorporated
P201	Vicon Industries Incorporated
P309	Western Pacific Industries

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FILE	SIC - 3841
NAME	SURGICAL & MEDICAL INSTRUMENTS

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Q323	Bard (C.R.) Incorporated
Q320	Bausch & Lomb Incorporated
Q324	Baxter Travenol Laboratories
Q325	Becton, Dickerson & Company
Q326	Bio-Rad Laboratories
Q328	Delmed Incorporated
Q283	Gelman Sciences Incorporated
Q245	Intermedics Incorporated
Q329	Laser Industries Limited
Q246	Medtronic Incorporated
Q330	Mountain Medical Equipment
Q333	National Patent Development
Q247	Xonics Incorporated

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FILE	SIC - 3861
NAME	PHOTOGRAPHIC EQUIPMENT & SUPPLIES

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R501	AM International
R336	Bell & Howell Company
R337	Compugraphic Corporation
R338	Eastman Kodak Company
R340	Matrix Corporation
R341	Orrox Corporation - NOW CMX
R069	Pitney Bowes Incorporated
R342	Polaroid Corporation
R343	Speed-O-Print Business Machines
R344	Visual Graphics
R345	Xerox Corporation

COMPANIES INCLUDED IN THIS STUDY  
SORTED ALPHABETICALLY

COMPANY NAME	SIC	FILE NAME
Abbott Laboratories	2830	B025
Acme Electric Corporation	3679	K121
Adams Russell	3662	I220
Advanced Micro Devices	3674	J207
Aeronca Incorporated	3728	M268
Air Products & Chemicals Inc.	2800	A018
Allied Corporation	2800	A001
Alpha Industries	3674	J208
AM International	3861	R501
Amdahl Corporation	3573A	D071
American Cyanamid Company	2800	A002
American Home Products Corporation	2830	B027
Ametek Incorporated	3679	K122
AMP	3679	K503
Analog Devices	3674	J209
Anderson Jacobson Incorporated	3573C	F072
Andrea Radio Corporation	3679	K161
Apple Computer Incorporated	3573B	E073
Applied Magnetics Corporation	3573C	F074
Applied Materials	3674	J504
AVX Corporation	3679	K219
Aydin Corporation	3661	H164
Badger Meter Incorporated	3820	O291
Baldor Electric	3679	K123
Bard (C.R.) Incorporated	3841	Q323
Barnes Engineering Company	3825	P165
Bausch & Lomb Incorporated	3841	Q320
Baxter Travenol Laboratories	3841	Q324
Becton, Dickerson & Company	3841	Q325
Bell & Howell Company	3861	R336
Bio-Rad Laboratories	3841	Q326
Boeing Company	3721	L258
Bolar Pharmaceutical Company Inc.	2830	B028
Bowmar Instrument Corporation	3820	O292
Briggs & Stratton	3510	C062
Bristol Meyers Company	2830	B029
Brunswick Corporation	3510	C063
Burndy Corporation	3679	K223
Burroughs Corporation	3573A	D076
Canadian Maraconi Company	3679	K166
Celanese Corporation	2800	A023
Centronics Data Computer	3573C	F078

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COMPANY NAME	SIC	FILE NAME
Cessna Aircraft Company	3721	L259
Champion Spark Plug	3679	K248
Cincinnati Milicron	3679	K506
Clarostat Manufacturing Company Inc.	3679	K203
Cognitronics Corporation	3573C	F079
Cohu Incorporated	3825	P311
Coleco Industries	3651	G131
Commodore International Limited	3573B	E080
Compugraphic Corporation	3861	R337
Computer Consoles	3573B	E081
Computervision Corporation	3573B	E082
Conrac Corporation	3825	P167
Control Data Corporation	3573A	D083
Corning Glass	3651	G507
Craig Corporation	3651	G132
Cray Research	3573A	D084
CTS Corporation	3679	K224
Cubic Corporation	3679	K168
Cummins Engine	3510	C064
Curtiss Wright Corporation	3728	M252
Data General Corporation	3573A	D085
Datapoint Corporation	3573B	E086
Dataproducts Corporation	3573C	F087
Dataram Corporation	3573C	F088
Delmed Incorporated	3841	Q328
Diagnostic/Retrieval Systems	3573B	E089
Digital Equipment Corporation	3573A	D090
Dow Chemical	2800	A003
Du Pont (E.I.)	2800	A004
Eastman Kodak Company	3861	R338
Eaton	3674	J508
EDO Corporated	3662	I170
EECO	3679	K228
EG&G	3679	K509
Electro Audio Dynamics	3679	K229
Electronic Associates Incorporated	3573B	E091
Electronic Memories & Mag.	3573C	F092
Electronics Corp of America	3679	K128
Electrosound Group Incorporated	3651	G146
Emerson Electric	3679	K510
Emerson Radio	3651	G133
Esquire Radio & Electronics Inc.	3651	G134
Essex Chemical Corporation	2800	A019
Esterline Corporation	3825	P293
E-Systems Incorporated	3662	I169
Fairchild Industries Incorporated	3721	L260

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COMPANY NAME	SIC	FILE NAME
Federal Signal Corporation	3679	K171
Fischer & Porter Company	3825	P305
Floating Point Systems Incorporated	3573B	E093
Flow General Incorporated	2830	B031
Fluke (John) Manufacturing Company	3820	O312
FMC Corporation	2800	A005
Forest Laboratories Incorporated	2830	B032
Foxboro Company	3820	O306
Gates Learjet Corporation	3721	L261
GCA	3674	J511
Gelman Sciences Incorporated	3841	Q283
General Datacomm Industries Inc.	3662	I149
General Defense Corporation	2800	A060
General Dynamics Corporation	3721	L262
General Electric	3679	K512
General Instrument Corporation	3679	K204
General Signal Corporation	3679	K314
Genisco Technology	3573C	F094
Genrad Incorporated	3825	P315
Gerber Scientific Incorporated	3811	N284
Gould Incorporated	3573B	E095
Grace (W.R.) & Company	2800	A006
Great Lakes Chemical Corporation	2800	A020
Grumman Corporation	3721	L263
GTE	3661	H513
GTI Corporation	3679	K232
Gulton Industries Incorporated	3679	K135
Harris Corporation	3662	I173
Hazeltine Corporation	3662	I174
Hercules Incorporated	2800	A007
Hewlett-Packard Company	3573A	D096
Hipotronics Incorporated	3679	K316
Honeywell Incorporated	3573A	D097
ICN Pharmaceuticals Incorporated	2830	B034
Imperial Chemical Industry	2800	A008
Instron Corporation	3811	N294
Instrument Systems Corporation	3662	I175
INTEL Corporation	3674	J210
Intermedics Incorporated	3841	Q245
International Business Machines Corp.	3573A	D098
International Power Machines Corp.	3679	K234
Intertec Data Systems Corporation	3573B	E099
Int'l Rectifier Corporation	3674	J211
Int'l Telephone & Telegraph	3661	H150
Johnson Controls Incorporated	3820	O295
Key Pharmaceuticals Incorporated	2830	B036

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COMPANY NAME	SIC	FILE NAME
KLA	3674	J514
Knogo Corporation	3679	K177
Kollmorgan Corporation	3679	K235
Kulicke & Soffa	3674	J515
Kyocera Corporation	3679	K236
Laser Industries Limited	3841	Q329
Lear Siegler Incorporated	3728	M270
Learonal Incorporated	2800	A021
Lilly (Eli) & Company	2830	B037
Litton Industries	3679	K516
Lockheed Corporation	3721	L280
Loral Corporation	3662	I179
LTX	3674	J517
Lundy Electronics & Systems	3573B	E101
Lynch Communication System	3661	H151
Management Assistance	3573B	E103
Mangood Corporation	3825	P068
Marion Laboratories	2830	B038
Mark Controls	3820	O297
Martin Marietta Corporation	3721	L281
Materials Research	3674	J518
Matrix Corporation	3861	R340
Matsushita Electric Industrial	3651	G137
McDonnell Douglas Corporation	3721	L265
Measurex Corporation	3820	O308
Medtronic Incorporated	3841	Q246
Merck & Company	2830	B039
Minnesota Mining & Manufacturing	3651	G519
Mitel Corporation	3661	H152
Modular Computer Systems	3573B	E104
Mohawk Data Sciences	3573C	F105
Monsanto Company	2800	A009
Moog Incorporated	3728	M272
Morton Thiokol Incorporated	2800	A010
Motorola Incorporated	3661	H180
Mountain Medical Equipment	3841	Q330
MSI Data Corporation	3573C	F102
M/A-Com Incorporated	3661	H212
National Patent Development	3841	Q333
National Semiconductor Corporation	3674	J213
NBI Incorporated	3573B	E106
NCR Corporation	3573A	D107
Nicolet Instrument	3811	N298
Nippon Electric Company	3651	G520
Nordson	3679	K522
North American Phillips	3651	G521

COMPANY NAME	SIC	FILE NAME
Northern Telephone Limited	3661	H153
Northrop Corporation	3721	L266
Nuclear Data	3679	K237
Oak Industries Incorporated	3661	H181
Olin Corporation	2800	A012
Orrox Corporation - NOW CMX	3861	R341
Outboard Marine Corporation	3510	C065
Paradyne Corporation	3662	I182
Pennwalt Corporation	2800	A014
Penril Corporation	3679	K183
Perkin Elmer Corporation	3811	N299
Pfizer Incorporated	2830	B040
Pioneer Electronic Corporation	3651	G138
Pitney Bowes Incorporated	3861	R069
Pittway Corporation	3679	K185
Plantronics Incorporated	3661	H154
Plessey PLC	3661	H186
Polaroid Corporation	3861	R342
Porta Systems Corporation	3661	H155
PPG Industries Incorporated	2800	A013
Prime Computer	3573B	E108
Raytheon Company	3662	I188
RCA Corporation	3651	G139
Recognition Equipment Incorporated	3573C	F110
Reichhold Chemical Incorporated	2800	A024
Reynolds & Reynolds	3573B	E111
Richardson-Vicks Incorporated	2830	B041
Robertshaw Controls	3820	O301
Robins (A.H.) Company	2830	B042
Rockwell International Corporation	3721	L282
Rogers Corporation	3679	K240
Rohm & Haas Company	2800	A015
Rolm Corporation	3573B	E112
Rorer Group	2830	B043
Sanders Associates Incorporated	3662	I189
Sargent Welch Scientific	3811	N287
Schering-Plough	2830	B044
Schlumberger	3820	O523
Scientific-Atlanta Incorporated	3661	H190
Searle (G.D.) & Company	2830	B045
Semtech Corporation	3679	K214
Servo Corporation of America	3679	K191
Sierracin Corporation	3728	M275
Signal Companies	3728	M276
Singer	3679	K524
Smithkline Beckman Corporation	2830	B047

COMPANY NAME	SIC	FILE NAME
Sony Corporation	3651	G140
Sparton Corporated	3661	H192
Spectra Physics	3811	N288
Speed-O-Print Business Machines	3861	R343
Sperry Corporation	3573A	D113
Squibb Corporation	2830	B048
Stauffer Chemical Company	2800	A016
Sterling Drug Company	2830	B049
Stewart-Warner Corporated	3661	H193
Storage Technology Corporation	3573C	F114
Sun Electric Corporation	3820	O317
Sunair Electronics Incorporated	3661	H194
Sundstrand Corporation	3728	M254
Sybron Corporation	3811	N335
Syntex Corporation	2830	B050
T Bar Incorporated	3662	I241
Talley Industries Incorporated	3825	P346
TDK Corporation	3651	G242
TEC Incorporated	3573C	F115
Tech Ops Incorporated	3820	O129
Techamerica Group Incorporated	2830	B051
Tech-Sym Corporated	3662	I196
Tektronix Incorporated	3825	P318
Teleconcepts Corporation	3661	H158
Teledyne Incorporated	3510	C066
Teleflex Incorporated	3825	P278
Telesciences Incorporated	3661	H159
Telex Corporated	3573C	F116
Teradyne Incorporated	3674	J319
Texas Instrument Incorporated	3674	J217
Texscan Corporation	3661	H197
Textron Incorporated	3721	L267
Thomas & Betts Corporation	3679	K243
Timeplex Incorporated	3661	H198
Torotel Incorporated	3661	H199
Tracor	3679	K525
Trans-Lux Corporation	3661	H160
TRE Corporation	3728	M277
TRW Incorporated	3661	H195
Union Carbide Corporation	2800	A017
United Industrial Corporation	3662	I200
United Technologies Corporation	3728	M255
Unitrode Corporation	3674	J218
Upjohn Company	2830	B053
Varian Associates Incorporation	3674	J205
Varo Incorporated	3679	K206

COMPANY NAME	SIC	FILE NAME
Veeco Instruments	3679	K244
Verbatim Corporation	3573C	F117
Vermont Research Incorporated	3573C	F118
Vernitron Corporation	3679	K126
Vicon Industries Incorporated	3825	P201
Vishay Intertechnology Incorporated	3811	N302
Visual Graphics	3861	R344
Wang Laboratories	3573B	E119
Warner-Lambert Company	2830	B054
Watkins-Johnson	3662	I202
Watsco Incorporated	3820	O303
Wells-Gardner Electronics	3651	G144
Wespercorp	3573C	F120
Western Pacific Industries	3825	P309
Westinghouse	3679	K528
Whitehall Corporation	3811	N290
Xerox Corporation	3861	R345
Xonics Incorporated	3841	Q247
Zenith Radio Corporation	3651	G145



## APPENDIX B

### LIST OF COMPANIES ADDED FROM ELECTRONIC BUSINESS 100

The twenty four electronic business firms added to this study. The electronic business firms are also listed in Appendix A.

THE ELECTRONIC BUSINESS 100  
COMPANIES ADDED TO THE STUDY

NO	FILE NUMBER	COMPANY NAME
1	501	AM International
2	503	AMP
3	504	Applied Materials, Inc.
4	506	Cincinnati Milicron
5	507	Corning Glass Works
6	508	Eaton Corporation
7	509	EG & G, Inc.
8	510	Emerson Electric
9	511	GCA
10	512	General Electric
11	513	GTE Corporation
12	514	KLA Instrument Co.
13	515	Kulicke & Soffa Industries, Inc.
14	516	Litton Industries
15	517	LTX
16	518	Materials Research
17	519	Minnesota Mining & Manufacturing
18	520	Nippon Electric Company
19	522	Nordson Corporation
20	521	North American Phillips
21	523	Schlumberger Limited
22	524	Singer Company
23	525	Tracor, Inc.
24	528	Westinghouse

## APPENDIX C

### LIST OF START UP COMPANIES IDENTIFIED IN THIS STUDY

Start up companies (84) identified in this study. The start up companies are also listed in Appendix A and are included in the 291 firms.

**START-UP COMPANIES  
IN THIS STUDY**

<b>FILE NAME</b>	<b>COMPANY NAME</b>
J207	Advanced Micro Devices
J208	Alpha Industries
D071	Amdahl Corporation
J209	Analog Devices
F072	Anderson Jacobson Incorporated
E073	Apple Computer Incorporated
F074	Applied Magnetics Corporation
J504	Applied Materials
K219	AVX Corporation
K123	Baldor Electric
Q326	Bio-Rad Laboratories
B028	Bolar Pharmaceutical Company Incorporated
O292	Bowmar Instrument Corporation
F078	Centronics Data Computer
F079	Cognitronics Corporation
E080	Commodore International Limited
R337	Compugraphic Corporation
E081	Computer Consoles
E082	Computervision Corporation
D084	Cray Research
D085	Data General Corporation
E086	Datapoint Corporation
F088	Dataram Corporation
Q328	Delmed Incorporated
E089	Diagnostic/Retrieval Systems
K229	Electro Audio Dynamics
F092	Electronic Memories & Magnetics
P293	Esterline Corporation
E093	Floating Point Systems Incorporated
B031	Flow General Incorporated
I149	General Datacomm Industries Incorporated
A060	General Defense Corporation
P315	Genrad Incorporated
K316	Hipotronics Incorporated
B034	ICN Pharmaceuticals Incorporated
J210	INTEL Corporation
Q245	Intermedics Incorporated
E099	Intertec Data Systems Corporation
K234	International Power Machines Corporation
B036	Key Pharmaceuticals Incorporated
J514	KLA
K177	Knogo Corporation
J515	Kulicke & Soffa
Q329	Laser Industries Limited
J517	LTX

FILE NAME	COMPANY NAME
B038	Marion Laboratories
J518	Materials Research
H152	Mitel Corporation
F105	Mohawk Data Sciences
F102	MSI Data Corporation
Q333	National Patent Development
J213	National Semiconductor Corporation
E106	NBI Incorporated
N298	Nicolet Instrument
K522	Nordson
R341	Orrox Corporation - NOW CMX
I182	Paradyne Corporation
K183	Penril Corporation
H154	Plantronics Incorporated
H155	Porta Systems Corporation
E108	Prime Computer
E112	Rolm Corporation
K214	Semtech Corporation
N288	Spectra Physics
I241	T Bar Incorporated
F115	TEC Incorporated
B051	Techamerica Group Incorporated
H158	Teleconcepts Corporation
H159	Telesciences Incorporated
J319	Teradyne Incorporated
H197	Texscan Corporation
H198	Timeplex Incorporated
H199	Torotel Incorporated
M277	TRE Corporation
J218	Unitrode Corporation
F117	Verbatim Corporation
F118	Vermont Research Incorporated
P201	Vicon Industries Incorporated
N302	Vishay Intertechnology Incorporated
R344	Visual Graphics
E119	Wang Laboratories
F120	Wespercorp
N290	Whitehall Corporation
Q247	Xonics Incorporated

## **APPENDIX D**

### **SOFTWARE**

**The primary software programs used for this study.**

### LOTUS 1-2-3

Lotus 1-2-3 is a popular and powerful program that contains a spreadsheet, business graphing capabilities, and data base management. Many manipulations can be performed on a set of structured data. Some of these manipulations include, macro and command languages, formatting worksheets, string functions, and statistical computations. The program was developed by:

LOTUS DEVELOPMENT CORPORATION  
55 Cambridge Parkway  
Cambridge, MA 02142

### POINT FIVE

Point Five is a program that allows the user to structure and format data files for advanced statistical functions. Some of the statistical functions include, covariance, time series analysis, correlations, and frequency distributions. For this study a program, Covar, was locally written to assist in statistical processing and computation of lag values. Point Five was developed by:

PACIFIC CREST SOFTWARE, INC.  
887 N.W. Grant Avenue  
Corvallis, OR 97330

### SYSTAT

Systat is a powerful statistical program that allows the user to manipulate any set or number of files in a multitude of ways. Manipulations include: Standard

Deviation, Mean, Maximum, Minimum, Multiple Regression, Factor Analysis, Cluster Analysis, and Rotations. The program was developed by:

SYSTAT INC.  
1800 Sherman Avenue  
Evanston, IL 60201

#### QUATTRO

Quattro is one of the newer spreadsheet programs with presentation quality graphing capability. The program also has database functions and can utilize files from other programs. The program was developed by:

BORLAND INTERNATIONAL INC.  
1800 Green Hills Road  
P.O. BOX 660001  
Scotts Valley, CA 95066-0001



## APPENDIX E

### ROI QUARTILE SORT FOR SELECTED VARIABLES

Five year average data (1979-1984) for firms in the first and fourth quartile of an ROI sort. Companies are listed by Standard Industrial classification (SIC). The data includes Common Equity, Net Income, R&D Spending, Total Assets, Sales, ROI, R&D as a percent of sales, and Market Share.

ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

	Variable							
FIRST QUARTILE	J	K	L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 2800	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
Chemicals	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Allied Corporation	\$2,226.2	\$299.0	\$250.4	\$6,398.0	\$7,745.2	0.394	0.030	0.042
Du Pont (E.I.)	\$9,998.4	\$1,049.8	\$812.8	\$21,407.4	\$25,848.4	0.367	0.032	0.137
General Defense Corp.	\$20.0	\$9.8	\$4.1	\$93.7	\$99.9	0.341	0.049	0.001
Leaonol Inc.	\$38.1	\$7.5	\$1.3	\$48.6	\$168.6	0.340	0.008	0.001
Great Lakes Chem. Corp.	\$127.4	\$22.6	\$6.4	\$200.4	\$192.3	0.308	0.033	0.001
Essex Chem. Corp.	\$37.9	\$6.3	\$2.8	\$123.3	\$162.5	0.283	0.017	0.001
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$2,074.7	\$232.5	\$179.6	\$4,711.9	\$5,702.8	0.399	0.028	0.031

\* Dollars in Millions

=====	=====	=====	=====	=====	=====	=====	=====	=====
FOURTH QUARTILE								
=====	=====	=====	=====	=====	=====	=====	=====	=====
Imperial Chem. Ind.	\$4,937.6	\$418.1	\$417.4	\$12,281.9	\$12,325.2	0.165	0.034	0.069
Union Carbide Corp.	\$4,974.2	\$406.8	\$224.6	\$10,303.4	\$9,546.4	0.165	0.024	0.054
American Cyanamid Co.	\$1,546.1	\$174.1	\$185.5	\$3,072.3	\$3,463.5	0.156	0.054	0.019
Hercules Inc.	\$1,171.5	\$146.3	\$66.9	\$2,110.4	\$2,574.5	0.144	0.026	0.015
Monsanto Co.	\$3,383.7	\$357.4	\$268.2	\$6,148.4	\$6,567.3	0.111	0.041	0.037
Dow Chemical	\$4,786.0	\$519.8	\$435.4	\$11,830.0	\$11,097.2	0.092	0.039	0.062
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$3,466.5	\$337.1	\$266.3	\$7,624.4	\$7,595.7	0.139	0.036	0.043

\* Dollars in Millions

ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

FIRST QUARTILE	Variable							
	J	K	L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 2830	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
DRUGS	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
American Home Products Co	\$1,787.3	\$557.3	\$139.4	\$2,763.4	\$4,370.8	0.575	0.032	0.179
Bolar Pharmaceutical Co.	\$17.5	\$3.7	\$1.1	\$19.8	\$20.1	0.402	0.049	0.001
Robins (A.H.) Co.	\$205.4	(\$57.0)	\$34.8	\$486.5	\$512.2	0.390	0.068	0.021
Smithkline Beckman Corp.	\$1,578.2	\$423.9	\$199.6	\$2,776.5	\$2,751.7	0.368	0.072	0.101
Bristol Meyers Co.	\$1,664.5	\$361.1	\$166.3	\$2,742.0	\$3,672.3	0.360	0.045	0.150
Lilly (Eli) & Co.	\$2,004.5	\$415.2	\$267.6	\$3,144.5	\$2,887.5	0.350	0.092	0.118
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$1,209.6	\$284.0	\$134.8	\$1,988.8	\$2,369.1	0.408	0.060	0.095

\* Dollars in Millions

FOURTH QUARTILE	Variable							
	J	K	L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
Schering-Plough	\$1,281.9	\$193.9	\$126.8	\$2,321.6	\$1,809.7	0.188	0.070	0.075
Squibb Corp.	\$1,108.4	\$137.5	\$117.6	\$1,955.4	\$1,634.7	0.170	0.071	0.070
Forest Laboratories Inc.	\$20.3	\$2.8	\$1.9	\$28.4	\$19.2	0.153	0.096	0.001
Techamerica Group Inc.	\$17.7	\$0.5	\$2.1	\$36.4	\$34.8	0.128	0.059	0.001
Flow General Inc.	\$60.8	(\$6.3)	\$3.7	\$132.6	\$118.6	0.088	0.029	0.005
ICN Pharmaceuticals Inc.	\$24.8	\$1.8	\$2.2	\$62.6	\$43.8	0.059	0.052	0.002
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$419.0	\$55.0	\$42.4	\$756.2	\$610.1	0.131	0.063	0.026

\* Dollars in Millions

ROI QUARTILE SORT FOR SELECTED VARIABLES  
Entire Industry

	Variable							
	J	K	L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC -3510	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
ENGINES AND TURBINES	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Briggs & Stratton	\$251.4	\$36.0	\$5.4	\$369.4	\$639.6	0.278	0.008	0.063
Brunswick Corp.	\$428.5	\$88.7	\$29.5	\$830.6	\$1,158.6	0.172	0.026	0.119
Outboard Marine Corp.	\$319.0	\$31.1	\$29.5	\$611.8	\$790.4	0.163	0.037	0.078
Teledyne Inc.	\$1,781.3	\$379.2	\$65.3	\$3,082.8	\$3,100.2	0.153	0.021	0.305
Cummins Engine	\$527.7	\$58.0	\$65.3	\$1,322.1	\$1,829.4	0.133	0.036	0.179
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$661.6	\$118.6	\$39.0	\$1,243.3	\$1,503.7	0.180	0.026	0.149

\* Dollars in Millions

ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

FIRST QUARTILE	Variable							
	J	K	L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 3573A	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
ELECTRONIC COMPUTING	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Amdahl Corp.	\$315.4	\$25.3	\$85.7	\$606.2	\$563.8	0.439	0.154	0.008
International Bus. Mach.	\$20,856.4	\$4,669.2	\$2,959.0	\$33,749.6	\$35,152.8	0.409	0.082	0.520
Hewlett-Packard Co.	\$2,449.6	\$412.2	\$425.6	\$3,583.2	\$4,337.0	0.299	0.097	0.064
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$7,873.8	\$1,702.2	\$1,156.8	\$12,646.3	\$13,351.2	0.382	0.111	0.197

\* Dollars in Millions

FOURTH QUARTILE								
=====	=====	=====	=====	=====	=====	=====	=====	=====
Burroughs Corp.	\$2,175.0	\$152.8	\$214.7	\$4,203.9	\$3,875.2	0.163	0.055	0.058
Digital Equipment Corp.	\$3,003.3	\$324.5	\$378.1	\$4,056.1	\$3,860.6	0.161	0.094	0.056
Data General Corp.	\$438.7	\$43.6	\$82.2	\$812.3	\$837.3	0.160	0.099	0.012
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$1,872.3	\$173.7	\$225.0	\$3,024.1	\$2,857.7	0.161	0.083	0.042

\* Dollars in Millions

ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

FIRST QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 3573B	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
ELECTRONIC COMPUTING	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Commodore Int'l Ltd.	\$143.6	\$62.7	\$22.1	\$352.6	\$513.0	0.928	0.049	0.066
Apple Computer Inc.	\$258.6	\$50.6	\$40.1	\$404.7	\$706.7	0.338	0.060	0.093
Computervision Corp.	\$183.3	\$33.6	\$38.1	\$311.6	\$348.7	0.290	0.109	0.053
Prime Computer	\$212.7	\$41.2	\$40.2	\$373.0	\$445.5	0.281	0.087	0.067
Reynolds & Reynolds	\$85.8	\$11.0	\$5.6	\$142.7	\$237.1	0.272	0.023	0.038
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$176.8	\$39.8	\$29.2	\$316.9	\$450.2	0.422	0.066	0.063

\* Dollars in Millions

FOURTH QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
Management Assistance	\$87.5	\$4.2	\$15.9	\$216.1	\$361.6	0.120	0.044	0.058
Computer Consoles	\$43.1	\$7.1	\$13.3	\$138.3	\$78.6	0.119	0.167	0.013
Intertec Data Systems Cor	\$19.7	(\$1.4)	\$1.0	\$24.7	\$15.1	0.064	0.135	0.003
Modular Computer Systems	\$58.9	(\$2.8)	\$9.2	\$78.5	\$82.9	0.015	0.112	0.014
Electronic Associates Inc	\$13.0	(\$2.8)	\$2.9	\$28.0	\$44.7	-0.169	0.067	0.008
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$44.4	\$0.9	\$8.4	\$97.1	\$116.6	0.030	0.105	0.019

\* Dollars in Millions

ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

FIRST QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 3573C	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
ELECTRONIC COMPUTING	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Mohawk Data Sciences	\$104.3	(\$38.0)	\$25.8	\$299.9	\$298.6	1.007	0.092	0.116
Telex Corp.	\$112.7	\$27.6	\$14.0	\$237.8	\$319.2	0.345	0.045	0.118
Genisco Technology	\$9.7	\$0.8	\$1.8	\$17.2	\$26.8	0.281	0.064	0.010
Verbatim Corp.	\$41.2	\$8.1	\$6.5	\$75.8	\$95.9	0.277	0.059	0.036
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$67.0	(\$0.4)	\$12.0	\$157.7	\$185.2	0.478	0.065	0.070

\* Dollars in Millions

FOURTH QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
TEC Inc.	\$5.5	\$0	\$0.8	\$10.6	\$17.2	0.070	0.043	0.007
Centronics Data Computer	\$60.5	(\$8.6)	\$8.6	\$142.3	\$139.3	0.014	0.059	0.054
Wespercorp	\$6.9	(\$2.3)	\$1.6	\$14.0	\$14.4	-0.226	0.109	0.006
Storage Technology Corp.	\$342.3	(\$71.0)	\$68.7	\$1,051.1	\$860.0	-2.511	0.080	0.335
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$103.8	(\$20.5)	\$19.9	\$304.5	\$257.7	-0.663	0.073	0.101

\* Dollars in Millions

ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

	Variable							
FIRST QUARTILE	J	K	L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 3651	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
RADIO-TV REC SETS	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Corning Glass	\$1,020.2	\$98.3	\$88.4	\$1,757.9	\$1,605.8	0.540	0.055	0.033
TDK Corp.	\$708.4	\$111.2	\$43.4	\$1,159.6	\$1,262.2	0.418	0.034	0.027
Nippon Electric Company	\$1,331.0	\$166.2	\$345.5	\$7,692.3	\$6,656.9	0.383	0.051	0.133
Coleco Industries	\$54.6	(\$4.3)	\$15.4	\$266.2	\$444.5	0.353	0.033	0.009
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$778.5	\$92.8	\$123.2	\$2,719.0	\$2,492.4	0.424	0.043	0.051

\* Dollars in Millions

FOURTH QUARTILE	=====	=====	=====	=====	=====	=====	=====	=====
RCA Corp.	\$1,886.7	\$227.5	\$208.9	\$7,688.6	\$8,668.4	0.105	0.024	0.175
Esquire Radio & Electron	\$18.5	\$1.9	\$0.5	\$26.7	\$52.3	0.100	0.012	0.001
Electrosound Group Inc.	\$9.0	(\$0.7)	\$0.7	\$22.5	\$32.3	0.088	0.020	0.001
Craig Corp.	\$29.2	(\$2.8)	\$0.7	\$43.1	\$80.4	-0.013	0.008	0.002
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$485.9	\$56.5	\$52.7	\$1,945.2	\$2,208.3	0.070	0.016	0.045

\* Dollars in Millions



ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

	Variable							
FIRST QUARTILE	J	K	L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 3661	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
TELEPHONE & TELEGRAPH	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Aydin Corp.	\$47.0	\$9.7	\$4.6	\$102.8	\$123.6	0.313	0.036	0.003
TRW Inc.	\$1,401.7	\$221.8	\$107.8	\$3,153.5	\$5,148.5	0.298	0.021	0.118
Plessey PLC	\$586.0	\$124.2	\$69.3	\$1,471.6	\$1,707.7	0.292	0.041	0.039
Motorola Inc.	\$1,673.2	\$232.3	\$290.8	\$3,033.9	\$4,100.2	0.285	0.070	0.092
Sparton Corp.	\$42.5	\$6.5	\$0.8	\$66.7	\$125.3	0.276	0.007	0.003
GTE	\$5,774.0	\$820.7	\$239.0	\$22,585.8	\$11,929.6	0.250	0.020	0.273
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$1,587.4	\$235.9	\$118.7	\$5,069.0	\$3,855.8	0.286	0.033	0.088

\* Dollars in Millions

=====	=====	=====	=====	=====	=====	=====	=====	=====
FOURTH QUARTILE								
=====	=====	=====	=====	=====	=====	=====	=====	=====
Timeplex Inc.	\$30.8	\$2.8	\$4.2	\$53.1	\$37.3	0.095	0.118	0.001
Mitel Corp.	\$158.9	\$0.3	\$19.5	\$369.6	\$208.8	0.083	0.081	0.005
Texscan Corp.	\$28.2	(\$6.9)	\$9.4	\$63.4	\$56.7	0.068	0.133	0.001
Torotel Inc.	\$8.4	\$0.1	\$2.0	\$20.6	\$25.9	0.068	0.076	0.001
Telesciences Inc.	\$15.9	(\$2.1)	\$10.6	\$57.6	\$45.9	-0.055	0.233	0.001
Teleconcepts Corp.	\$8.2	(\$1.4)	\$0	\$15.4	\$17.4	-0.064	0.003	0.000
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$41.7	(\$1.2)	\$7.6	\$96.6	\$65.3	0.033	0.107	0.002

\* Dollars in Millions

ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

	Variable							
FIRST QUARTILE	J	K	L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 3662	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
RADIO-TV TRANSMITTING EQ	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
United Industrial Corp.	\$65.2	\$13.7	\$1.8	\$138.6	\$219.0	0.321	0.008	0.022
E-Systems Inc.	\$202.1	\$37.7	\$122.8	\$323.5	\$665.1	0.313	0.183	0.069
Raytheon Co.	\$1,668.9	\$293.7	\$181.3	\$3,426.3	\$5,555.6	0.268	0.032	0.585
EOO Corp.	\$38.7	\$7.0	\$3.0	\$104.4	\$100.2	0.250	0.031	0.011
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$493.7	\$88.0	\$77.2	\$998.2	\$1,635.0	0.288	0.064	0.172

\* Dollars in Millions

FOURTH QUARTILE	=====	=====	=====	=====	=====	=====	=====	=====
T Bar Inc.	\$14.8	\$1.2	\$1.9	\$32.7	\$31.8	0.153	0.057	0.003
General Datacomm Ind. Inc	\$36.7	\$4.0	\$6.5	\$90.3	\$80.6	0.126	0.082	0.008
Paradyne Corp.	\$157.5	\$13.5	\$15.3	\$224.9	\$184.7	0.094	0.083	0.018
Instrument Systems Corp.	\$22.7	(\$1.7)	\$1.7	\$76.6	\$104.7	0.080	0.016	0.013
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$57.9	\$4.2	\$6.3	\$106.1	\$100.5	0.118	0.035	0.056

\* Dollars in Millions

ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

FIRST QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 3674	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
SEMICONDUCTORS	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Unitrode Corp.	\$76.5	\$14.7	\$7.1	\$117.7	\$139.2	0.308	0.049	0.011
Advanced Micro Devices	\$231.6	\$52.2	\$83.0	\$409.6	\$492.7	0.254	0.163	0.038
Analog Devices	\$108.5	\$15.9	\$14.7	\$190.5	\$198.7	0.235	0.072	0.016
Eaton	\$1,002.5	\$71.3	\$93.4	\$2,289.1	\$2,851.5	0.232	0.033	0.233
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$354.8	\$38.5	\$49.6	\$751.7	\$920.5	0.257	0.079	0.075

\* Dollars in Millions

FOURTH QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
Int'l Rectifier Corp.	\$41.4	\$0.5	\$4.6	\$113.2	\$117.5	0.115	0.041	0.010
Applied Materials	\$45.2	\$3.6	\$16.3	\$88.5	\$103.0	0.109	0.152	0.008
Materials Research	\$29.5	\$1.3	\$4.7	\$48.8	\$72.3	0.102	0.065	0.006
National Semiconductor Co	\$461.2	\$27.1	\$136.6	\$986.5	\$1,373.5	0.094	0.098	0.111
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$144.3	\$8.1	\$40.6	\$309.3	\$416.6	0.100	0.044	0.030

\* Dollars in Millions

ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

FIRST QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 3679	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
ELECTRONIC COMP. (NEC)	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Canadian Marconi Co.	\$87.9	\$20.3	\$11.6	\$158.9	\$166.5	0.457	0.063	0.003
AMP	\$735.4	\$148.4	\$124.6	\$1,151.2	\$1,392.3	0.420	0.090	0.024
EG&G	\$158.0	\$40.4	\$12.0	\$286.6	\$827.3	0.410	0.015	0.014
Veeco Instruments	\$60.0	\$10.8	\$6.0	\$101.1	\$122.2	0.348	0.049	0.002
Emerson Electric	\$1,601.9	\$296.9	\$90.6	\$2,482.3	\$3,652.3	0.321	0.025	0.063
Litton Industries	\$1,621.8	\$292.5	\$230.4	\$3,833.4	\$4,375.6	0.312	0.053	0.076
Thomas & Betts Corp.	\$189.4	\$31.1	\$14.1	\$232.8	\$275.7	0.296	0.051	0.005
General Electric	\$10,273.8	\$1,857.4	\$859.2	\$21,817.2	\$26,688.6	0.290	0.032	0.463
Pittway Corp.	\$191.7	\$28.7	\$4.3	\$294.3	\$406.3	0.286	0.010	0.007
Cubic Corp.	\$76.7	\$13.4	\$2.6	\$154.0	\$253.3	0.277	0.010	0.004
Ametek Inc.	\$161.0	\$31.2	\$10.8	\$291.4	\$444.8	0.273	0.024	0.008
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$1,378.0	\$251.9	\$124.2	\$2,800.3	\$3,509.5	0.335	0.038	0.061

\* Dollars in Millions

FOURTH QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
AVX Corp.	\$82.3	\$7.7	\$5.3	\$179.0	\$150.8	0.119	0.036	0.003
Electro Audio Dynamics	\$9.6	(\$1.0)	\$0.9	\$48.8	\$35.0	0.117	0.024	0.001
Varo Inc.	\$50.6	\$3.2	\$3.5	\$76.2	\$88.8	0.114	0.039	0.002
GTI Corp.	\$8.7	\$0.4	\$0.3	\$13.7	\$19.6	0.101	0.015	0.000
Rogers Corp.	\$34.8	\$3.1	\$4.5	\$76.8	\$108.0	0.101	0.042	0.002
Servo Corp. of America	\$4.9	\$0.3	\$1.3	\$9.6	\$13.5	0.097	0.095	0.000
EECO	\$20.2	\$1.0	\$3.8	\$31.2	\$39.2	0.094	0.100	0.001
Cincinnati Milicron	\$322.8	\$31.4	\$31.4	\$657.2	\$746.0	0.077	0.044	0.013
Int'l Power Machines Corp	\$12.7	\$1.3	\$1.4	\$18.2	\$24.5	0.034	0.062	0.000
Nuclear Data	\$16.2	\$0.3	\$1.4	\$34.9	\$49.2	0.031	0.027	0.001
Semtech Corp.	\$9.4	(\$0.9)	\$0.6	\$11.8	\$12.6	-0.045	0.046	0.000
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$52.0	\$4.3	\$4.9	\$105.2	\$117.0	0.076	0.048	0.002

\* Dollars in Millions

ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

FIRST QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 3721	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
AIRCRAFT	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Martin Marietta Corp.	\$830.1	\$85.9	\$87.9	\$2,280.4	\$3,317.7	0.830	0.025	0.061
Lockheed Corp.	\$549.7	\$199.3	\$233.6	\$2,601.6	\$5,967.3	0.392	0.037	0.121
Grumman Corp.	\$257.9	\$72.1	\$45.8	\$1,102.4	\$2,052.4	0.374	0.022	0.040
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$545.9	\$119.1	\$122.5	\$1,994.8	\$3,779.1	0.532	0.028	0.074

\* Dollars in Millions

FOURTH QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
Northrop Corp.	\$557.0	\$81.4	\$220.5	\$1,479.2	\$2,613.6	0.178	0.085	0.050
Fairchild Industries Inc.	\$224.4	\$36.8	\$22.4	\$897.2	\$996.5	0.175	0.023	0.019
Cessna Aircraft Co.	\$331.9	\$17.8	\$50.6	\$645.1	\$821.9	0.154	0.065	0.017
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$371.1	\$45.3	\$97.8	\$1,007.2	\$1,477.3	0.169	0.058	0.029

\* Dollars in Millions

ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

FIRST QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 3728	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
AIRCRAFT PARTS	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Aeronca Inc.	\$6.4	\$1.4	\$0.7	\$27.8	\$49.8	0.336	0.016	0.003
United Technologies Corp.	\$2,576.8	\$488.7	\$842.7	\$8,301.8	\$14,114.2	0.327	0.059	0.622
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$1,291.6	\$245.0	\$421.7	\$4,164.8	\$7,082.0	0.332	0.038	0.313

\* Dollars in Millions

FOURTH QUARTILE								
=====	=====	=====	=====	=====	=====	=====	=====	=====
Signal Companies	\$2,017.5	\$173.5	\$191.7	\$4,355.9	\$5,425.5	0.078	0.035	0.197
Curtiss Wright Corp.	\$216.3	\$26.4	\$1.7	\$319.5	\$178.2	0.063	0.010	0.008
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$1,116.9	\$100.0	\$96.7	\$2,337.7	\$2,801.8	0.071	0.023	0.103

\* Dollars in Millions

ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

	Variable							
FIRST QUARTILE	J	K	L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 3811	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
ENGINEERING LAB & RES EQ.	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Whitehall Corp.	\$29.6	\$7.3	\$1.8	\$50.8	\$58.1	0.510	0.028	0.026
Gerber Scientific Inc.	\$67.6	\$11.3	\$10.3	\$144.6	\$144.6	0.236	0.072	0.063
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$48.6	\$9.3	\$6.0	\$97.7	\$101.3	0.373	0.050	0.045

\* Dollars in Millions

FOURTH QUARTILE								
=====	=====	=====	=====	=====	=====	=====	=====	=====
Sargent Welch Scientific	\$54.6	\$4.9	\$1.1	\$62.3	\$78.8	0.151	0.014	0.036
Spectra Physics	\$71.2	\$2.1	\$13.1	\$138.6	\$145.2	0.129	0.090	0.064
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$62.9	\$3.5	\$7.1	\$100.5	\$112.0	0.140	0.052	0.050

\* Dollars in Millions

ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

FIRST QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 3820	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
MEASURING & CONTROL INST	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Schlumberger	\$5,098.0	\$1,164.9	\$299.5	\$7,775.8	\$5,913.4	0.267	0.050	0.663
Johnson Controls Inc.	\$333.7	\$52.4	\$19.1	\$849.4	\$1,218.7	0.256	0.016	0.136
Tech Ops Inc.	\$12.7	\$2.6	\$1.0	\$25.1	\$26.2	0.229	0.041	0.003
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$1,814.8	\$406.6	\$106.5	\$2,883.4	\$2,386.1	0.251	0.036	0.267

\* Dollars in Millions

FOURTH QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
Mark Controls	\$53.1	\$2.7	\$4.4	\$164.2	\$271.9	0.118	0.016	0.031
Badger Meter Inc.	\$20.2	\$0.2	\$1.5	\$40.2	\$57.0	0.114	0.026	0.006
Sun Electric Corp.	\$82.1	(\$0.3)	\$6.1	\$172.0	\$171.3	0.036	0.036	0.020
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$51.8	\$0.9	\$4.0	\$125.5	\$166.7	0.089	0.026	0.019

\* Dollars in Millions



ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

FIRST QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 3825	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
ELEC MEAS & TEST INST.	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Teleflex Inc.	\$46.1	\$8.7	\$4.9	\$83.3	\$115.2	0.289	0.044	0.043
Esterline Corp.	\$92.8	\$15.2	\$10.7	\$173.0	\$226.6	0.250	0.047	0.086
Tektronix Inc.	\$698.7	\$81.7	\$134.0	\$1,107.4	\$1,244.0	0.226	0.106	0.471
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$279.2	\$35.2	\$49.9	\$454.6	\$528.6	0.255	0.066	0.200

\* Dollars in Millions

FOURTH QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
Barnes Engineering Co.	\$4.1	(\$1.7)	\$0.7	\$18.4	\$38.5	0.103	0.016	0.007
Mangood Corp.	\$4.4	\$0.1	\$0.8	\$60.0	\$27.7	0.096	0.033	0.010
Talley Industries Inc.	\$90.6	\$2.2	\$3.4	\$206.8	\$306.6	0.077	0.011	0.116
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$33.0	\$0.2	\$1.6	\$95.1	\$124.3	0.092	0.020	0.044

\* Dollars in Millions

ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

FIRST QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 3841	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
SURGICAL & MEDICAL INST	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Xonics Inc.	\$5.2	(\$11.8)	\$1.5	\$43.6	\$74.3	0.397	0.021	0.017
Mountain Medical Eq.	\$12.9	\$2.4	\$0.5	\$26.9	\$23.3	0.300	0.024	0.005
Bausch & Lomb Inc.	\$291.8	\$40.4	\$18.9	\$508.6	\$507.1	0.298	0.037	0.118
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$103.3	\$10.3	\$7.0	\$193.0	\$201.6	0.312	0.027	0.047

\* Dollars in Millions

FOURTH QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
Gelman Sciences Inc.	\$14.8	\$2.1	\$2.4	\$32.4	\$40.6	0.111	0.058	0.009
Delmed Inc.	\$10.9	\$0.5	\$1.4	\$42.4	\$42.1	0.100	0.050	0.010
Bio-Rad Laboratories	\$16.4	\$1.4	\$4.5	\$51.0	\$60.0	0.088	0.074	0.013
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$14.0	\$1.3	\$2.8	\$41.9	\$47.6	0.100	0.061	0.011

\* Dollars in Millions

ROI QUARTILE SORT FOR SELECTED VARIABLES  
1st and 4th Quartiles by Industry

FIRST QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
SIC - 3861	COMMON	NET	R&D	TOTAL	SALES	ROI %	R&D %	MARKET
PHOTOGRAPHIC EQUIPMENT	EQUITY	INCOME		ASSETS			SALES	SHARE %
=====	=====	=====	=====	=====	=====	=====	=====	=====
Xerox Corp.	\$4,056.8	\$468.4	\$515.1	\$8,338.0	\$8,275.1	0.290	0.062	0.350
Matrix Corp.-NJ	\$29.8	\$4.7	\$2.2	\$46.1	\$43.1	0.257	0.046	0.002
Eastman Kodak Co.	\$6,986.9	\$1,008.5	\$685.9	\$10,105.6	\$10,331.3	0.231	0.066	0.445
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$3,691.2	\$493.9	\$401.1	\$6,163.2	\$6,216.5	0.259	0.058	0.266

\* Dollars in Millions

FOURTH QUARTILE	J	K	Variable L	M	O	P	Q	T
=====	=====	=====	=====	=====	=====	=====	=====	=====
Polaroid Corp.	\$934.0	\$43.1	\$122.3	\$1,365.5	\$1,338.1	0.118	0.092	0.058
Speed-O-Print Bus. Machin	\$7.4	\$0.2	\$0.1	\$7.5	\$5.1	-0.026	0.018	0.000
Orrox Corp. - NOW CMX	\$3.2	(\$1.7)	\$1.5	\$7.2	\$10.1	-0.175	0.146	0.000
=====	=====	=====	=====	=====	=====	=====	=====	=====
Averages	\$314.8	\$13.8	\$41.3	\$460.1	\$451.1	-0.028	0.085	0.019

\* Dollars in Millions

## APPENDIX F

### ANALYSIS OF CLUSTERS

Appendix F is a summary of the second set of Cluster Analysis which was compiled by industry and clustered by company within each industry.

The three tables of the appendix provide:

1. A list of industries where the first quartile firms (sorted by ROI) were clustered.
2. A list of industries where all companies were clustered.
3. A list of industries that did not have first quartile firms in a cluster.

CLUSTER ANALYSIS  
FIRST QUARTILE (ROI) COMPANIES CLUSTERED  
(BY INDUSTRY - SIC)

<u>SIC</u> <u>INDUSTRY</u>	<u>FIRST QUARTILE COMPANIES</u> <u>IN THE CLUSTER</u>
2830 DRUGS	American Home Products Bolar Pharmaceutical Co. Inc. Bristol Meyers Company
3573B COMPUTERS (Small)	Commodore International Ltd. Apple Computer Inc.
3573C COMPUTERS (Peripherals)	Mohawk Data Sciences Genisco Technology Verbatim Corporation
3651 RADIO-TV RECEIVING SETS (Consumer)	Corning Glass Coleco Industries
3661 TELEPHONE & TELEGRAPH APPARATUS	Aydin Corporation Plessey
3662 RADIO-TV TRANSMITTING EQUIPMENT	United Industrial Corp. EDO Corporation
3674 SEMICONDUCTORS	Unitrode Corporation Analog Devices Eaton
3841 SURGICAL & MEDICAL INSTRUMENTS	Xonics Corporation Mountain Medical Equipment Bausch & Lomb Inc.
3861 PHOTOGRAPHIC EQUIPMENT & SUPPLIES	Matrix Corporation Eastman Kodak Company

CLUSTER ANALYSIS  
ALL COMPANIES CLUSTERED  
(BY INDUSTRY - SIC)

<u>SIC</u> <u>INDUSTRY</u>	<u>COMPANIES</u> <u>IN THE CLUSTER</u>
3679 ELECTRONIC COMPONENTS (NEC)	All companies - the top three are Canadian Marconi Co., Amp, and EG&G
3721 AIRCRAFT	All companies - the top three are Martin Marietta Corp., Lockheed Corp., and Grumman Corp.

CLUSTER ANALYSIS  
INDUSTRIES WITH OUT  
CLUSTERS  
(BY INDUSTRY - SIC)

<u>SIC</u>	<u>INDUSTRY</u>
2800	CHEMICALS
3573A	COMPUTERS (Large)
3728	AIRCRAFT PARTS & AUXILIARY EQUIPMENT
3811	ENGINEERING LAB & RESEARCH EQUIPMENT
3820	MEASURING & CONTROL INSTRUMENTS
3825	ELECTRICAL MEASUREMENT & TEST INSTRUMENTS

## APPENDIX G

### MULTIPLE REGRESSION MEAN $r^2$

Single and multiple regression  $r^2$  for ten models sorted into the first and fourth quartile based on five year averages (1979-1984) of ROI.

Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL SALES O=C+L	MODEL SALES O=C+L+M	MODEL NET INC K=C+L	MODEL NET INC K=C+L+M	MODEL MKT SHR T=C+L	MODEL MKT SHR T=C+L+M	MODEL MKT SHR T=C+Q	MODEL ROI P=C+L	MODEL ROI P=C+L+M	MODEL ROI P=C+Q
CHEMICALS & ALLIED PROD. SIC 2800										
Allied Corporation	0.923	0.988	0.453	0.632	0.929	0.946	0.764	0.158	0.752	0.012
Du Pont (E.I.)	0.938	0.973	0.753	0.768	0.910	0.931	0.394	0.269	0.629	0.008
General Defense Corp.	0.044	0.982	0.055	0.987	0.039	0.791	0.562	0.023	0.743	0.154
Learonal Inc.	0.589	0.923	0.858	0.956	0.106	0.206	0.063	0.221	0.245	0.199
Great Lakes Chem. Corp.	0.987	0.987	0.898	0.904	0.440	0.458	0.400	0.005	0.121	0.552
Essex Chem. Corp.	0.929	0.945	0.703	0.708	0.719	0.746	0.510	0.001	0.291	0.119
MEAN R SQUARED	0.735	0.966	0.620	0.826	0.524	0.680	0.449	0.113	0.464	0.174
Standard Deviation	0.336	0.024	0.290	0.132	0.358	0.266	0.212	0.108	0.253	0.183
C.I. @ 95% Upper Limit	1.407	1.015	1.201	1.089	1.239	1.212	0.873	0.329	0.969	0.540
Lower Limit	0.063	0.918	0.039	0.563	-0.192	0.148	0.024	-0.104	-0.042	-0.192
Union Carbide Corp.	0.816	0.988	0.124	0.631	0.308	0.781	0.233	0.435	0.463	0.000
Imperial Chem. Ind.	0.976	0.976	0.195	0.322	0.035	0.183	0.100	0.310	0.315	0.314
American Cyanamid Co.	0.854	0.991	0.714	0.838	0.708	0.709	0.395	0.676	0.702	0.412
Hercules Inc.	0.886	0.963	0.714	0.751	0.215	0.334	0.138	0.691	0.697	0.017
Monsanto Co.	0.749	0.986	0.544	0.681	0.538	0.729	0.234	0.532	0.556	0.001
Dow Chemical	0.906	0.991	0.246	0.784	0.620	0.893	0.647	0.536	0.544	0.018
MEAN R SQUARED	0.865	0.983	0.423	0.668	0.404	0.605	0.291	0.530	0.546	0.127
Standard Deviation	0.071	0.010	0.244	0.169	0.237	0.255	0.184	0.132	0.134	0.169
C.I. @ 95% Upper Limit	1.007	1.003	0.910	1.005	0.879	1.116	0.660	0.794	0.814	0.466
Lower Limit	0.722	0.962	-0.065	0.331	-0.071	0.094	-0.078	0.266	0.278	-0.212

LEGEND

O=SALES K=NET INCOME  
C=CONSTANT T=MARKET SHARE  
L=R&D DOLLARS Q=R&D AS A PERCENT OF SALES  
M=TOTAL ASSETS P=ROI



Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL SALES O=C+L	MODEL SALES O=C+L+M	MODEL NET INC K=C+L	MODEL NET INC K=C+L+M	MODEL MKT SHR T=C+L	MODEL MKT SHR T=C+L+M	MODEL MKT SHR T=C+Q	MODEL ROI P=C+L	MODEL ROI P=C+L+M	MODEL ROI P=C+Q
DRUGS SIC 2830										
American Home Products Co	0.826	0.996	0.919	0.997	0.729	0.760	0.118	0.615	0.656	0.003
Bolar Pharmaceutical Co.	0.924	0.936	0.925	0.931	0.391	0.402	0.457	0.501	0.522	0.507
Robins (A.H.) Co.	0.970	0.996	0.163	0.196	0.217	0.638	0.095	0.584	0.654	0.439
Smithkline Beckman Corp.	0.908	0.994	0.966	0.991	0.889	0.966	0.361	0.184	0.190	0.053
Bristol Meyers Co.	0.967	0.996	0.997	0.997	0.180	0.558	0.025	0.494	0.633	0.330
Lilly (Eli) & Co.	0.960	0.991	0.976	0.994	0.497	0.805	0.486	0.219	0.238	0.000
MEAN R SQUARED	0.926	0.985	0.824	0.851	0.484	0.688	0.257	0.433	0.482	0.222
Standard Deviation	0.050	0.022	0.297	0.294	0.257	0.181	0.184	0.169	0.195	0.210
C.I. @ 95% Upper Limit	1.026	1.029	1.418	1.439	0.998	1.051	0.625	0.772	0.873	0.643
Lower Limit	0.825	0.941	0.230	0.263	-0.030	0.325	-0.111	0.094	0.091	-0.199
Schering-Plough	0.919	0.988	0.648	0.789	0.417	0.601	0.608	0.674	0.737	0.001
Squibb Corp.	0.919	0.928	0.702	0.709	0.901	0.922	0.763	0.428	0.856	0.484
Forest Laboratories Inc.	0.778	0.815	0.792	0.815	0.374	0.374	0.112	0.005	0.037	0.149
Techamerica Group Inc.	0.831	0.900	0.754	0.820	0.239	0.255	0.134	0.591	0.927	0.614
Flow General Inc.	0.860	0.930	0.344	0.629	0.714	0.838	0.672	0.681	0.696	0.674
ICN Pharmaceuticals Inc.	0.261	0.777	0.039	0.211	0.359	0.732	0.283	0.032	0.036	0.209
MEAN R SQUARED	0.761	0.890	0.547	0.662	0.501	0.620	0.429	0.402	0.548	0.355
Standard Deviation	0.229	0.072	0.270	0.213	0.230	0.240	0.262	0.284	0.370	0.250
C.I. @ 95% Upper Limit	1.220	1.034	1.086	1.087	0.961	1.100	0.952	0.969	1.287	0.855
Lower Limit	0.303	0.746	0.007	0.237	0.041	0.140	-0.095	-0.165	-0.191	-0.145

LEGEND

O=SALES K=NET INCOME  
C=CONSTANT T=MARKET SHARE  
L=R&D DOLLARS Q=R&D AS A PERCENT OF SALES  
M=TOTAL ASSETS P=ROI

Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL SALES O=C+L	MODEL SALES O=C+L+M	MODEL NET INC K=C+L	MODEL NET INC K=C+L+M	MODEL MKT SHR T=C+L	MODEL MKT SHR T=C+L+M	MODEL MKT SHR T=C+Q	MODEL ROI P=C+L	MODEL ROI P=C+L+M	MODEL ROI P=C+Q
ELECTRONIC COMPUTING SIC 3573A										
Amdahl Corp.	0.930	0.957	0.418	0.308	0.617	0.721	0.395	0.204	0.347	0.969
International Bus. Mach.	0.954	0.998	0.924	0.971	0.004	0.240	0.031	0.253	0.298	0.254
Hewlett-Packard Co.	0.994	0.996	0.980	0.842	0.910	0.923	0.049	0.128	0.140	0.031
MEAN R SQUARED	0.959	0.984	0.774	0.707	0.510	0.628	0.158	0.195	0.262	0.418
Standard Deviation	0.026	0.019	0.253	0.287	0.377	0.286	0.168	0.051	0.088	0.400
C.I. @ 95% Upper Limit	1.012	1.021	1.280	1.281	1.265	1.201	0.493	0.298	0.438	1.218
Lower Limit	0.907	0.946	0.268	0.133	-0.245	0.055	-0.177	0.092	0.085	-0.382
Burroughs Corp.	0.994	0.994	0.523	0.523	0.000	0.014	0.067	0.317	0.325	0.001
Digital Equipment Corp.	0.969	0.999	0.753	0.987	0.820	0.966	0.109	0.278	0.300	0.103
Data General Corp.	0.990	0.996	0.617	0.979	0.900	0.906	0.216	0.001	0.048	0.785
MEAN R SQUARED	0.984	0.996	0.631	0.830	0.573	0.629	0.131	0.199	0.224	0.296
Standard Deviation	0.011	0.002	0.094	0.217	0.407	0.435	0.063	0.141	0.125	0.348
C.I. @ 95% Upper Limit	1.006	1.000	0.820	1.263	1.387	1.499	0.256	0.480	0.475	0.992
Lower Limit	0.962	0.992	0.442	0.396	-0.240	-0.242	0.005	-0.083	-0.026	-0.400
LEGEND	O=SALES                      K=NET INCOME C=CONSTANT                T=MARKET SHARE L=R&D DOLLARS            Q=R&D AS A PERCENT OF SALES M=TOTAL ASSETS           P=ROI									

Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL
	SALES	SALES	NET INC	NET INC	MKT SHR	MKT SHR	MKT SHR	ROI	ROI	ROI
	O=C+L	O=C+L+M	K=C+L	K=C+L+M	T=C+L	T=C+L+M	T=C+Q	P=C+L	P=C+L+M	P=C+Q
ELECTRONIC COMPUTING SIC 3573B										
Commodore Int'l Ltd.	0.896	0.925	0.943	0.955	0.852	0.922	0.013	0.456	0.463	0.123
Apple Computer Inc.	0.975	0.987	0.853	0.876	0.984	0.984	0.725	0.651	0.692	0.306
Computervision Corp.	0.998	0.998	0.898	0.920	0.689	0.788	0.064	0.003	0.020	0.001
Prime Computer	0.980	0.998	0.857	0.927	0.590	0.899	0.011	0.000	0.427	0.514
Reynolds & Reynolds	0.822	0.989	0.208	0.478	0.878	0.882	0.814	0.551	0.706	0.692
MEAN R SQUARED	0.934	0.979	0.752	0.831	0.799	0.895	0.325	0.332	0.462	0.327
Standard Deviation	0.066	0.028	0.274	0.178	0.141	0.064	0.364	0.277	0.249	0.252
C.I. @ 95% Upper Limit	1.067	1.035	1.299	1.188	1.080	1.022	1.054	0.886	0.959	0.830
Lower Limit	0.802	0.924	0.204	0.474	0.517	0.768	-0.403	-0.222	-0.036	-0.176
Management Assistance	0.963	0.987	0.294	0.839	0.559	0.795	0.407	0.164	0.223	0.270
Computer Consoles	0.963	0.987	0.766	0.769	0.554	0.606	0.173	0.304	0.354	0.507
Intertec Data Systems	0.010	0.919	0.266	0.611	0.476	0.803	0.937	0.078	0.201	0.640
Modular Computer Systems	0.667	0.897	0.308	0.700	0.309	0.384	0.486	0.378	0.423	0.267
Electronic Associates Inc	0.117	0.149	0.190	0.304	0.576	0.670	0.438	0.063	0.332	0.055
MEAN R SQUARED	0.544	0.788	0.365	0.645	0.495	0.652	0.488	0.197	0.307	0.348
Standard Deviation	0.408	0.321	0.205	0.186	0.099	0.153	0.249	0.124	0.083	0.204
C.I. @ 95% Upper Limit	1.361	1.431	0.774	1.017	0.693	0.958	0.986	0.446	0.473	0.757
Lower Limit	-0.273	0.145	-0.045	0.272	0.297	0.345	-0.010	-0.051	0.140	-0.061

LEGEND

O=SALES                      K=NET INCOME  
C=CONSTANT                T=MARKET SHARE  
L=R&D DOLLARS            Q=R&D AS A PERCENT OF SALES  
M=TOTAL ASSETS            P=ROI

Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL SALES O=C+L	MODEL SALES O=C+L+M	MODEL NET INC K=C+L	MODEL NET INC K=C+L+M	MODEL MKT SHR T=C+L	MODEL MKT SHR T=C+L+M	MODEL MKT SHR T=C+Q	MODEL ROI P=C+L	MODEL ROI P=C+L+M	MODEL ROI P=C+Q
ELECTRONIC COMPUTING SIC 3573C										
Mohawk Data Sciences	0.548	0.839	0.250	0.385	0.122	0.326	0.153	0.166	0.211	0.181
Telex Corp.	0.933	0.950	0.695	0.696	0.006	0.270	0.002	0.016	0.016	0.664
Genisco Technology	0.928	0.946	0.041	0.050	0.130	0.130	0.224	0.059	0.074	0.194
Verbatim Corp.	0.954	0.996	0.862	0.886	0.823	0.970	0.699	0.445	0.676	0.701
MEAN R SQUARED	0.841	0.933	0.462	0.504	0.270	0.424	0.270	0.172	0.244	0.435
Standard Deviation	0.169	0.058	0.330	0.317	0.323	0.323	0.261	0.167	0.259	0.248
C.I. @ 95% Upper Limit	1.179	1.048	1.123	1.139	0.916	1.070	0.791	0.506	0.763	0.931
Lower Limit	0.502	0.818	-0.199	-0.131	-0.376	-0.222	-0.252	-0.163	-0.274	-0.061
TEC Inc.	0.579	0.958	0.155	0.342	0.065	0.375	0.119	0.303	0.334	0.278
Centronics Data Computer	0.829	0.984	0.258	0.316	0.206	0.421	0.479	0.093	0.093	0.571
Wespercorp	0.826	0.846	0.449	0.935	0.587	0.679	0.009	0.670	0.801	0.429
Storage Technology Corp.	0.861	0.974	0.288	0.860	0.660	0.844	0.218	0.377	0.894	0.007
MEAN R SQUARED	0.774	0.941	0.288	0.613	0.380	0.580	0.206	0.361	0.531	0.321
Standard Deviation	0.113	0.055	0.105	0.286	0.250	0.192	0.174	0.207	0.330	0.209
C.I. @ 95% Upper Limit	1.000	1.051	0.498	1.185	0.880	0.963	0.554	0.774	1.190	0.739
Lower Limit	0.547	0.830	0.077	0.042	-0.121	0.197	-0.142	-0.053	-0.129	-0.097
LEGEND	O=SALES                      K=NET INCOME C=CONSTANT                T=MARKET SHARE L=R&D DOLLARS            Q=R&D AS A PERCENT OF SALES M=TOTAL ASSETS          P=ROI									

Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL SALES O=C+L	MODEL SALES O=C+L+M	MODEL NET INC K=C+L	MODEL NET INC K=C+L+M	MODEL MKT SHR T=C+L	MODEL MKT SHR T=C+L+M	MODEL MKT SHR T=C+Q	MODEL ROI P=C+L	MODEL ROI P=C+L+M	MODEL ROI P=C+Q
RADIO-TV REC SETS SIC 3651										
Corning Glass	0.965	0.986	0.405	0.552	0.808	0.885	0.938	0.328	0.493	0.209
TDK Corp.	0.985	0.993	0.919	0.921	0.884	0.887	0.597	0.049	0.060	0.047
Nippon Electric Company	0.984	0.994	0.982	0.990	0.807	0.941	0.373	0.559	0.561	0.286
Coleco	0.907	0.912	0.191	0.499	0.812	0.891	0.275	0.002	0.048	0.064
MEAN R SQUARED	0.960	0.971	0.624	0.741	0.828	0.901	0.546	0.235	0.291	0.152
Standard Deviation	0.032	0.034	0.336	0.217	0.033	0.023	0.255	0.225	0.238	0.100
C.I. @ 95% Upper Limit	1.024	1.040	1.296	1.175	0.893	0.947	1.055	0.685	0.766	0.351
Lower Limit	0.897	0.903	-0.047	0.306	0.763	0.855	0.036	-0.216	-0.185	-0.048
RCA Corp.	0.870	0.946	0.249	0.252	0.411	0.754	0.578	0.767	0.769	0.001
Esquire Radio & Electron	0.754	0.780	0.690	0.694	0.339	0.792	0.193	0.323	0.801	0.403
Electrosound Group Inc.	0.756	0.791	0.001	0.067	0.113	0.458	0.084	0.001	0.007	0.010
Craig Corp.	0.695	0.912	0.326	0.349	0.019	0.037	0.036	0.078	0.078	0.002
MEAN R SQUARED	0.769	0.857	0.317	0.341	0.221	0.510	0.223	0.292	0.414	0.104
Standard Deviation	0.063	0.073	0.247	0.228	0.160	0.302	0.213	0.299	0.372	0.173
C.I. @ 95% Upper Limit	0.896	1.003	0.810	0.796	0.541	1.115	0.648	0.890	1.158	0.449
Lower Limit	0.642	0.712	-0.177	-0.115	-0.100	-0.094	-0.203	-0.305	-0.331	-0.241

LEGEND

O=SALES                      K=NET INCOME  
C=CONSTANT                T=MARKET SHARE  
L=R&D DOLLARS            Q=R&D AS A PERCENT OF SALES  
M=TOTAL ASSETS          P=ROI

Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL
TELEPHONE & TELEGRAPH SIC 3661	SALES O=C+L	SALES O=C+L+M	NET INC K=C+L	NET INC K=C+L+M	MKT SHR T=C+L	MKT SHR T=C+L+M	MKT SHR T=C+Q	ROI P=C+L	ROI P=C+L+M	ROI P=C+Q
Rydin Corp.	0.831	0.971	0.713	0.967	0.720	0.871	0.640	0.170	0.171	0.221
TRW Inc.	0.758	0.993	0.755	0.940	0.348	0.921	0.071	0.817	0.861	0.876
Plessey PLC	0.739	0.950	0.559	0.959	0.002	0.150	0.070	0.797	0.854	0.426
Motorola Inc.	0.961	0.995	0.917	0.945	0.897	0.909	0.034	0.059	0.478	0.265
Sparton Corp.	0.201	0.954	0.152	0.719	0.158	0.259	0.004	0.146	0.249	0.377
GTE	0.881	0.998	0.682	0.967	0.706	0.927	0.138	0.673	0.689	0.264
MEAN R SQUARED	0.729	0.977	0.630	0.916	0.472	0.673	0.160	0.444	0.550	0.405
Standard Deviation	0.247	0.020	0.238	0.089	0.324	0.333	0.219	0.324	0.273	0.222
C.I. @ 95% Upper Limit	1.223	1.016	1.107	1.094	1.121	1.339	0.597	1.091	1.097	0.849
Lower Limit	0.234	0.938	0.153	0.739	-0.177	0.007	-0.278	-0.204	0.004	-0.040
Timeplex Inc.	0.914	0.980	0.810	0.947	0.902	0.921	0.134	0.193	0.218	0.211
Mitel Corp.	0.828	0.926	0.481	0.878	0.772	0.914	0.505	0.710	0.924	0.328
Torotel Inc.	0.949	0.996	0.008	0.170	0.713	0.756	0.474	0.409	0.643	0.364
Texscan Corp.	0.786	0.971	0.421	0.759	0.790	0.917	0.666	0.472	0.524	0.506
Telesciences Inc.	0.841	0.912	0.269	0.753	0.290	0.327	0.119	0.082	0.138	0.737
Teleconcepts Corp.	0.037	0.971	0.105	0.164	0.135	0.687	0.083	0.014	0.266	0.011
MEAN R SQUARED	0.726	0.959	0.349	0.612	0.600	0.754	0.330	0.313	0.452	0.360
Standard Deviation	0.313	0.030	0.264	0.322	0.283	0.211	0.227	0.241	0.275	0.227
C.I. @ 95% Upper Limit	1.351	1.019	0.876	1.255	1.167	1.175	0.783	0.796	1.001	0.813
Lower Limit	0.100	0.899	-0.178	-0.031	0.033	0.332	-0.123	-0.169	-0.097	-0.094

LEGEND

O=SALES K=NET INCOME  
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L=R&D DOLLARS Q=R&D AS A PERCENT OF SALES  
M=TOTAL ASSETS P=ROI

Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL
RADIO-TV TRANSMITTING EQ. SALES	SALES	SALES	NET INC	NET INC	MKT SHR	MKT SHR	MKT SHR	ROI	ROI	ROI
SIC 3662	O=C+L	O=C+L+M	K=C+L	K=C+L+M	T=C+L	T=C+L+M	T=C+Q	P=C+L	P=C+L+M	P=C+Q
United Industrial Corp.	0.422	0.089	0.206	0.981	0.073	0.155	0.014	0.004	0.320	0.108
E-Systems Inc.	0.937	0.951	0.898	0.899	0.303	0.316	0.137	0.011	0.026	0.525
Raytheon Co.	0.830	0.990	0.818	0.944	0.056	0.349	0.053	0.048	0.479	0.285
EDC Corp.	0.644	0.863	0.484	0.888	0.692	0.748	0.006	0.153	0.221	0.024
MEAN R SQUARED	0.708	0.723	0.602	0.928	0.281	0.392	0.053	0.054	0.262	0.236
Standard Deviation	0.196	0.369	0.276	0.037	0.257	0.218	0.052	0.060	0.164	0.192
C.I. @ 95% Upper Limit	1.100	1.461	1.154	1.002	0.794	0.828	0.156	0.173	0.590	0.619
Lower Limit	0.317	-0.015	0.049	0.854	-0.232	-0.044	-0.051	-0.065	-0.067	-0.148
T Bar Inc.	0.938	0.973	0.180	0.534	0.739	0.837	0.830	0.854	0.861	0.844
General Datacomm Ind. Inc	0.988	0.992	0.612	0.871	0.952	0.991	0.113	0.020	0.817	0.005
Paradyne Corp.	0.987	0.996	0.221	0.634	0.963	0.978	0.070	0.803	0.946	0.222
Instrument Systems Corp.	0.106	0.402	0.461	0.467	0.214	0.719	0.134	0.337	0.464	0.258
MEAN R SQUARED	0.755	0.841	0.369	0.627	0.717	0.881	0.287	0.504	0.772	0.332
Standard Deviation	0.375	0.253	0.177	0.153	0.304	0.111	0.314	0.344	0.184	0.311
C.I. @ 95% Upper Limit	1.505	1.348	0.722	0.933	1.325	1.104	0.916	1.192	1.140	0.954
Lower Limit	0.005	0.334	0.015	0.320	0.109	0.658	-0.342	-0.185	0.404	-0.290
LEGEND	O=SALES                      K=NET INCOME C=CONSTANT                T=MARKET SHARE L=R&D DOLLARS            Q=R&D AS A PERCENT OF SALES M=TOTAL ASSETS          P=ROI									

Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL SALES O=C+L	MODEL SALES O=C+L+M	MODEL NET INC K=C+L	MODEL NET INC K=C+L+M	MODEL MKT SHR T=C+L	MODEL MKT SHR T=C+L+M	MODEL MKT SHR T=C+Q	MODEL ROI P=C+L	MODEL ROI P=C+L+M	MODEL ROI P=C+Q
SEMICONDUCTORS SIC 3674										
Unitrode Corp.	0.925	0.984	0.931	0.984	0.097	0.169	0.180	0.003	0.412	0.185
Advanced Micro Devices	0.982	0.996	0.910	0.914	0.937	0.980	0.727	0.013	0.033	0.022
Analog Devices	0.902	0.998	0.845	0.877	0.739	0.827	0.034	0.319	0.598	0.118
Eaton	0.801	0.957	0.001	0.312	0.865	0.923	0.891	0.109	0.110	0.040
MEAN R SQUARED	0.903	0.984	0.672	0.772	0.660	0.725	0.458	0.111	0.288	0.091
Standard Deviation	0.065	0.016	0.389	0.268	0.332	0.325	0.359	0.127	0.228	0.065
C.I. @ 95% Upper Limit	1.033	1.016	1.449	1.308	1.324	1.376	1.177	0.365	0.745	0.221
Lower Limit	0.772	0.951	-0.105	0.235	-0.005	0.074	-0.261	-0.143	-0.168	-0.039
Int'l Rectifier Corp.	0.419	0.898	0.002	0.037	0.341	0.691	0.064	0.000	0.050	0.152
Applied Materials	0.978	0.985	0.245	0.290	0.658	0.915	0.731	0.008	0.164	0.001
Materials Research	0.768	0.891	0.017	0.488	0.095	0.569	0.085	0.405	0.564	0.763
National Semiconductor Co	0.977	0.995	0.222	0.287	0.471	0.497	0.201	0.522	0.549	0.001
MEAN R SQUARED	0.786	0.942	0.122	0.276	0.391	0.668	0.270	0.234	0.332	0.229
Standard Deviation	0.228	0.048	0.112	0.160	0.205	0.159	0.271	0.233	0.228	0.314
C.I. @ 95% Upper Limit	1.242	1.038	0.346	0.595	0.801	0.985	0.812	0.701	0.789	0.858
Lower Limit	0.329	0.846	-0.103	-0.044	-0.018	0.351	-0.272	-0.233	-0.125	-0.399
LEGEND	O=SALES                      K=NET INCOME C=CONSTANT                T=MARKET SHARE L=R&D DOLLARS            Q=R&D AS A PERCENT OF SALES M=TOTAL ASSETS          P=ROI									



Single and Multiple Regression R Squared 1st and 4th Quartiles										
Sorted by ROI										
	MODEL SALES O=C+L	MODEL SALES O=C+L+M	MODEL NET INC K=C+L	MODEL NET INC K=C+L+M	MODEL MKT SHR T=C+L	MODEL MKT SHR T=C+L+M	MODEL MKT SHR T=C+Q	MODEL ROI P=C+L	MODEL ROI P=C+L+M	MODEL ROI P=C+Q
ELECTRONIC COMP. (NEC) SIC 3679										
Canadian Maraconi Co.	0.901	0.958	0.810	0.917	0.059	0.578	0.162	0.648	0.648	0.248
AMP	0.999	0.999	0.981	0.979	0.972	0.973	0.737	0.010	0.597	0.012
EG&G	0.982	0.990	0.963	0.981	0.916	0.967	0.787	0.404	0.486	0.112
Veeco Instruments	0.946	0.991	0.870	0.938	0.917	0.918	0.000	0.202	0.559	0.315
Emerson Electric	0.960	0.975	0.971	0.975	0.930	0.948	0.834	0.171	0.179	0.241
Litton Industries	0.766	0.555	0.719	0.709	0.793	0.729	0.835	0.608	0.337	0.409
Thomas & Betts Corp.	0.980	0.991	0.892	0.935	0.784	0.836	0.190	0.527	0.542	0.402
General Electric Co.	0.913	0.919	0.936	0.968	0.412	0.448	0.535	0.424	0.436	0.503
Pittway Corp.	0.870	0.994	0.569	0.801	0.715	0.818	0.654	0.126	0.132	0.045
Cubic Corp.	0.753	0.970	0.753	0.901	0.585	0.851	0.067	0.116	0.388	0.036
Ametek Inc.	0.925	0.971	0.950	0.951	0.291	0.350	0.089	0.046	0.298	0.246
MEAN R SQUARED	0.909	0.938	0.856	0.914	0.670	0.765	0.445	0.298	0.418	0.234
Standard Deviation	0.079	0.123	0.125	0.081	0.286	0.206	0.326	0.220	0.161	0.159
C.I. @ 95% Upper Limit	1.067	1.183	1.105	1.077	1.243	1.176	1.097	0.738	0.741	0.551
Lower Limit	0.750	0.692	0.607	0.751	0.098	0.954	-0.208	-0.142	0.096	-0.084
AVX Corp.	0.920	0.968	0.546	0.903	0.730	0.950	0.274	0.456	0.510	0.594
Electro Audio Dynamics	0.002	0.032	0.012	0.043	0.044	0.044	0.016	0.002	0.003	0.000
Varo Inc.	0.513	0.838	0.003	0.103	0.017	0.212	0.038	0.200	0.020	0.007
GTI Corp.	0.083	0.510	0.162	0.261	0.059	0.117	0.010	0.207	0.218	0.448
Rogers Corp.	0.933	0.985	0.588	0.594	0.520	0.709	0.002	0.148	0.185	0.360
Servo Corp. of America	0.766	0.856	0.016	0.092	0.025	0.126	0.054	0.071	0.171	0.113
EECO	0.059	0.956	0.083	0.349	0.016	0.146	0.094	0.000	0.753	0.447
Cincinnati Milicron	0.441	0.868	0.000	0.671	0.090	0.532	0.621	0.011	0.475	0.142
Int'l Power Machines Corp	0.291	0.959	0.083	0.720	0.751	0.791	0.815	0.595	0.595	0.431
Nuclear Data	0.616	0.963	0.042	0.246	0.254	0.511	0.581	0.329	0.366	0.065
Semtech Corp.	0.523	0.855	0.010	0.031	0.003	0.009	0.124	0.088	0.103	0.003
MEAN R SQUARED	0.468	0.799	0.140	0.365	0.228	0.377	0.239	0.192	0.309	0.237
Standard Deviation	0.316	0.274	0.207	0.293	0.282	0.318	0.280	0.187	0.236	0.210
C.I. @ 95% Upper Limit	1.101	1.347	0.553	0.951	0.792	1.012	0.799	0.565	0.781	0.658
Lower Limit	-0.165	0.251	-0.273	-0.221	-0.336	-0.258	-0.321	-0.182	-0.163	-0.183
LEGEND	O=SALES                      K=NET INCOME C=CONSTANT                  T=MARKET SHARE L=R&D DOLLARS              Q=R&D AS A PERCENT OF SALES M=TOTAL ASSETS              P=ROI									

Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL SALES O=C+L	MODEL SALES O=C+L+M	MODEL NET INC K=C+L	MODEL NET INC K=C+L+M	MODEL MKT SHR T=C+L	MODEL MKT SHR T=C+L+M	MODEL MKT SHR T=C+Q	MODEL ROI P=C+L	MODEL ROI P=C+L+M	MODEL ROI P=C+Q
AIRCRAFT SIC 3721										
Martin Marietta Corp.	0.728	0.973	0.144	0.611	0.224	0.232	0.251	0.064	0.081	0.126
Lockheed Corp.	0.882	0.974	0.886	0.896	0.175	0.220	0.282	0.277	0.439	0.329
Grumman Corp.	0.922	0.941	0.703	0.709	0.202	0.645	0.261	0.454	0.454	0.451
MEAN R SQUARED	0.844	0.963	0.578	0.739	0.200	0.366	0.265	0.265	0.325	0.302
Standard Deviation	0.084	0.015	0.316	0.118	0.020	0.198	0.013	0.159	0.172	0.134
C.I. @ 95% Upper Limit	1.011	0.993	1.209	0.975	0.240	0.761	0.291	0.584	0.669	0.570
Lower Limit	0.677	0.932	-0.054	0.502	0.160	-0.029	0.239	-0.054	-0.020	0.034
Northrop Corp.	0.764	0.934	0.163	0.940	0.218	0.379	0.061	0.210	0.755	0.365
Fairchild Industries Inc.	0.784	0.841	0.293	0.476	0.286	0.355	0.128	0.013	0.013	0.017
Cessna Aircraft Co.	0.742	0.768	0.018	0.187	0.010	0.165	0.346	0.048	0.120	0.346
MEAN R SQUARED	0.763	0.848	0.158	0.534	0.171	0.300	0.178	0.090	0.296	0.243
Standard Deviation	0.017	0.068	0.112	0.310	0.117	0.096	0.122	0.086	0.327	0.160
C.I. @ 95% Upper Limit	0.798	0.984	0.383	1.155	0.406	0.491	0.422	0.262	0.951	0.562
Lower Limit	0.729	0.712	-0.067	-0.086	-0.063	0.108	-0.065	-0.081	-0.359	-0.077
LEGEND	O=SALES                      K=NET INCOME C=CONSTANT                T=MARKET SHARE L=R&D DOLLARS        Q=R&D AS A PERCENT OF SALES M=TOTAL ASSETS        P=ROI									

Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL SALES O=C+L	MODEL SALES O=C+L+M	MODEL NET INC K=C+L	MODEL NET INC K=C+L+M	MODEL MKT SHR T=C+L	MODEL MKT SHR T=C+L+M	MODEL MKT SHR T=C+Q	MODEL ROI P=C+L	MODEL ROI P=C+L+M	MODEL ROI P=C+Q
AIRCRAFT PARTS SIC 3728										
Aeronca Inc.	0.986	0.191	0.853	0.864	0.927	0.968	0.183	0.152	0.157	0.684
United Technologies Corp.	0.740	0.987	0.957	0.969	0.004	0.203	0.023	0.180	0.182	0.100
MEAN R SQUARED	0.863	0.589	0.905	0.917	0.466	0.586	0.103	0.166	0.170	0.392
Standard Deviation	0.123	0.398	0.052	0.053	0.462	0.383	0.080	0.014	0.012	0.292
C.I. @ 95% Upper Limit	1.109	1.385	1.009	1.022	1.389	1.351	0.263	0.194	0.194	0.976
Lower Limit	0.617	-0.207	0.801	0.811	-0.458	-0.180	-0.057	0.138	0.145	-0.192
Signal Companies	0.839	0.962	0.272	0.277	0.746	0.842	0.475	0.027	0.034	0.163
Curtiss-Wright Corp.	0.964	0.381	0.180	0.411	0.024	0.063	0.286	0.105	0.131	0.214
MEAN R SQUARED	0.902	0.672	0.226	0.344	0.385	0.453	0.381	0.066	0.083	0.189
Standard Deviation	0.063	0.291	0.046	0.067	0.361	0.390	0.095	0.039	0.049	0.025
C.I. @ 95% Upper Limit	1.027	1.253	0.318	0.478	1.107	1.232	0.570	0.144	0.180	0.239
Lower Limit	0.776	0.090	0.134	0.210	-0.337	-0.326	0.192	-0.012	-0.014	0.138
LEGEND	O=SALES                      K=NET INCOME C=CONSTANT                T=MARKET SHARE L=R&D DOLLARS            Q=R&D AS A PERCENT OF SALES M=TOTAL ASSETS          P=ROI									

Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL SALES O=C+L	MODEL SALES O=C+L+M	MODEL NET INC K=C+L	MODEL NET INC K=C+L+M	MODEL MKT SHR T=C+L	MODEL MKT SHR T=C+L+M	MODEL MKT SHR T=C+Q	MODEL ROI P=C+L	MODEL ROI P=C+L+M	MODEL ROI P=C+Q
ENGINEERING LAB & RES EQ SIC 3811										
Whitehall Corp.	0.740	0.848	0.957	0.969	0.004	0.203	0.023	0.180	0.182	0.100
Gerber Scientific Inc.	0.986	0.997	0.853	0.864	0.927	0.968	0.183	0.152	0.157	0.684
MEAN R SQUARED	0.863	0.923	0.905	0.917	0.466	0.586	0.103	0.166	0.170	0.392
Standard Deviation	0.123	0.074	0.052	0.053	0.462	0.382	0.080	0.014	0.012	0.292
C.I. @ 95% Upper Limit	1.109	1.071	1.009	1.022	1.389	1.351	0.263	0.194	0.194	0.976
Lower Limit	0.617	0.774	0.801	0.811	-0.458	-0.179	-0.057	0.138	0.145	-0.192
Sargent Welch Scientific	0.839	0.856	0.272	0.277	0.746	0.842	0.475	0.027	0.034	0.163
Spectra Physics	0.951	0.976	0.001	0.084	0.828	0.858	0.268	0.181	0.241	0.370
MEAN R SQUARED	0.895	0.916	0.137	0.181	0.787	0.850	0.372	0.104	0.138	0.267
Standard Deviation	0.056	0.060	0.136	0.097	0.041	0.008	0.104	0.077	0.103	0.103
C.I. @ 95% Upper Limit	1.007	1.036	0.408	0.374	0.869	0.866	0.579	0.258	0.345	0.474
Lower Limit	0.783	0.796	-0.134	-0.013	0.705	0.834	0.164	-0.050	-0.069	0.060

LEGEND

O=SALES K=NET INCOME  
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Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL
	SALES	SALES	NET INC	NET INC	MKT SHR	MKT SHR	MKT SHR	ROI	ROI	ROI
	O=C+L	O=C+L+M	K=C+L	K=C+L+M	T=C+L	T=C+L+M	T=C+Q	P=C+L	P=C+L+M	P=C+Q
MENSURING & CONTROL INST.										
SIC 3820										
Schlumberger	0.917	0.884	0.778	0.909	0.910	0.921	0.711	0.594	0.699	0.390
Johnson Controls Inc.	0.951	0.992	0.031	0.083	0.242	0.397	0.194	0.010	0.255	0.007
Tech Ops Inc.	0.772	0.711	0.831	0.947	0.196	0.345	0.016	0.028	0.042	0.014
MEAN R SQUARED	0.880	0.862	0.547	0.646	0.449	0.554	0.307	0.211	0.332	0.137
Standard Deviation	0.078	0.116	0.365	0.399	0.326	0.260	0.295	0.271	0.274	0.179
C.I. @ 95% Upper Limit	1.035	1.094	1.277	1.444	1.102	1.075	0.897	0.753	0.879	0.495
Lower Limit	0.725	0.631	-0.184	-0.151	-0.203	0.034	-0.283	-0.332	-0.215	-0.221
Mark Controls	0.954	0.975	0.509	0.752	0.941	0.960	0.855	0.496	0.561	0.556
Badger Meter Inc.	0.035	0.890	0.138	0.138	0.184	0.279	0.413	0.429	0.432	0.044
Sun Electric Corp.	0.937	0.968	0.754	0.866	0.652	0.665	0.053	0.237	0.238	0.258
MEAN R SQUARED	0.642	0.944	0.467	0.585	0.592	0.635	0.440	0.387	0.410	0.286
Standard Deviation	0.429	0.039	0.253	0.320	0.312	0.279	0.328	0.110	0.133	0.210
C.I. @ 95% Upper Limit	1.501	1.021	0.973	1.225	1.216	1.192	1.096	0.607	0.676	0.706
Lower Limit	-0.217	0.867	-0.039	-0.054	-0.031	0.077	-0.216	0.168	0.145	-0.134
LEGEND	O=SALES                      K=NET INCOME C=CONSTANT                T=MARKET SHARE L=R&D DOLLARS            Q=R&D AS A PERCENT OF SALES M=TOTAL ASSETS            P=ROI									

Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL SALES O=C+L	MODEL SALES O=C+L+M	MODEL NET INC K=C+L	MODEL NET INC K=C+L+M	MODEL MKT SHR T=C+L	MODEL MKT SHR T=C+L+M	MODEL MKT SHR T=C+Q	MODEL ROI P=C+L	MODEL ROI P=C+L+M	MODEL ROI P=C+Q
ELEC MEAS. & TEST INST. SIC 3825										
Teleflex Inc.	0.772	0.991	0.831	0.947	0.196	0.345	0.016	0.028	0.042	0.014
Esterline Corp.	0.808	0.916	0.682	0.780	0.157	0.230	0.268	0.016	0.125	0.000
Tektronix Inc.	0.937	0.996	0.754	0.866	0.652	0.665	0.053	0.237	0.230	0.250
MEAN R SQUARED	0.839	0.968	0.756	0.864	0.335	0.413	0.112	0.094	0.132	0.088
Standard Deviation	0.071	0.037	0.061	0.068	0.225	0.184	0.111	0.101	0.077	0.115
C.I. @ 95% Upper Limit	0.981	1.041	0.877	1.001	0.784	0.781	0.335	0.297	0.286	0.317
Lower Limit	0.697	0.894	0.634	0.728	-0.114	0.045	-0.110	-0.109	-0.022	-0.141
Barnes Engineering Co.	0.035	0.875	0.138	0.138	0.184	0.279	0.413	0.429	0.432	0.044
Mangood Corp.	0.814	0.814	0.235	0.291	0.000	0.034	0.314	0.001	0.070	0.011
Talley Industries Inc.	0.599	0.860	0.037	0.082	0.052	0.056	0.153	0.131	0.135	0.095
MEAN R SQUARED	0.483	0.850	0.137	0.170	0.079	0.123	0.293	0.187	0.212	0.050
Standard Deviation	0.328	0.026	0.081	0.088	0.077	0.111	0.107	0.179	0.158	0.035
C.I. @ 95% Upper Limit	1.140	0.902	0.298	0.347	0.234	0.344	0.508	0.545	0.527	0.119
Lower Limit	-0.174	0.798	-0.025	-0.006	-0.076	-0.098	0.079	-0.171	-0.103	-0.019
LEGEND	O=SALES                      K=NET INCOME C=CONSTANT                T=MARKET SHARE L=R&D DOLLARS        Q=R&D AS A PERCENT OF SALES M=TOTAL ASSETS        P=ROI									

Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL SALES O=C+L	MODEL SALES O=C+L+M	MODEL NET INC K=C+L	MODEL NET INC K=C+L+M	MODEL MKT SHR T=C+L	MODEL MKT SHR T=C+L+M	MODEL MKT SHR T=C+Q	MODEL ROI P=C+L	MODEL ROI P=C+L+M	MODEL ROI P=C+Q
SURGICAL & MEDICAL INST. SIC 3841										
Xonics Inc.	0.284	0.797	0.516	0.622	0.109	0.484	0.249	0.246	0.355	0.012
Mountain Medical Eq.	0.834	0.975	0.128	0.755	0.737	0.997	0.030	0.670	0.704	0.326
Bausch & Lomb Inc.	0.886	0.964	0.566	0.770	0.628	0.805	0.538	0.463	0.471	0.175
MEAN R SQUARED	0.668	0.912	0.403	0.716	0.491	0.762	0.272	0.460	0.510	0.171
Standard Deviation	0.272	0.081	0.196	0.067	0.274	0.212	0.208	0.173	0.145	0.128
C.I. @ 95% Upper Limit	1.213	1.075	0.795	0.849	1.039	1.185	0.688	0.806	0.800	0.427
Lower Limit	0.123	0.749	0.012	0.583	-0.057	0.339	-0.144	0.113	0.220	-0.085
Gelman Sciences Inc.	0.902	0.994	0.324	0.351	0.019	0.627	0.032	0.023	0.053	0.011
Delmed Inc.	0.044	0.946	0.298	0.430	0.000	0.829	0.787	0.038	0.187	0.252
Bio-Rad Laboratories	0.988	0.988	0.133	0.166	0.908	0.911	0.626	0.797	0.866	0.828
MEAN R SQUARED	0.645	0.976	0.252	0.316	0.309	0.789	0.482	0.286	0.369	0.364
Standard Deviation	0.426	0.021	0.085	0.111	0.424	0.119	0.325	0.361	0.356	0.343
C.I. @ 95% Upper Limit	1.497	1.019	0.421	0.537	1.156	1.028	1.131	1.009	1.080	1.049
Lower Limit	-0.208	0.933	0.083	0.094	-0.538	0.550	-0.168	-0.437	-0.343	-0.322

LEGEND

O=SALES K=NET INCOME  
C=CONSTANT T=MARKET SHARE  
L=R&D DOLLARS Q=R&D AS A PERCENT OF SALES  
M=TOTAL ASSETS P=ROI

Single and Multiple Regression R Squared  
1st and 4th Quartiles

Sorted by ROI

	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL	MODEL
	SALES	SALES	NET INC	NET INC	MKT SHR	MKT SHR	MKT SHR	ROI	ROI	ROI
	O=C+L	O=C+L+M	K=C+L	K=C+L+M	T=C+L	T=C+L+M	T=C+Q	P=C+L	P=C+L+M	P=C+Q
PHOTOGRAPHIC EQUIPMENT SIC 3861										
Xerox Corp.	0.971	0.980	0.639	0.736	0.511	0.738	0.538	0.632	0.648	0.002
Matrix Corp.-NJ	0.976	0.976	0.953	0.958	0.978	0.980	0.391	0.066	0.084	0.643
Eastman Kodak Co.	0.947	0.989	0.615	0.787	0.349	0.502	0.263	0.792	0.805	0.506
MEAN R SQUARED	0.965	0.982	0.736	0.827	0.613	0.740	0.397	0.497	0.512	0.384
Standard Deviation	0.013	0.005	0.154	0.095	0.267	0.195	0.112	0.311	0.310	0.276
C.I. @ 95% Upper Limit	0.990	0.993	1.044	1.017	1.146	1.130	0.622	1.120	1.132	0.935
Lower Limit	0.939	0.971	0.428	0.637	0.079	0.350	0.173	-0.126	-0.107	-0.168
Polaroid Corp.	0.670	0.982	0.000	0.158	0.346	0.363	0.038	0.724	0.750	0.189
Speed-O-Print Bus. Machin	0.286	0.301	0.092	0.123	0.649	0.652	0.247	0.393	0.442	0.059
Orrox Corp. - NOW CMX	0.738	0.818	0.606	0.615	0.629	0.632	0.163	0.529	0.544	0.290
MEAN R SQUARED	0.565	0.700	0.233	0.299	0.541	0.549	0.149	0.549	0.579	0.179
Standard Deviation	0.199	0.290	0.267	0.224	0.138	0.132	0.086	0.136	0.128	0.095
C.I. @ 95% Upper Limit	0.963	1.281	0.766	0.747	0.818	0.813	0.321	0.820	0.835	0.368
Lower Limit	0.167	0.120	-0.301	-0.150	0.265	0.285	-0.022	0.277	0.322	-0.010
LEGEND	O=SALES                      K=NET INCOME C=CONSTANT                T=MARKET SHARE L=R&D DOLLARS            Q=R&D AS A PERCENT OF SALES M=TOTAL ASSETS           P=ROI									



## APPENDIX H

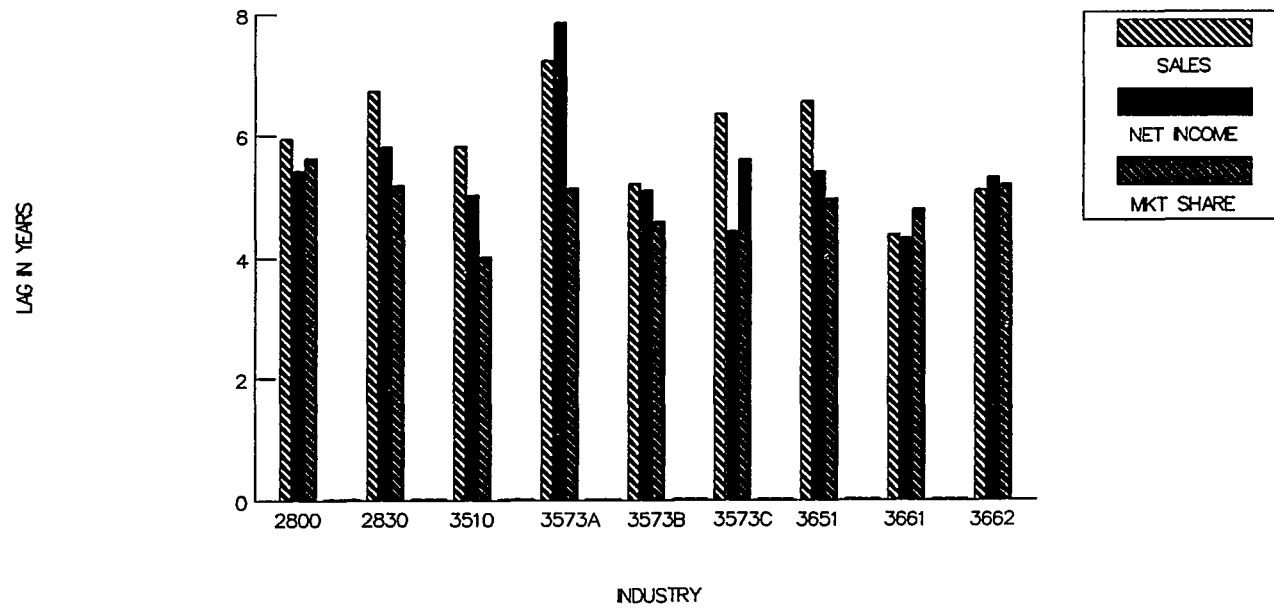
### TIME SERIES LAG ANALYSIS

This appendix includes graphic lag by industry, a list of lag values for each firm by Standard Industrial Classification (SIC), and graphs of the lag data for first quartile firms in each industry.

If the data did not indicate that there was lag from the time of R&D investment to the effect on a dependent variable, the first quartile company graph will not have a bar for that variable.

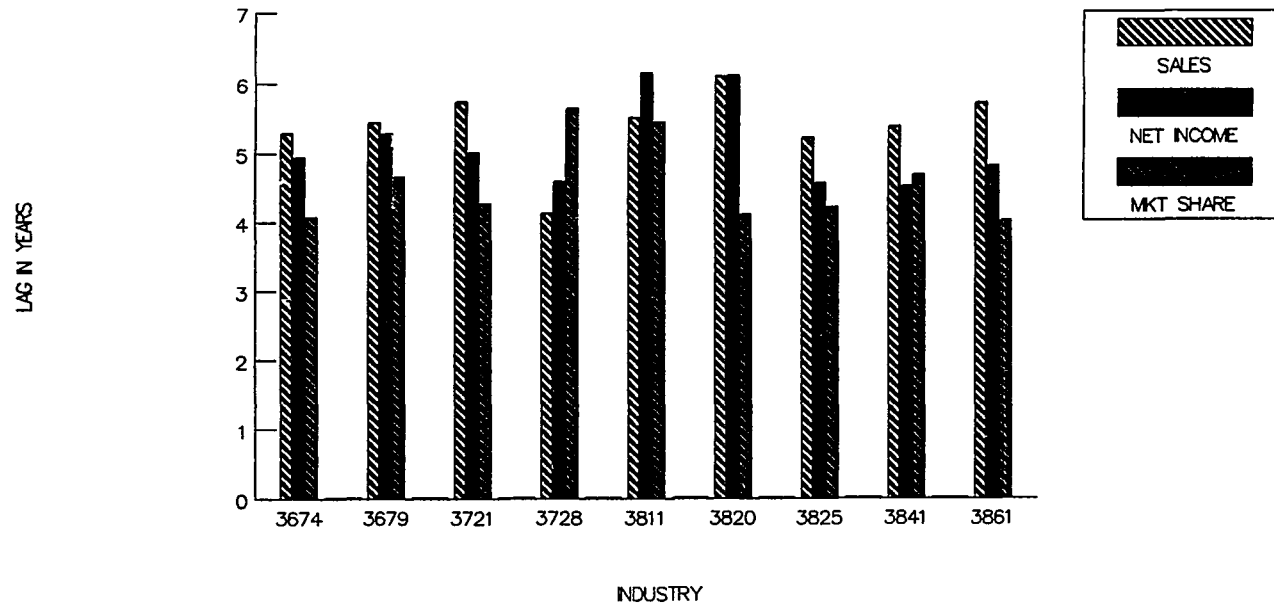
# LAG BY INDUSTRY

2800 — 3662



## LAG BY INDUSTRY

3674 — 3861



TIME SERIES LAG ANALYSIS  
(FROM R&D INVESTMENT TO IMPACT ON THE VARIABLE)

		VARIABLE			
		O	K	T	
FILE NO.	SIC - 2800 Chemicals & Allied Prod	NO. YRS	SALES	NET INCOME	MARKET SHARE
A018	Air Prod. & Chem. Inc.	14	5	5	6
A001	Allied Corporation	20	3	2	4
A002	American Cyanamid Co.	21	N	10	6
A023	Celanese Corp.	21	10	3	8
A003	Dow Chemical	19	6	N	5
A004	Du Pont (E.I.)	14	6	5	7
A019	Essex Chem. Corp.	13	2	2	2
A005	FMC Corp	21	8	8	6
A060	General Defense Corp.	6	3	3	3
A006	Grace (W.R.) & Co.	21	8	8	5
A020	Great Lakes Chem. Corp.	14	N	N	N
A007	Hercules Inc.	21	N	6	3
A008	Imperial Chem. Ind.	17	N	5	6
A021	Learonal Inc.	18	7	7	8
A009	Monsanto Co.	21	7	7	4
A010	Morton Thiokol Inc.	18	7	4	N
A012	Olin Corp.	15	5	7	7
A014	Pennwalt Corp.	15	N	8	5
A013	PPG Ind. Inc.	21	6	4	8
A024	Reichhold Chem. Inc.	15	N	6	6
A015	Rohm & Haas Co.	17	6	4	5
A016	Stauffer Chem. Co.	21	N	N	N
A017	Union Carbide Corp.	21	N	4	8
AVERAGE LAG			5.93	5.40	5.60

\* N = No meaningful figure

TIME SERIES LAG ANALYSIS  
CONTINUED

		VARIABLE			
		O	K	T	
FILE NO.	SIC - 2830 DRUGS	NO. YRS	SALES	NET INCOME	MARKET SHARE
B025	Abbott Laborator	21	N	N	5
B027	American Home Prod. Corp.	15	N	N	5
B028	Bolar Pharmaceutical Co.	10	5	5	5
B029	Bristol Meyers Co.	21	N	N	N
B031	Flow General Inc.	11	4	2	4
B032	Forest Laboratories Inc.	14	N	N	2
B034	ICN Pharmaceuticals Inc.	14	4	4	5
B036	Key Pharmaceuticals Inc.	13	7	7	7
B037	Lilly (Eli) & Co.	21	N	N	N
B038	Marion Laboratories	20	8	9	N
B039	Merck & Co.	21	7	6	N
B040	Pfizer Inc.	21	N	N	N
B041	Richardson-Vicks Inc.	21	7	2	N
B042	Robins (A.H.) Co.	21	N	5	N
B043	Rorer Group	17	7	9	3
B044	Schering-Plough	21	6	5	N
B045	Searle (G.D.) & Co.	17	8	10	6
B047	Smithkline Beckman Corp.	21	8	8	8
B048	Squibb Corp.	18	10	N	5
B049	Sterling Drug Co.	15	7	7	4
B050	Syntex Corp.	21	N	N	8
B051	Techamerica Group Inc.	6	N	2	N
B053	Upjohn Co.	21	N	N	N
B054	Warner-Lambert Co.	21	6	N	N
AVERAGE LAG			6.71	5.79	5.15

		VARIABLE			
		O	K	T	
FILE NO.	SIC -3510 ENGINES AND TURBINES	NO. YRS	SALES	NET INCOME	MARKET SHARE
C062	Briggs & Stratton	14	7	N	4
C063	Brunswick Corp.	14	6	4	2
C064	Cummins Engine	21	6	6	4
C065	Outboard Marine Corp.	20	6	N	4
C066	Teledyne Inc.	14	4	N	6
AVERAGE LAG			5.80	5.00	4.00

\* N = No meaningful figure

TIME SERIES LAG ANALYSIS  
CONTINUED

		VARIABLE			
			O	K	T
FILE NO.	SIC - 3573A - Mainframe ELECTRONIC COMPUTING EQ.	NO. YRS	SALES	NET INCOME	MARKET SHARE
D071	Amdahl Corp.	10	4	7	5
D076	Burroughs Corp.	21	N	N	2
D083	Control Data Corp.	16	8	N	6
D084	Cray Research	9	N	6	N
D085	Data General Corp.	16	N	N	N
D090	Digital Equipment Corp.	19	N	N	5
D096	Hewlett-Packard Co.	21	N	6	7
D097	Honeywell Inc.	15	10	8	5
D098	International Bus. Mach.	15	5	10	3
D107	NCR Corp.	21	9	10	8
D113	Sperry Corp.	21	N	N	5
AVERAGE LAG			7.20	7.83	5.11

		VARIABLE			
			O	K	T
FILE NO.	SIC - 3573B - Small ELECTRONIC COMPUTING EQ.	NO. YRS	SALES	NET INCOME	MARKET SHARE
E073	Apple Computer Inc.	7	N	N	5
E080	Commodore Int'l Ltd.	12	N	N	N
E081	Computer Consoles	14	5	6	6
E082	Computervision Corp.	13	7	8	7
E086	Datapoint Corp.	15	N	N	N
E089	Diagnostic/Retrieval Sys.	6	3	2	2
E091	Electronic Associates Inc	21	N	6	6
E093	Floating Point Sys. Inc.	7	2	2	2
E095	Gould Inc.	14	N	N	6
E099	Intertec Data Systems	5	2	N	2
E101	Lundy Electronics & Sys.	12	N	5	5
E103	Management Assistance	10	6	4	2
E104	Modular Computer Systems	12	N	3	3
E106	NBI Inc.	8	4	3	4
E108	Prime Computer	11	8	7	N
E111	Reynolds & Reynolds	12	6	6	N
E112	Rolm Corp.	10	7	7	7
E119	Wang Laboratories	14	7	7	7
AVERAGE LAG			5.18	5.08	4.57

\* N = No meaningful figure

TIME SERIES LAG ANALYSIS  
CONTINUED

		VARIABLE			
		O	K	T	
FILE NO.	SIC - 3573C - PERIPHERALS ELECTRONIC COMPUTING EQ.	NO. YRS	SALES	NET INCOME	MARKET SHARE
F072	Anderson Jacobson Inc.	16	7	5	8
F074	Applied Magnetics Corp.	16	9	6	6
F078	Centronics Data Computer	14	4	2	N
F079	Cognitronics Corp.	11	N	3	3
F087	Dataproducs Corp.	21	N	8	8
F088	Dataram Corp.	12	N	4	5
F092	Electronic Memories & Mag.	12	3	5	4
F094	Genisco Technology	14	8	7	8
F102	MSI Data Corp.	13	5	4	N
F105	Mohawk Data Sciences	19	10	3	6
F110	Recognition Equipment Inc.	15	N	6	5
F114	Storage Technology Corp.	14	8	3	8
F115	TEC Inc.	17	8	4	4
F116	Telex Corp.	15	N	5	7
F117	Verbatim Corp.	11	5	4	4
F118	Vermont Research Inc.	11	5	3	2
F120	Wespercorp	9	4	3	N
AVERAGE LAG			6.33	4.41	5.57

\* N = No meaningful figure

TIME SERIES LAG ANALYSIS  
CONTINUED

		VARIABLE			
		O	K	T	
FILE NO.	SIC - 3651 RADIO-TV RECEIVING SETS	NO. YRS	SALES	NET INCOME	MARKET SHARE
G131	Coleco Industries	13	7	2	7
G507	Corning Glass	12	7	7	4
G132	Craig Corp.	14	7	7	6
G146	Electrosound Group Inc.	12	N	5	3
G133	Emerson Radio	6	4	3	4
G134	Esquire Radio & Elec. Inc.	15	10	10	2
G137	Matsushita Electric Indl.	13	4	4	4
G519	Minnesota Mining & Mfg.	11	8	8	5
G520	Nippon Electric Company	9	6	6	5
G521	North American Phillips	10	5	3	5
G138	Pioneer Electronic Corp.	9	4	3	3
G139	RCA Corp.	15	9	4	4
G140	Sony Corp.	9	7	7	N
G242	TDK Corp.	11	6	5	6
G144	Wells-Gardner Electronics	15	9	9	9
G145	Zenith Radio Corp.	13	5	3	7
AVERAGE LAG			6.53	5.38	4.93

\* N = No meaningful figure



TIME SERIES LAG ANALYSIS  
CONTINUED

		VARIABLE			
		O	K	T	
FILE NO.	SIC - 3661 TELEPHONE & TELEGRAPH APP	NO. YRS	SALES	NET INCOME	MARKET SHARE
H164	Aydin Corp.	14	5	5	7
H513	GTE	7	3	3	N
H150	Int'l Tele & Tele	21	8	N	N
H151	Lynch Communication System	17	6	6	7
H152	Mitel Corp.	9	4	2	N
H180	Motorola Inc.	15	6	6	5
H212	M/A-Com Inc.	14	N	N	10
H153	Northern Tele Ltd.	12	3	9	6
H181	Oak Industries Inc.	15	9	3	9
H154	Plantronics Inc.	15	4	N	N
H186	Plessey PLC	10	3	2	2
H155	Porta Systems Corp.	11	5	7	7
H190	Scientific-Atlanta Inc.	17	3	3	3
H192	Sparton Corp.	14	N	5	2
H193	Stewart-Warner Corp.	13	6	5	4
H194	Sunair Electronics Inc.	14	4	4	N
H158	Teleconcepts Corp.	11	2	2	2
H159	Telesciences Inc.	16	4	5	4
H197	Texscan Corp.	15	3	2	3
H198	Timeplex Inc.	12	2	4	2
H199	Torotel Inc.	12	3	3	4
H160	Trans-Lux Corp.	15	4	3	4
H195	TRW Inc.	13	N	7	N
AVERAGE LAG			4.35	4.30	4.76

\* N = No meaningful figure

TIME SERIES LAG ANALYSIS  
CONTINUED

		VARIABLE			
		O	K	T	
FILE NO.	SIC - 3662 RADIO-TV TRANSMITTING EQ.	NO. YRS	SALES	NET INCOME	MARKET SHARE
I220	Adams Russell	12	N	2	N
I170	EDO Corp.	17	4	5	3
I169	E-Systems Inc.	13	8	2	8
I149	General Datacomm Ind. Inc	12	6	6	6
I173	Harris Corp.	14	6	8	8
I174	Hazeltine Corp.	15	4	6	2
I175	Instrument Systems Corp.	7	3	5	4
I179	Loral Corp.	14	4	5	4
I182	Paradyne Corp.	8	5	N	5
I188	Raytheon Co.	21	6	6	7
I189	Sanders Associates Inc.	14	N	7	3
I241	T Bar Inc.	11	N	5	N
I196	Tech-Sym Corp.	17	6	7	6
I200	United Industrial Corp.	14	3	3	7
I202	Watkins-Johnson	13	6	7	4
AVERAGE LAG			5.08	5.29	5.15

\* N = No meaningful figure

TIME SERIES LAG ANALYSIS  
CONTINUED

		VARIABLE			
		O	K	T	
FILE NO.	SIC - 3674 SEMICONDUCTORS	NO. YRS	SALES	NET INCOME	MARKET SHARE
J207	Advanced Micro Devices	13	N	6	5
J208	Alpha Inds.	12	7	2	2
J209	Analog Devices	14	3	5	3
J504	Applied Materials	9	N	6	5
J508	Eaton	10	N	8	2
J511	GCA	8	N	N	N
J210	INTEL Corp.	14	6	5	6
J211	Int'l Rectifier Corp.	18	5	5	3
J514	KLA	6	3	3	3
J515	Kulicke & Soffa	10	6	N	N
J517	LTX	5	4	4	4
J518	Materials Research	8	5	3	4
J213	National Semiconductor	15	6	6	3
J319	Teradyne Inc.	10	7	N	6
J217	Texas Instrument Inc.	13	N	5	6
J218	Unitrode Corp.	14	6	6	7
J205	Varian Associates Inc.	21	N	5	2
AVERAGE LAG			5.27	4.93	4.07

\* N = No meaningful figure

TIME SERIES LAG ANALYSIS  
CONTINUED

		VARIABLE			
		O	K	T	
FILE NO.	SIC - 3679 ELECTRONIC COMPONENTS NEC	NO. YRS	SALES	NET INCOME	MARKET SHARE
K121	Acme Electric Corp.	17	4	3	4
K122	Ametek Inc.	15	8	5	6
K503	AMP	13	7	7	7
K161	Andrea Radio Corp.	15	9	2	4
K219	AVX Corp.	12	6	7	7
K123	Baldor Electric	10	2	8	N
K223	Burndy Corp.	14	7	N	4
K166	Canadian Maraconi Co.	21	8	8	4
K248	Champion Spark Plug	15	8	4	3
K506	Cincinnati Milicron	11	N	6	4
K203	Clarostat Mfg. Co. Inc.	18	N	5	2
K224	CTS Corp.	13	4	N	5
K168	Cubic Corp.	15	5	5	5
K228	EECO	14	4	6	3
K509	EG&G	8	5	5	5
K229	Electro Audio Dynamics	13	3	3	7
K128	Electronics Corp of Am.	18	7	3	5
K510	Emerson Electric	11	N	N	5
K171	Federal Signal Corp.	10	5	6	5
K512	General Electric	8	2	5	5
K204	General Instrument Corp.	21	8	6	9
K314	General Signal Corp.	12	7	N	N
K232	GTI Corp.	12	4	3	3
K135	Gulton Industries Inc.	15	7	3	4
K316	Hipotronics Inc.	8	N	3	5
K234	Int'l Power Machines Corp	5	2	4	2
K177	Knogo Corp.	12	3	4	3
K235	Kollmorgan Corp.	15	N	N	N
K236	Kyocera Corp.	9	4	N	4
K516	Litton Industries	11	7	N	3
K522	Nordson	16	6	7	3
K237	Nuclear Data	21	N	6	3
K183	Penril Corp.	11	4	N	4
K185	Pittway Corp.	13	2	2	2
K240	Rogers Corp.	21	N	6	6

TIME SERIES LAG ANALYSIS  
CONTINUED

		VARIABLE			
		O	K	T	
FILE NO.	SIC - 3679 CONTINUED ELECTRONIC COMPONENTS NEC	NO. YRS	SALES	NET INCOME	MARKET SHARE
K214	Semtech Corp.	16	7	6	5
K191	Servo Corp. of America	21	N	9	4
K524	Singer	11	7	4	3
K243	Thomas & Betts Corp.	21	9	10	10
K525	Tracor	11	8	7	7
K206	Varo Inc.	15	2	5	4
K244	Veeco Instruments	21	N	N	N
K126	Vernitron Corp.	14	5	6	7
K528	Westinghouse	7	4	N	N
AVERAGE LAG			5.43	5.26	4.64

TIME SERIES LAG ANALYSIS  
CONTINUED

		VARIABLE			
		O		K	T
FILE NO.	SIC - 3721 AIRCRAFT	NO. YRS	SALES	NET INCOME	MARKET SHARE
L258	Boeing Co.	15	7	6	N
L259	Cessna Aircraft Co.	14	N	N	N
L260	Fairchild Industries Inc.	14	N	N	N
L261	Gates Learjet Corp.	15	4	4	N
L262	General Dynamics Corp.	14	6	4	3
L263	Grumman Corp.	15	9	N	6
L280	Lockheed Corp.	21	N	N	7
L281	Martin Marietta Corp.	15	7	4	2
L265	McDonnell Douglas Corp.	16	N	5	7
L266	Northrop Corp.	14	5	3	2
L282	Rockwell International	14	N	N	2
L267	Textron Inc.	21	2	9	5
AVERAGE LAG			5.71	5.00	4.25

		VARIABLE			
		O		K	T
FILE NO.	SIC - 3728 AIRCRAFT PARTS & AUX. EQ.	NO. YRS	SALES	NET INCOME	MARKET SHARE
M268	Aeronca Inc.	15	3	4	4
M252	Curtiss Wright Corp.	21	6	6	N
M270	Lear Siegler Inc.	14	3	3	4
M272	Moog Inc.	15	2	2	7
M275	Sierracin Corp.	14	2	6	6
M276	Signal Companies	14	5	N	5
M254	Sundstrand Corp.	15	5	5	4
M277	TRE Corp.	14	N	N	8
M255	United Technologies Corp.	14	7	6	7
AVERAGE LAG			4.13	4.57	5.63

\* N = No meaningful figure

TIME SERIES LAG ANALYSIS  
CONTINUED

		VARIABLE			
		O	K	T	
FILE NO.	SIC - 3811 ENGINEERING LAB & RES.	NO. YRS	SALES	NET INCOME	MARKET SHARE
N284	Gerber Scientific Inc.	18	N	6	N
N294	Instron Corp.	21	N	7	5
N298	Nicolet Instrument	14	N	8	6
N299	Perkin Elmer Corp.	21	7	7	7
N287	Sargent Welch Scientific	15	N	N	3
N288	Spectra Physics	17	6	3	6
N335	Sybron Corp.	19	2	5	N
N302	Vishay Intertechnology	12	N	6	6
N290	Whitehall Corp.	15	7	7	5
AVERAGE LAG			5.50	6.13	5.43

		VARIABLE			
		O	K	T	
FILE NO.	SIC - 3820 MEASURING & CONTROL INST.	NO. YRS	SALES	NET INCOME	MARKET SHARE
0291	Badger Meter Inc.	19	3	7	2
0292	Bowmar Instrument Corp.	13	4	3	5
0312	Fluke (John) Mfg. Co.	14	7	6	6
0306	Foxboro Co.	18	10	9	2
0295	Johnson Controls Inc.	15	8	7	5
0297	Mark Controls	15	10	8	N
0308	Measurex Corp.	13	6	5	3
0301	Robertshaw Controls	21	9	8	3
0523	Schlumberger	10	7	N	N
0317	Sun Electric Corp.	12	2	5	4
0129	Tech Ops Inc.	13	2	5	6
0303	Watsco Inc.	14	5	4	5
AVERAGE LAG			6.08	6.09	4.10

\* N = No meaningful figure

TIME SERIES LAG ANALYSIS  
CONTINUED

		VARIABLE			
		O		K	T
FILE NO.	SIC - 3825 ELECTRICAL MEASUREMENT	NO. YRS	SALES	NET INCOME	MARKET SHARE
P165	Barnes Engineering Co.	21	5	7	5
P311	Cohu Inc.	11	3	3	3
P167	Conrac Corp.	15	3	4	5
P293	Esterline Corp.	14	7	7	3
P305	Fischer & Porter Co.	15	N	3	2
P315	Genrad Inc.	11	6	3	N
P068	Mangood Corp.	14	4	2	4
P346	Talley Industries Inc.	14	5	2	5
P318	Tektronix Inc.	21	10	10	5
P278	Teleflex Inc.	21	3	2	5
P201	Vicon Industries Inc.	11	N	7	N
P309	Western Pacific Ind.	10	6	N	5
AVERAGE LAG			5.20	4.55	4.20

		VARIABLE			
		O		K	T
FILE NO.	SIC - 3841 SURGICAL & MEDICAL INST	NO. YRS	SALES	NET INCOME	MARKET SHARE
Q323	Bard (C.R.) Inc.	14	5	5	6
Q320	Bausch & Lomb Inc.	21	5	3	5
Q324	Baxter Travenol Lab.	21	4	4	4
Q325	Becton, Dickerson & Co.	20	9	N	N
Q326	Bio-Rad Laboratories	11	7	6	N
Q328	Delmed Inc.	6	2	N	2
Q283	Gelman Sciences Inc.	15	N	6	N
Q245	Intermedics Inc.	10	5	2	5
Q329	Laser Industries Ltd.	5	4	3	4
Q246	Medtronic Inc.	15	6	6	5
Q330	Mountain Medical Eq.	5	N	N	N
Q333	National Patent Dev.	12	7	6	5
Q247	Xonics Inc.	12	5	4	6
AVERAGE LAG			5.36	4.50	4.67

\* N = No meaningful figure



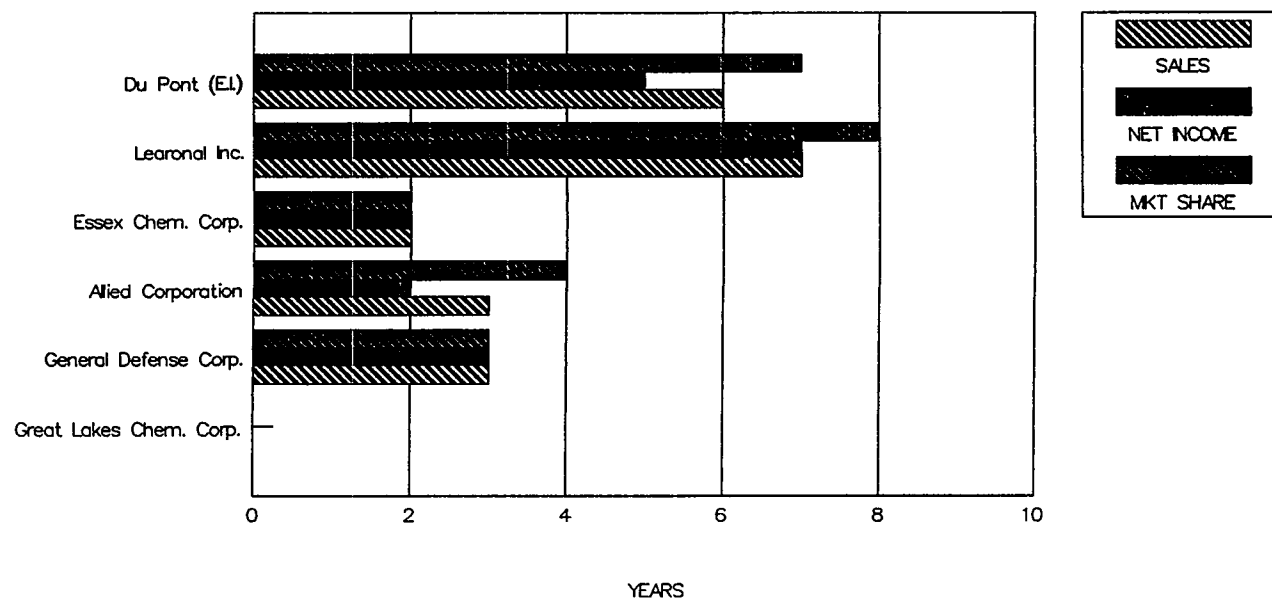
TIME SERIES LAG ANALYSIS  
CONTINUED

		VARIABLE			
		O	K	T	
FILE NO.	SIC - 3861 PHOTOGRAPHIC EQ. & SUPPL.	NO. YRS	SALES	NET INCOME	MARKET SHARE
R501	AM International	8	2	5	2
R336	Bell & Howell Co.	21	6	7	4
R337	Compugraphic Corp.	13	7	5	6
R338	Eastman Kodak Co.	20	7	6	N
R340	Matrix Corp.-NJ	7	N	3	4
R341	Orrox Corp. - NOW CMX	11	6	7	6
R069	Pitney Bowes Inc.	21	10	4	N
R342	Polaroid Corp.	21	7	3	3
R343	Speed-O-Print Bus. Mach.	15	4	5	4
R344	Visual Graphics	16	3	3	3
R345	Xerox Corp.	21	5	N	N
AVERAGE LAG			5.70	4.80	4.00

\* N = No meaningful figure

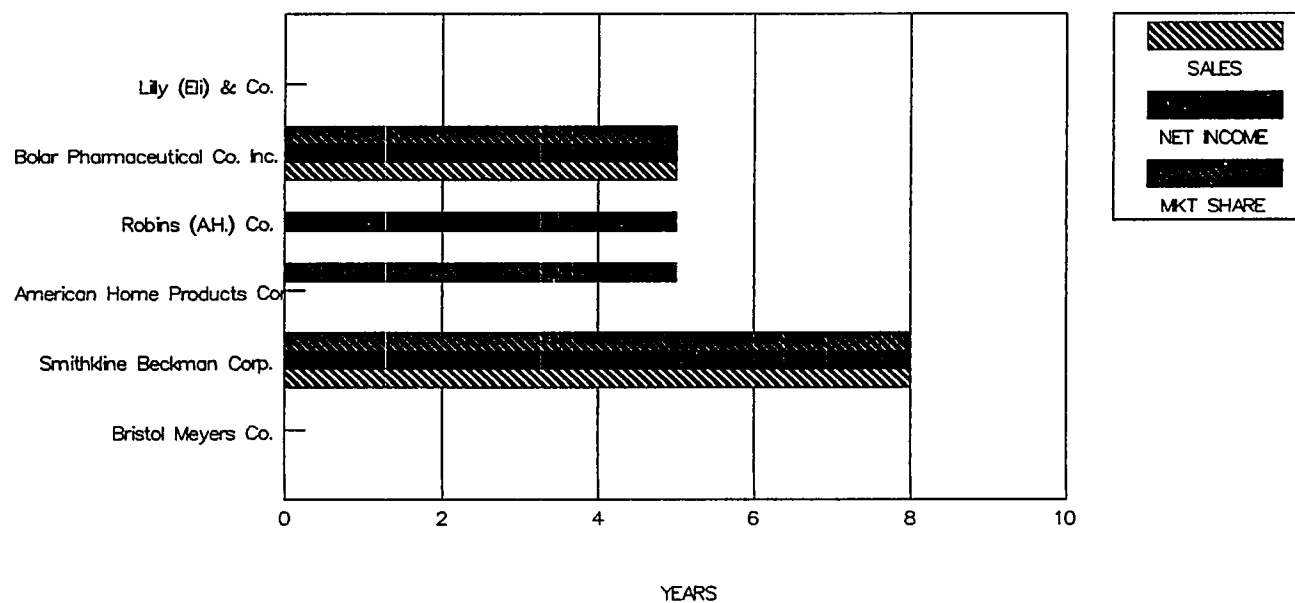
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SIC 2800



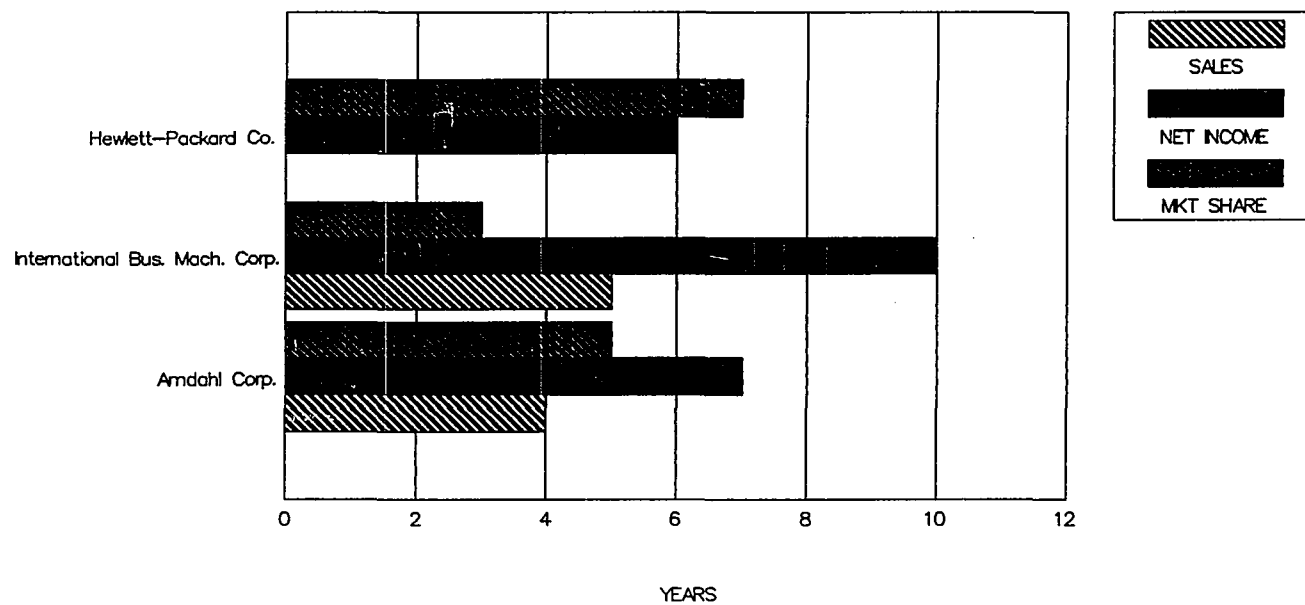
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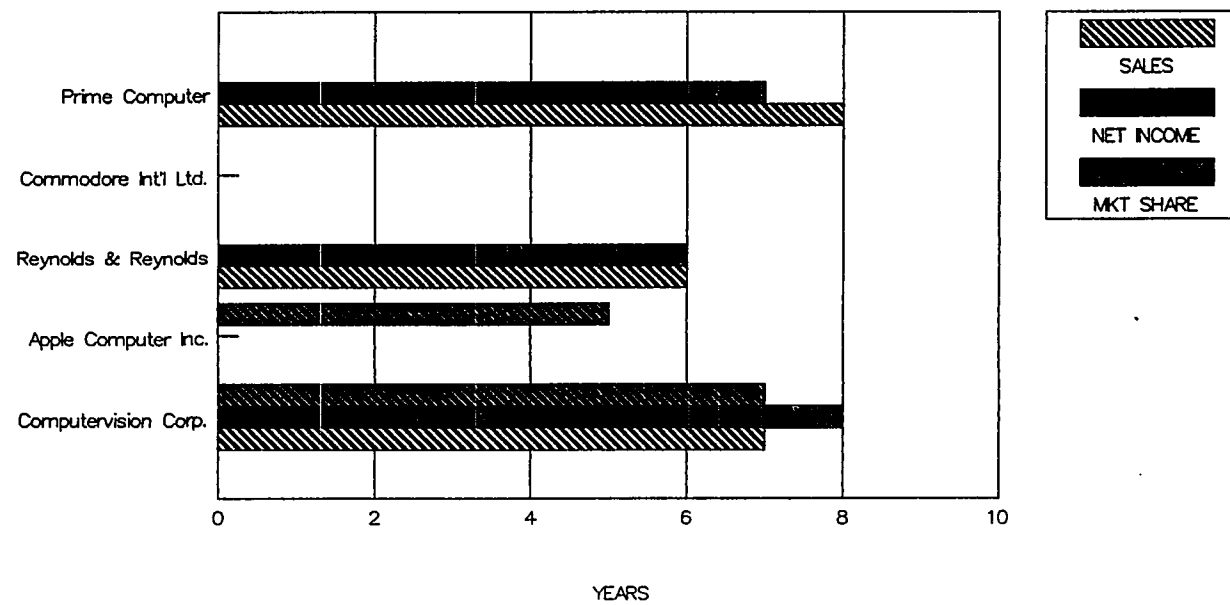
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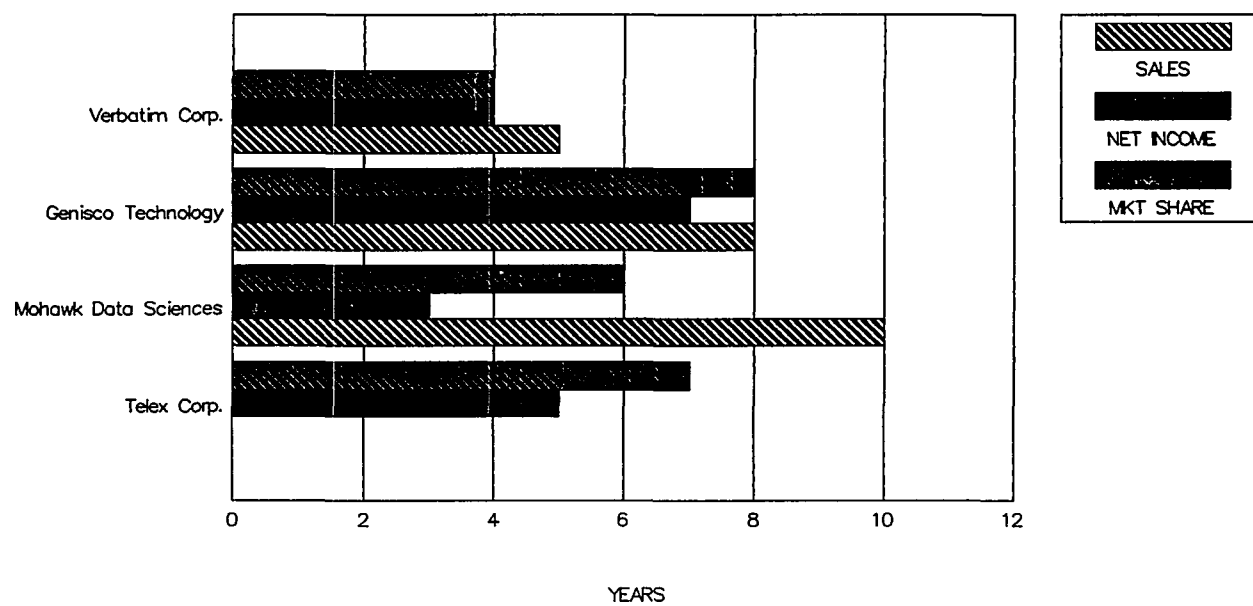
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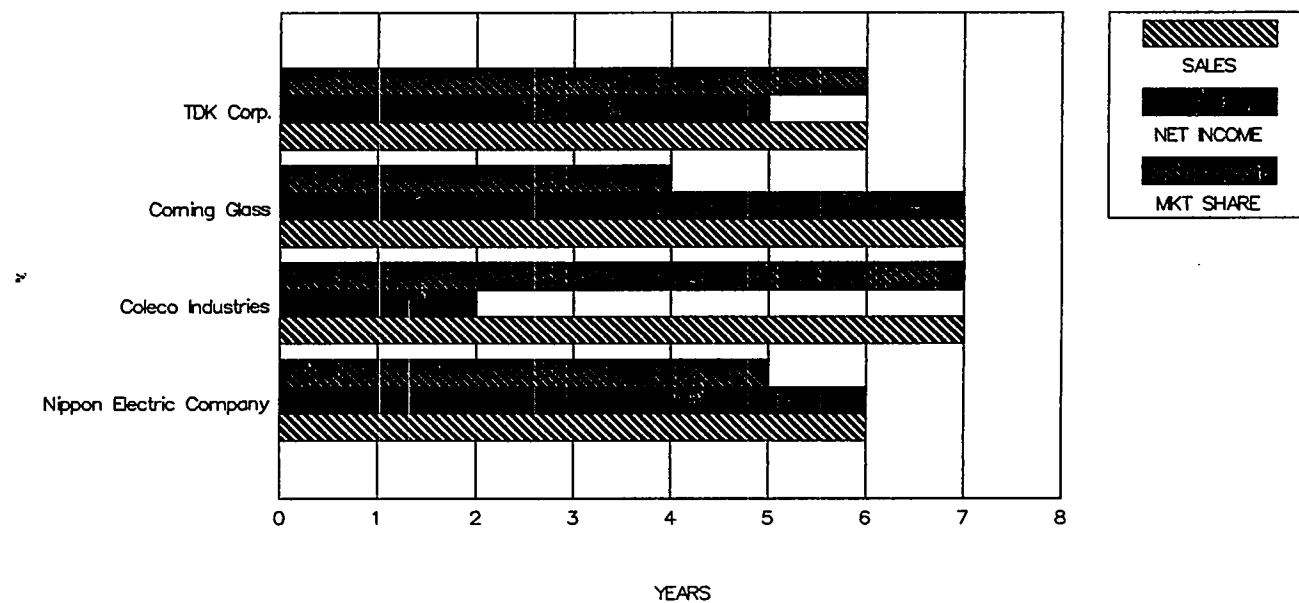
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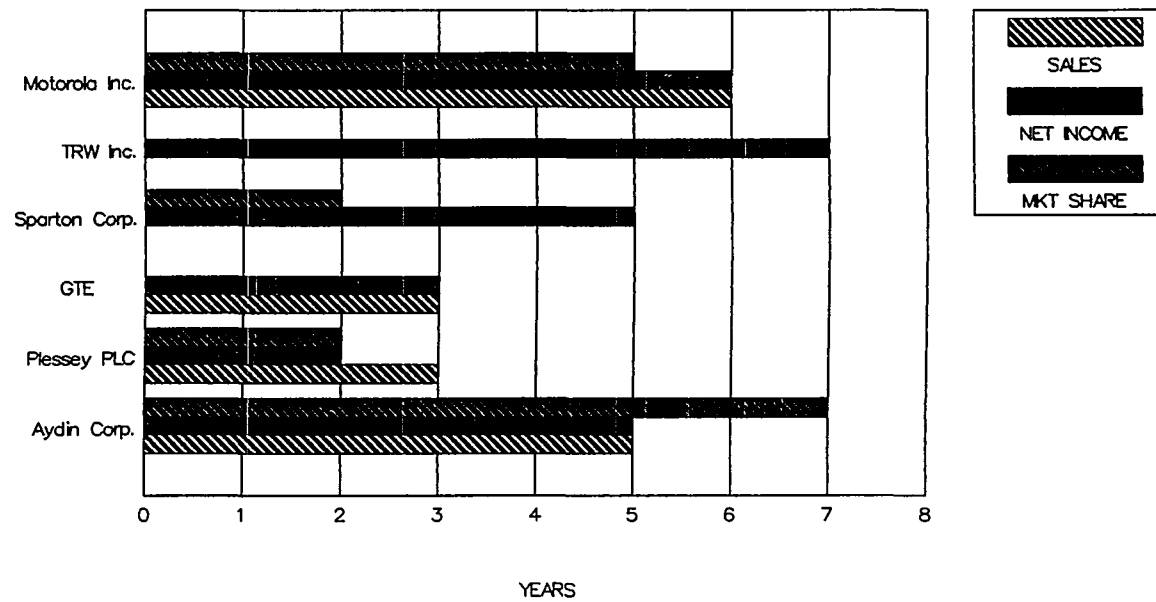
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SIC 3651



# LAG FIRST QUARTILE

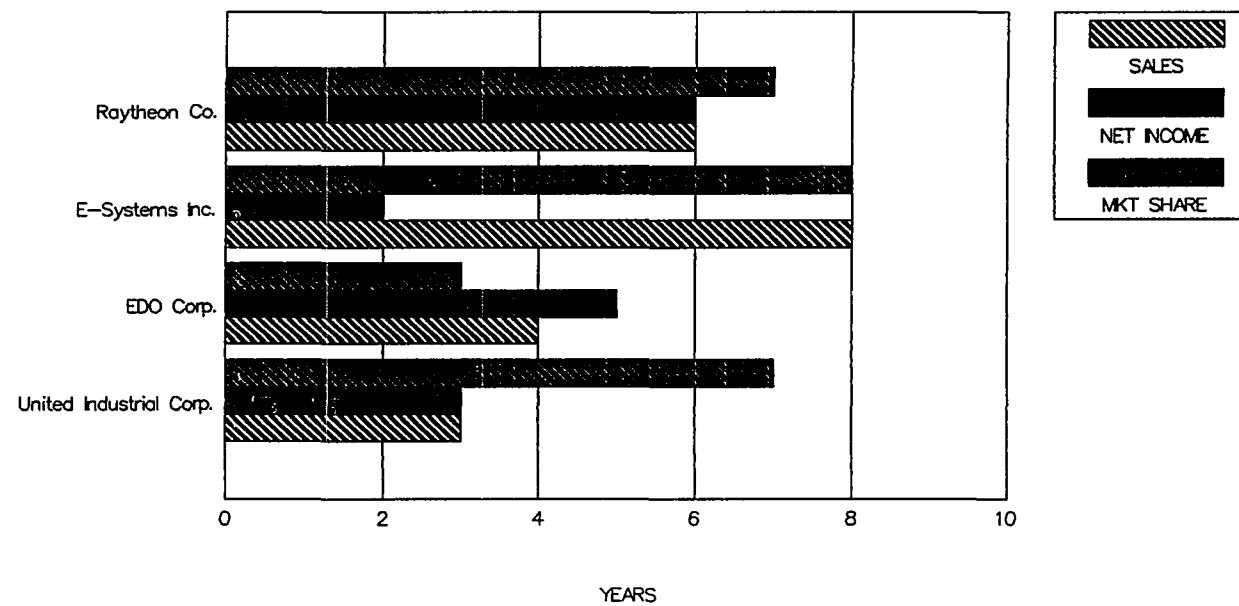
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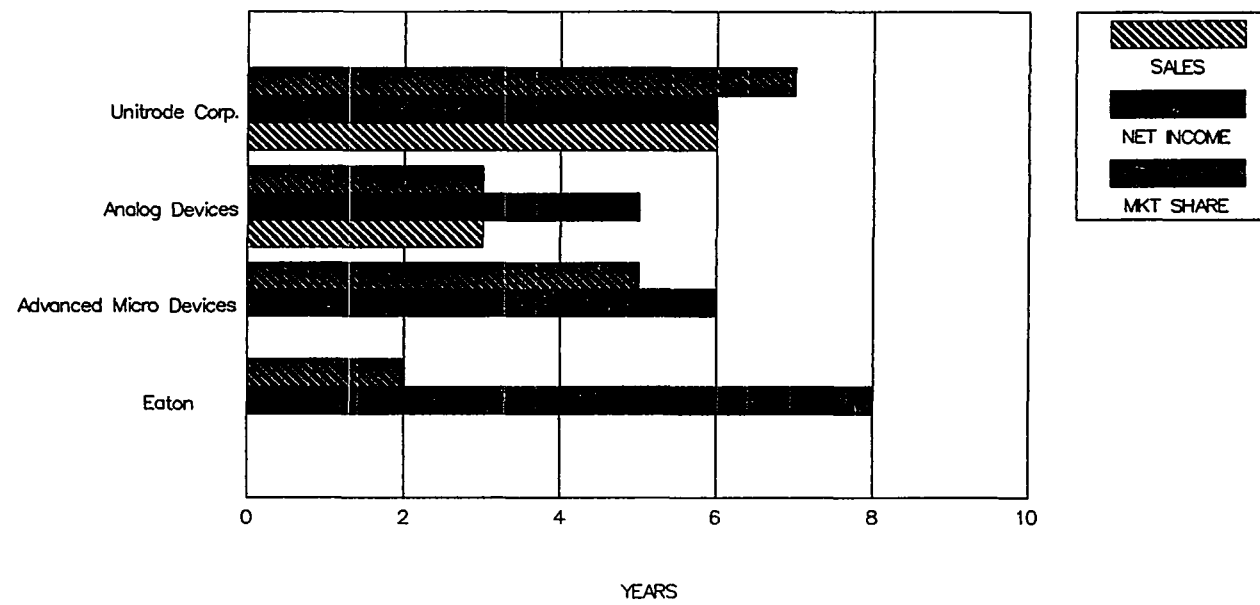
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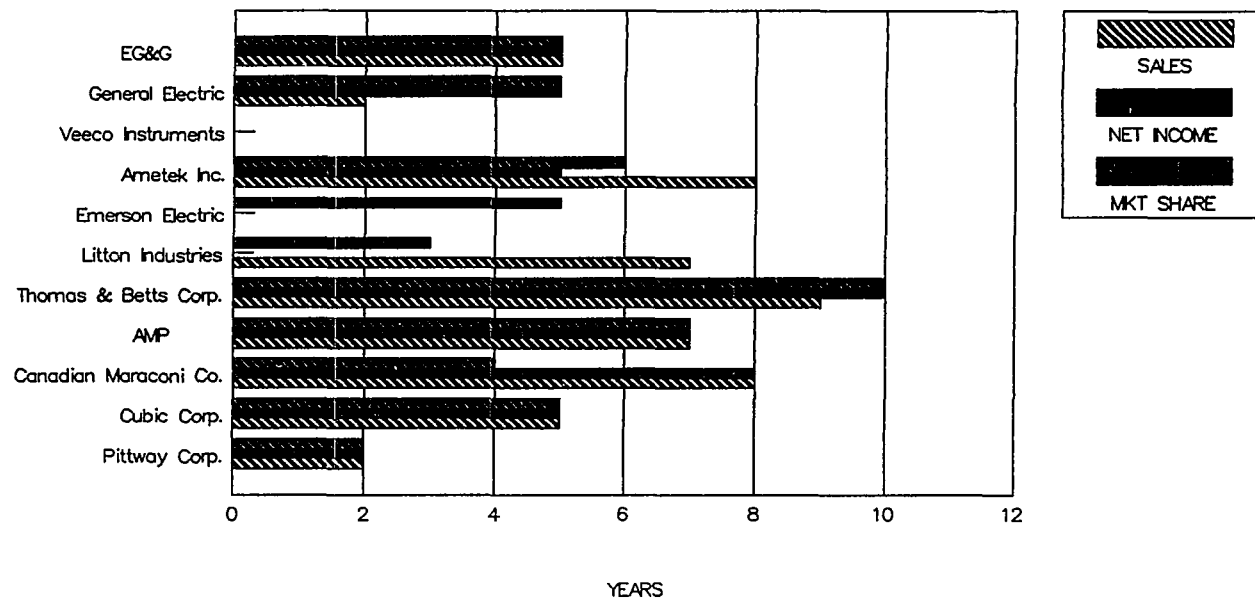
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SIC 3674



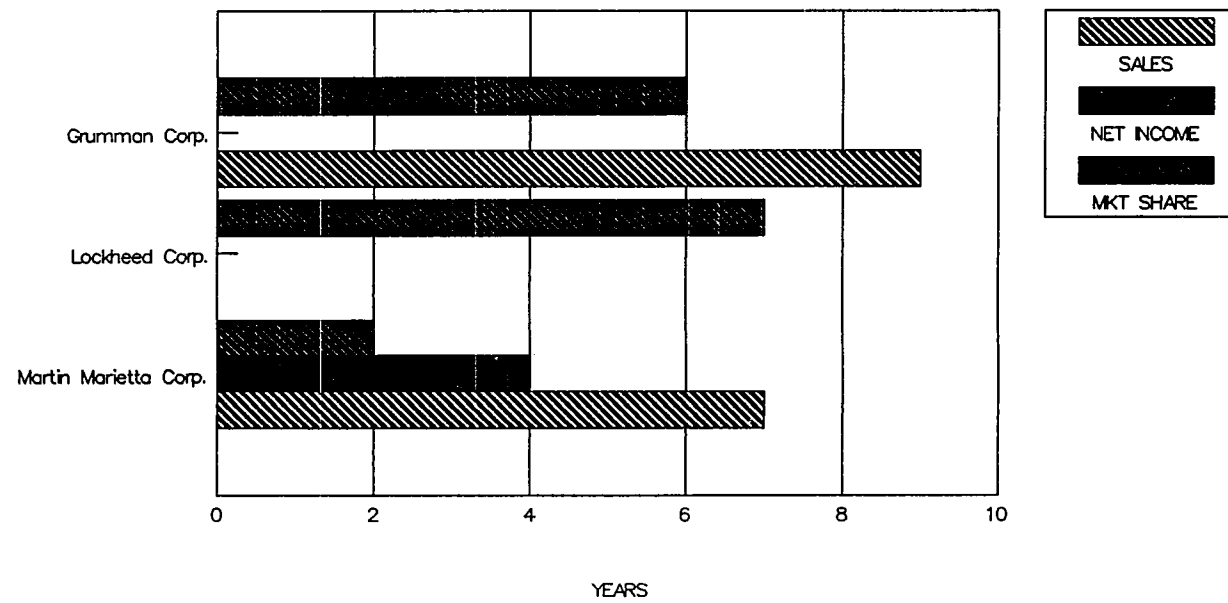
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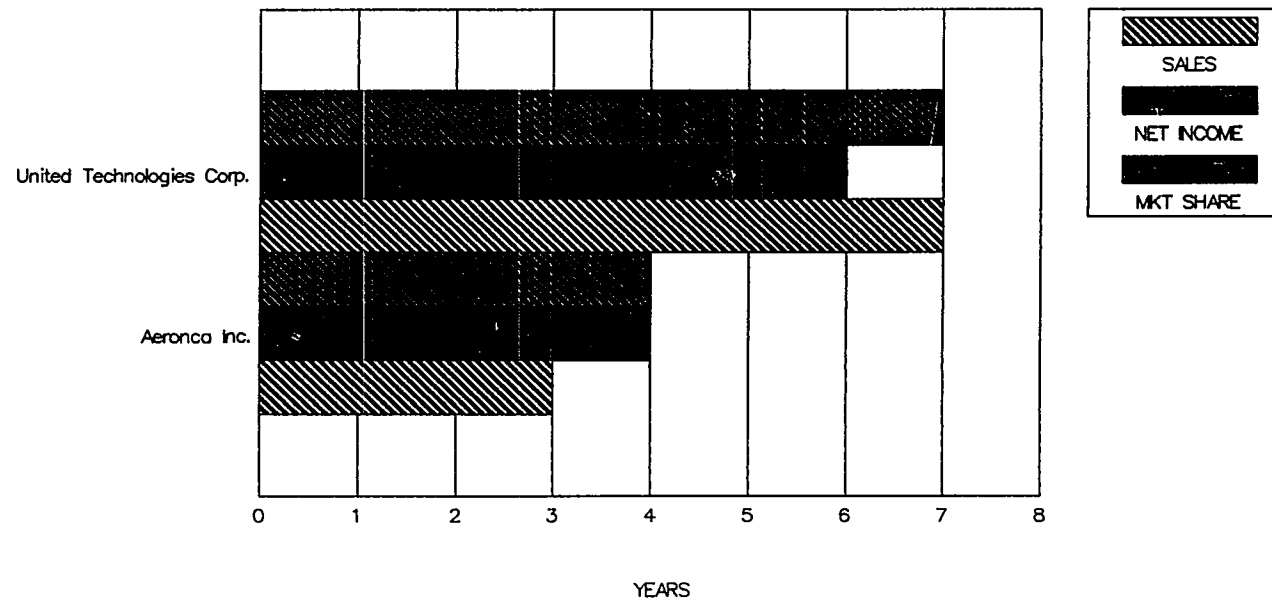
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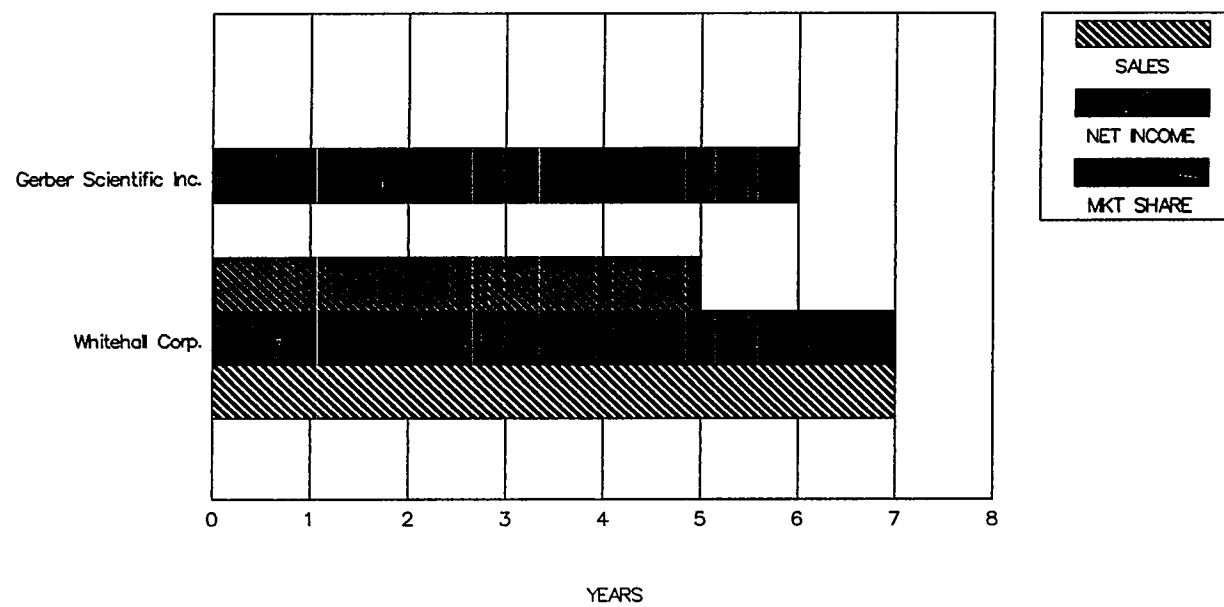
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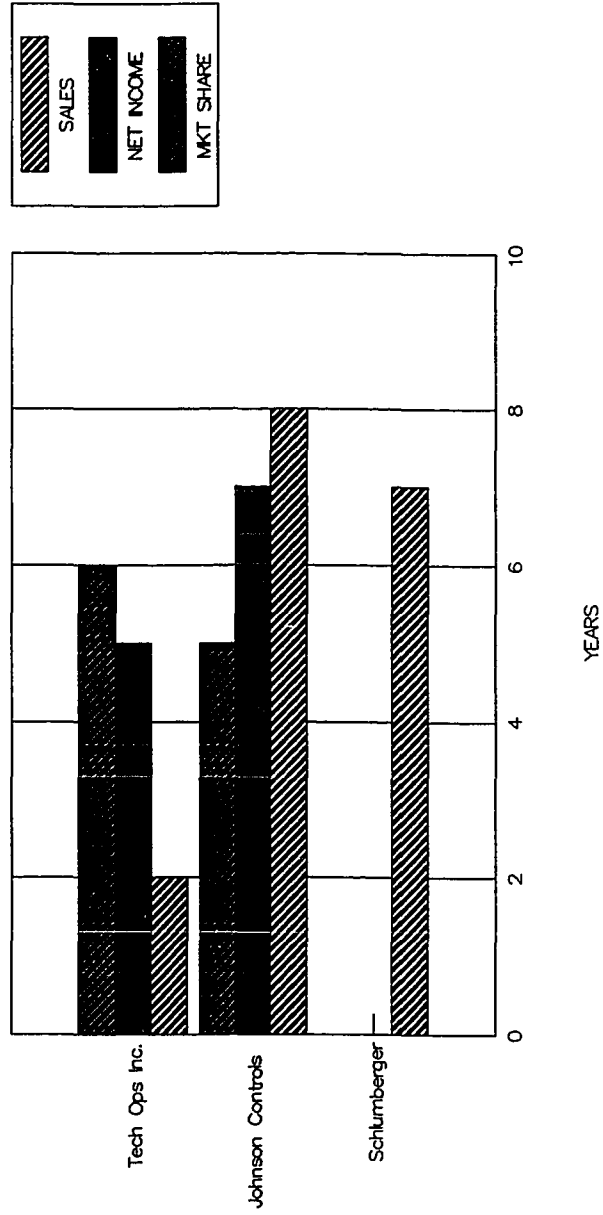
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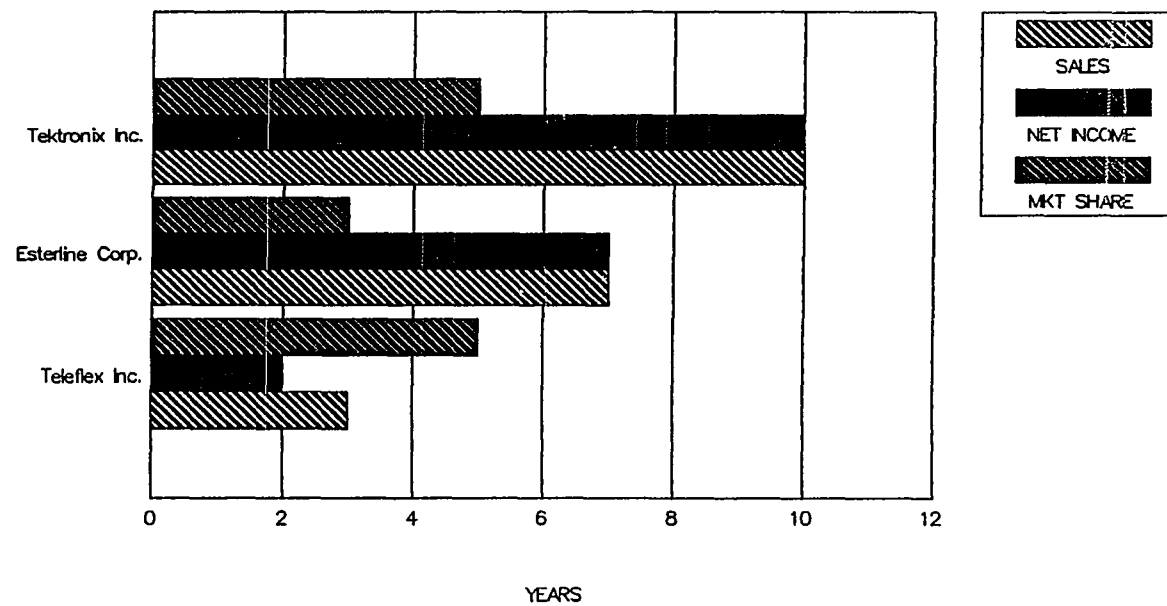
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SIC 3820



# LAG FIRST QUARTILE

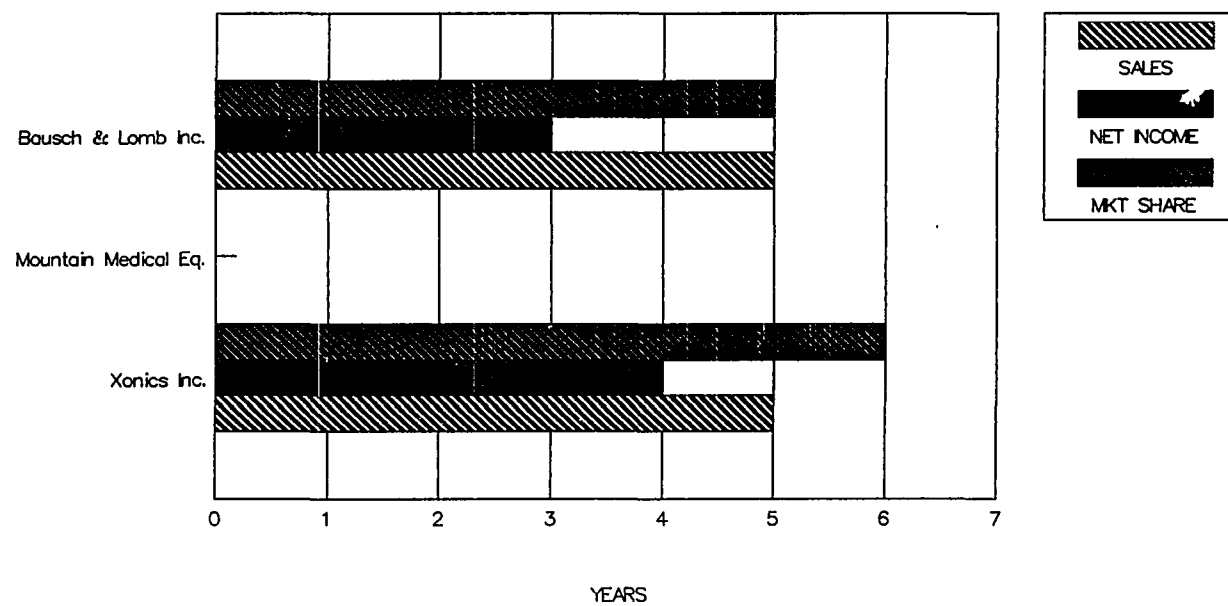
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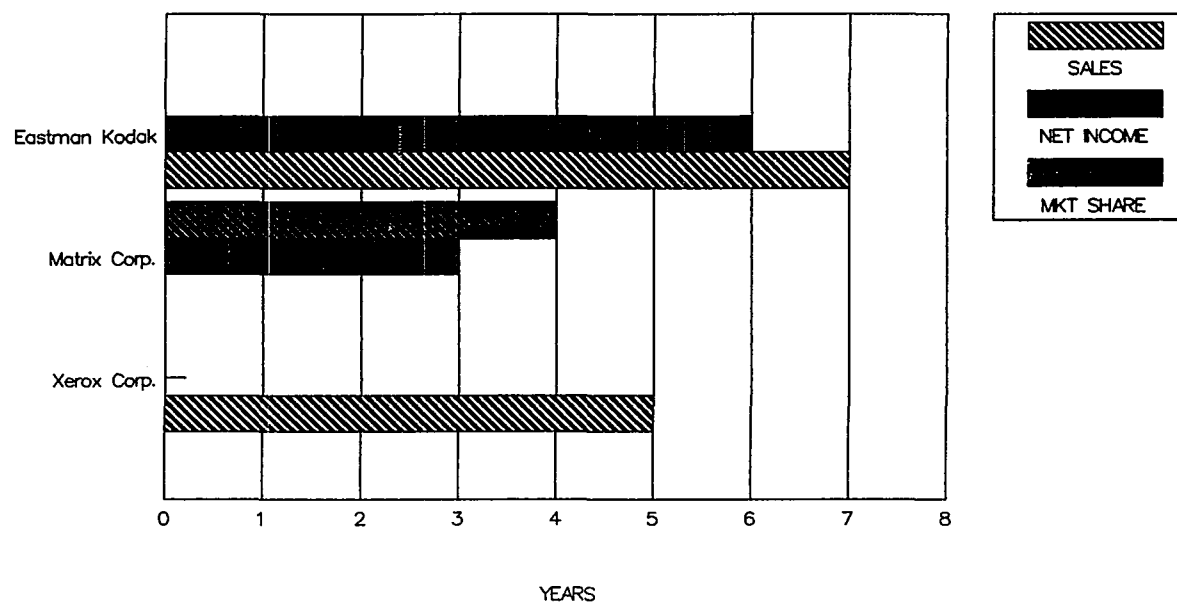
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SIC 3841



# LAG FIRST QUARTILE

SIC 3861



## APPENDIX I

### COVARIANCE ANALYSIS

This appendix contains the results of the covariance analysis for two and four digit Standard Industrial Classification (SIC) computations.

COVARIANCE TABULATION BY INDUSTRY (FOUR DIGIT SIC)  
(Total Assets held constant)

VAR. NAME	SIC - 2800 CHEMICALS	F VALUE	COMPUTED F VALUE	R
LN	R&D VS NET INCOME	3.290	0.372	SIG
LS	R&D VS SALES	3.290	0.392	
LR	R&D VS ROI	3.290	0.656	
LM	R&D VS MARKET SHARE	3.290	0.438	
QN	% R&D VS NET INCOME	3.290	0.438	
QS	% R&D VS SALES	3.290	1.275	
QR	% R&D VS ROI	3.290	1.880	
QM	% R&D VS MARKET SHARE	3.290	0.628	
VAR. NAME	SIC - 2830 DRUGS	F VALUE	COMPUTED F VALUE	R
LN	R&D VS NET INCOME	3.150	0.239	SIG
LS	R&D VS SALES	3.150	0.222	
LR	R&D VS ROI	3.150	0.563	
LM	R&D VS MARKET SHARE	3.150	0.608	
QN	% R&D VS NET INCOME	3.150	0.080	
QS	% R&D VS SALES	3.150	2.904	
QR	% R&D VS ROI	3.150	0.446	
QM	% R&D VS MARKET SHARE	3.150	3.682	
VAR. NAME	SIC - 3573B ELECTRONIC COMPUTING	F VALUE	COMPUTED F VALUE	R
LN	R&D VS NET INCOME	3.600	0.563	SIG
LS	R&D VS SALES	3.600	8.118	
LR	R&D VS ROI	3.600	1.561	
LM	R&D VS MARKET SHARE	3.600	0.192	
QN	% R&D VS NET INCOME	3.600	1.757	
QS	% R&D VS SALES	3.600	1.108	
QR	% R&D VS ROI	3.600	1.108	
QM	% R&D VS MARKET SHARE	3.600	1.021	

\*\*\* R=Remarks

SIG=Significant

VAR. NAME	SIC - 3573C ELECTRONIC COMPUTING	F VALUE	COMPUTED F VALUE	R
LN	R&D VS NET INCOME	3.600	1.604	
LS	R&D VS SALES	3.600	21.766	SIG
LR	R&D VS ROI	3.600	11.808	SIG
LM	R&D VS MARKET SHARE	3.600	28.624	SIG
QN	% R&D VS NET INCOME	3.600	1.317	
QS	% R&D VS SALES	3.600	0.601	
QR	% R&D VS ROI	3.600	0.422	
QM	% R&D VS MARKET SHARE	3.600	0.612	
VAR. NAME	SIC - 3651 RADIO-TV RECEIVING SETS	F VALUE	COMPUTED F VALUE	R
LN	R&D VS NET INCOME	3.600	0.714	
LS	R&D VS SALES	3.600	0.765	
LR	R&D VS ROI	3.600	2.307	
LM	R&D VS MARKET SHARE	3.600	0.706	
QN	% R&D VS NET INCOME	3.600	0.383	
QS	% R&D VS SALES	3.600	1.849	
QR	% R&D VS ROI	3.600	3.734	SIG
QM	% R&D VS MARKET SHARE	3.600	2.504	
VAR. NAME	SIC - 3661 TELEPHONE & TELEGRAPH	F VALUE	COMPUTED F VALUE	R
LN	R&D VS NET INCOME	3.290	4.331	SIG
LS	R&D VS SALES	3.290	23.342	SIG
LR	R&D VS ROI	3.290	2.304	
LM	R&D VS MARKET SHARE	3.290	23.427	SIG
QN	% R&D VS NET INCOME	3.290	0.794	
QS	% R&D VS SALES	3.290	0.286	
QR	% R&D VS ROI	3.290	1.278	
QM	% R&D VS MARKET SHARE	3.290	0.305	
VAR. NAME	SIC - 3662 RADIO-TV TRANS. EQ.	F VALUE	COMPUTED F VALUE	R
LN	R&D VS NET INCOME	4.350	0.039	
LS	R&D VS SALES	4.350	0.346	
LR	R&D VS ROI	4.350	0.239	
LM	R&D VS MARKET SHARE	4.350	0.200	
QN	% R&D VS NET INCOME	4.350	1.005	
QS	% R&D VS SALES	4.350	0.169	
QR	% R&D VS ROI	4.350	0.627	
QM	% R&D VS MARKET SHARE	4.350	0.505	

\*\*\* R=Remarks

SIG=Significant

VAR. NAME	SIC - 3674 SEMICONDUCTORS	F VALUE	COMPUTED F VALUE	R
LN	R&D VS NET INCOME	3.600	0.424	SIG
LS	R&D VS SALES	3.600	1.562	
LR	R&D VS ROI	3.600	4.521	
LM	R&D VS MARKET SHARE	3.600	0.948	
QN	% R&D VS NET INCOME	3.600	0.812	
QS	% R&D VS SALES	3.600	0.568	
QR	% R&D VS ROI	3.600	0.247	
QM	% R&D VS MARKET SHARE	3.600	0.189	
VAR. NAME	SIC - 3679 ELECTRONIC COMP. (NEC)	F VALUE	COMPUTED F VALUE	R
LN	R&D VS NET INCOME	2.850	0.141	SIG
LS	R&D VS SALES	2.850	0.625	
LR	R&D VS ROI	2.850	3.538	
LM	R&D VS MARKET SHARE	2.850	1.345	
QN	% R&D VS NET INCOME	2.850	0.364	
QS	% R&D VS SALES	2.850	1.806	
QR	% R&D VS ROI	2.850	1.983	
QM	% R&D VS MARKET SHARE	2.850	0.392	
VAR. NAME	SIC - 3721 AIRCRAFT	F VALUE	COMPUTED F VALUE	R
LN	R&D VS NET INCOME	4.350	0.954	
LS	R&D VS SALES	4.350	3.109	
LR	R&D VS ROI	4.350	0.262	
LM	R&D VS MARKET SHARE	4.350	3.480	
QN	% R&D VS NET INCOME	4.350	0.257	
QS	% R&D VS SALES	4.350	1.407	
QR	% R&D VS ROI	4.350	1.881	
QM	% R&D VS MARKET SHARE	4.350	0.872	
VAR. NAME	SIC - 3820 MEASURING & CNTRL INST.	F VALUE	COMPUTED F VALUE	R
LN	R&D VS NET INCOME	4.350	10.798	SIG SIG
LS	R&D VS SALES	4.350	4.373	
LR	R&D VS ROI	4.350	2.990	
LM	R&D VS MARKET SHARE	4.350	3.567	
QN	% R&D VS NET INCOME	4.350	0.583	
QS	% R&D VS SALES	4.350	0.843	
QR	% R&D VS ROI	4.350	0.247	
QM	% R&D VS MARKET SHARE	4.350	0.839	

\*\*\* R=Remarks

SIG=Significant

VAR. NAME	SIC - 3825 MEASUREMENT/TEST INST.	F VALUE	COMPUTED F VALUE	R
LN	R&D VS NET INCOME	4.350	0.162	
LS	R&D VS SALES	4.350	0.812	
LR	R&D VS ROI	4.350	0.835	
LM	R&D VS MARKET SHARE	4.350	0.846	
QN	% R&D VS NET INCOME	4.350	0.910	
QS	% R&D VS SALES	4.350	1.998	
QR	% R&D VS ROI	4.350	1.449	
QM	% R&D VS MARKET SHARE	4.350	2.354	
VAR. NAME	SIC - 3841 SURGICAL & MEDICAL INST.	F VALUE	COMPUTED F VALUE	R
LN	R&D VS NET INCOME	4.350	0.427	
LS	R&D VS SALES	4.350	0.725	
LR	R&D VS ROI	4.350	0.207	
LM	R&D VS MARKET SHARE	4.350	0.969	
QN	% R&D VS NET INCOME	4.350	0.528	
QS	% R&D VS SALES	4.350	1.638	
QR	% R&D VS ROI	4.350	4.467	SIG
QM	% R&D VS MARKET SHARE	4.350	4.514	SIG

\*\*\* R=Remarks

SIG=Significant

COVARIANCE TABULATION BY INDUSTRY (TWO DIGIT SIC)  
(Total Assets held constant)

VAR. NAME	SIC - 2800 CHEMICALS AND DRUGS	F VALUE	COMPUTED F VALUE	R
LR	R&D VS ROI	2.850	0.311	SIG
LM	R&D VS MARKET SHARE	2.850	9.067	
QR	% R&D VS ROI	2.850	1.200	
QM	% R&D VS MARKET SHARE	2.850	2.842	
VAR. NAME	SIC - 3573 COMPUTERS	F VALUE	COMPUTED F VALUE	R
LR	R&D VS ROI	2.790	0.139	SIG
LM	R&D VS MARKET SHARE	2.790	4.330	
QR	% R&D VS ROI	2.790	0.546	
QM	% R&D VS MARKET SHARE	2.790	0.546	
VAR. NAME	SIC - 3600 ELECTRONICS	F VALUE	COMPUTED F VALUE	R
LR	R&D VS ROI	2.720	4.946	SIG
LM	R&D VS MARKET SHARE	2.720	6.428	SIG
QR	% R&D VS ROI	2.720	4.946	SIG
QM	% R&D VS MARKET SHARE	2.720	6.428	SIG
VAR. NAME	SIC - 3700 AIRCRAFT	F VALUE	COMPUTED F VALUE	R
LR	R&D VS ROI	3.290	0.709	
LM	R&D VS MARKET SHARE	3.290	0.528	
QR	% R&D VS ROI	3.290	1.034	
QM	% R&D VS MARKET SHARE	3.290	0.467	
VAR. NAME	SIC - 3800 INSTRUMENTS	F VALUE	COMPUTED F VALUE	R
LR	R&D VS ROI	2.805	0.552	SIG
LM	R&D VS MARKET SHARE	2.805	5.938	
QR	% R&D VS ROI	2.805	0.960	
QM	% R&D VS MARKET SHARE	2.805	1.842	

\*\*\* R=Remarks                      SIG=Significant



## APPENDIX J

### START UP ANALYSIS

Appendix J is a summary of Start Up and Mature firm regression models. The tables include:

1. A summary of the  $r^2$  models.
2. A summary of Start-Up and Mature firm company averages for 12 variables.
3. A summary of the first and fourth quartile results including standard deviation, maximum and minimum numbers.

START-UP AND MATURE FIRM  
SINGLE AND MULTIPLE REGRESSION  
 $R^2$

MODEL	SALES = CONSTANT + R&D \$	SALES = CONSTANT + R&D \$ + TOTAL ASSETS	NET INCOME = CONSTANT + R&D \$	NET INCOME = CONSTANT + R&D \$ + TOTAL ASSETS
FIRST QUARTILE				
START-UP FIRMS	.778	.896	.672	.769
MATURE FIRMS	.875	.931	.729	.836
FOURTH QUARTILE				
START-UP FIRMS	.621	.893	.250	.487
MATURE FIRMS	.652	.815	.264	.408

## START-UP AND MATURE COMPANY AVERAGES

Variable	J	K	L	M
ROI SORT AVERAGES	COMMON EQUITY	NET INCOME	R&D	TOTAL ASSETS
MATURE FIRMS	\$1,020.1	\$149.7	\$115.0	\$2,237.8
START-UP FIRMS	\$87.5	\$10.0	\$15.3	\$161.7

Data in millions of dollars

Variable	N	O	P	Q
ROI SORT AVERAGES	PRETAX INCOME	SALES	ROI	R&D AS % of SALES
MATURE FIRMS	\$448.1	\$2,426.5	0.203	0.044
START-UP FIRMS	\$137.4	\$195.5	0.175	0.079

Data in millions of dollars

Variable	R	S	T
ROI SORT AVERAGES	RETURN ASSETS	RETURN EQUITY	MARKET SHARE
MATURE FIRMS	0.084	-0.034	0.078
START-UP FIRMS	0.067	-0.051	0.022

**START-UP AND MATURE COMPANY COMPARISON  
FIRST QUARTILE**

**21 Start-ups & 52 Mature Firms**

VARIABLES	J	K	L	M
ALL-SIC ROI SORT	COMMON EQUITY	NET INCOME	R&D	TOTAL ASSETS
START-UP AVERAGES	\$102.394	\$16.466	\$19.945	\$188.801
Std. Dev.	100.352	7.213	28.470	212.230
Maximum	315.352	62.700	85.698	606.215
Minimum	5.157	-37.965	0.337	12.575
MATURE AVERAGES	\$1760.806	\$312.239	\$217.369	\$3580.407
Std. Dev.	3407.371	688.393	441.386	6218.021
Maximum	20856.400	4669.200	2959.000	33749.600
Minimum	6.396	-57.000	0.546	17.230

Data in millions of dollars

VARIABLES	O	P	Q	T
ALL-SIC ROI SORT	SALES	ROI as a Percent	R&D as a % of SALES	MARKET SHARE
START-UP AVERAGES	\$328.589	0.371	0.072	0.032
Std. Dev.	284.765	0.091	0.049	0.025
Maximum	2280.722	1.007	0.167	0.116
Minimum	14.782	0.236	0.013	0.000
MATURE AVERAGES	\$4394.584	0.349	0.045	0.100
Std. Dev.	7045.684	0.091	0.029	0.131
Maximum	35152.800	0.830	0.183	0.622
Minimum	23.336	0.280	0.008	0.001

**START-UP AND MATURE COMPANY COMPARISON  
FOURTH QUARTILE**

**21 Start-ups & 52 Mature Firms**

VARIABLES	J	K	L	M
ALL-SIC ROI SORT	COMMON EQUITY	NET INC	R&D	TOTAL ASSETS
START-UP AVERAGES	\$55.460	\$0.973	\$11.265	\$115.400
Std. Dev.	104.089	7.514	29.747	220.237
Maximum	461.174	27.051	136.586	986.522
Minimum	3.181	-8.581	0.026	10.636
MATURE FIRMS AVERAGES	\$437.826	\$42.121	\$44.216	\$992.124
Std. Dev.	889.562	106.845	84.017	2138.914
Maximum	4786.000	519.800	435.400	11830.000
Minimum	4.125	-71.039	0.100	7.523

Data in millions of dollars

VARIABLES	O	P	Q	T
ALL-SIC ROI SORT	SALES	ROI as a Percent	R&D as a % of SALES	MARKET SHARE
START-UP AVERAGES	\$124.382	0.031	0.084	0.013
Std. Dev.	296.924	0.053	0.049	0.025
Maximum	1373.455	0.102	0.233	0.116
Minimum	10.079	-0.226	0.003	0.000
MATURE FIRMS AVERAGES	\$1129.431	0.049	0.045	0.054
Std. Dev.	2241.464	0.363	0.028	0.092
Maximum	11097.200	0.154	0.112	0.373
Minimum	5.107	-2.511	0.008	0.000

## APPENDIX K

### INTERVIEW QUESTIONNAIRE

Appendix K contains the questionnaire used in conducting corporate interviews and its results.

## CORPORATE QUESTIONNAIRE

1. How are your R&D budgets determined? Check one or more methods.

- ☐ By percent of sales
- ☐ Zero based budgets
- ☐ Prior budgets
- ☐ Other

2. If your R&D program depends on a few large contracts from commercial, government, or other sources, indicate below the primary sources.

- ☐ Commercial
- ☐ Government
- ☐ Vendors
- ☐ Other

3. For your primary product line, how long do you feel it takes from the time of R&D investment to a payoff in sales, ROI, or market share?

- ☐ One to two years
- ☐ Three to five years
- ☐ Five to ten years
- ☐ Over ten years

4. How essential is R&D to your product line?

- ☐ Critical
- ☐ Significant
- ☐ Some Importance
- ☐ Little Importance
- ☐ No Importance

5. What is your corporate expenditure mix of basic and applied research?

Percent Basic	_____	%
Percent Applied	_____	%

6. What are your sources of R&D funding and the approximate percent of your total R&D budget from each source?

- |                                      |       |   |
|--------------------------------------|-------|---|
| <input type="checkbox"/> Corporate   | _____ | % |
| <input type="checkbox"/> Government  | _____ | % |
| <input type="checkbox"/> Other firms | _____ | % |
| <input type="checkbox"/> Consortium  | _____ | % |
| <input type="checkbox"/> Other       | _____ | % |

7. Do you feel that foreign firms have an advantage over U.S. firms in conducting R&D programs?

Circle one.                    YES        NO

8. Are smaller firms at a disadvantage in maintaining an effective R&D program in your industry or maintaining State of the Art products?

Circle one.                    YES        NO

9. How rapidly do you attempt to recover R&D costs?

- ☐ One to two years
- ☐ Three to five years
- ☐ Five to ten years
- ☐ Over ten years

10. Does your company utilize a "follower" or "leader" technological approach in guiding your R&D program?

- ☐ Follower
- ☐ Leader
- ☐ Leader for some products, Follower for others.

11. Rank (1-6) the following factors, according to their influence on R&D efforts:

- ☐ Customers
- ☐ Competitors
- ☐ Government
- ☐ Corporate Requirements
- ☐ Strategic Planning
- ☐ Vendors or Suppliers
- ☐ Other \_\_\_\_\_

12. What is your average time for basic and applied research to reach the Market Entry stage?

Basic Research \_\_\_\_\_ years  
Applied Research \_\_\_\_\_ years

13. How long is the average Product Life Cycle for the products in your industry?

\_\_\_\_\_ years.



14. What factors are important in determining the success of your R&D program? Rank (1-4) the items below in importance.

- ☐ Budgets
- ☐ Management
- ☐ Facilities
- ☐ Total Assets

## RESULTS

1. How are your R&D budgets determined? Check one or more methods.

NUMBER OF  
RESPONSES

3	By percent of sales
2	Zero based budgets
1	Prior budgets
7	Other

2. If your R&D program depends on a few large contracts from commercial, government, or other sources, indicate below the primary sources.

NUMBER OF  
RESPONSES

3	Commercial
3	Government
2	Vendors
5	Other

3. For your primary product line, how long do you feel it takes from the time of R&D investment to a payoff in sales, RBI, or market share?

NUMBER OF  
RESPONSES

3	One to two years
6	Three to five years
4	Five to ten years
0	Over ten years

4. How essential is R&D to your product line?

NUMBER OF  
RESPONSES

6	Critical
5	Significant
2	Some Importance
0	Little Importance
0	No Importance

5. What is your corporate expenditure mix of basic and applied research?

AVERAGE

Percent Basic	17.24 %
Percent Applied	82.76 %

6. What are your sources of R&D funding and the approximate percent of your total R&D budget from each source?

AVERAGE

Corporate	93 %
Government	4 %
Other firms	3 %
Consortium	0 %
Other	0 %

7. Do you feel that foreign firms have an advantage over U.S. firms in conducting R&D programs?

NUMBER OF  
RESPONSES

6	YES
7	NO

8. Are smaller firms at a disadvantage in maintaining an effective R&D program in your industry or maintaining State of the Art products?

NUMBER OF  
RESPONSES

7	YES
6	NO

9. How rapidly do you attempt to recover R&D costs?

NUMBER OF  
RESPONSES

5	One to two years
4	Three to five years
3	Five to ten years
1	Over ten years

10. Does your company utilize a "follower" or "leader" technological approach in guiding your R&D program?

NUMBER OF  
RESPONSES

5	Follower
2	Leader
6	Leader for some products, Follower for others.

11. Rank (1-6) the following factors, according to their influence on R&D efforts:

<u>RANKED NUMBER ONE</u>	<u>RANKED NUMBER TWO</u>	<u>RANKED NUMBER THREE</u>	<u>RANKED NUMBER FOUR</u>	
3	2	0	1	Customers
8	3	1	0	Competitors
0	0	0	0	Government
1	1	3	0	Corporate Req.
0	0	0	0	Strategic Planning
0	0	0	1	Vendors/Suppliers
0	0	0	0	Other

12. What is your average time for basic and applied research to reach the Market Entry stage?

	<u>NUMBER OF YEARS</u>	<u>NUMBER OF RESPONSES</u>
Basic Research	10.00	5
Applied Research	3.35	13

13. How long is the average Product Life Cycle for the products in your industry?

<u>AVERAGE YEARS</u>	<u>RANGE</u>
6.64	1 TO 10

14. What factors are important in determining the success of your R&D program? Rank (1-4) the items below in importance.

<u>RANKED NUMBER ONE</u>	<u>RANKED NUMBER TWO</u>	<u>RANKED NUMBER THREE</u>	<u>RANKED NUMBER FOUR</u>	
6	5	1	0	Budgets
3	4	1	0	Management
0	1	4	1	Facilities
0	0	0	3	Total Assets
4	2	0	0	* Technical Staff

\*This variable was written in on 6 surveys

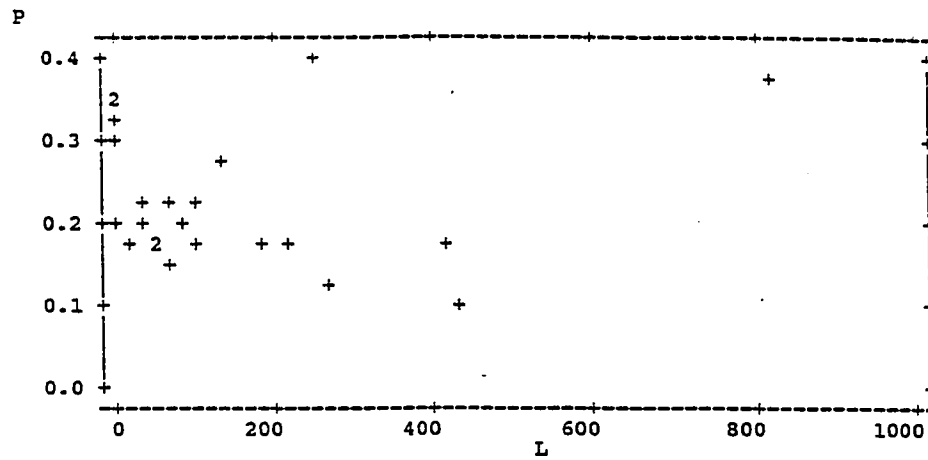
## APPENDIX L

### PLOT OF ROI VS R&D DOLLAR INVESTMENT BY INDUSTRY

Appendix L contains 18 graphs plotting ROI vs. R&D dollar investment by industry.

The companies are plotted with a + unless there are multiple companies at the same point and then the number of companies at that plot point will be printed. For example, in SIC 3510 there is a 2 in the plot which indicates that two firms are located at that data point.

PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 2800

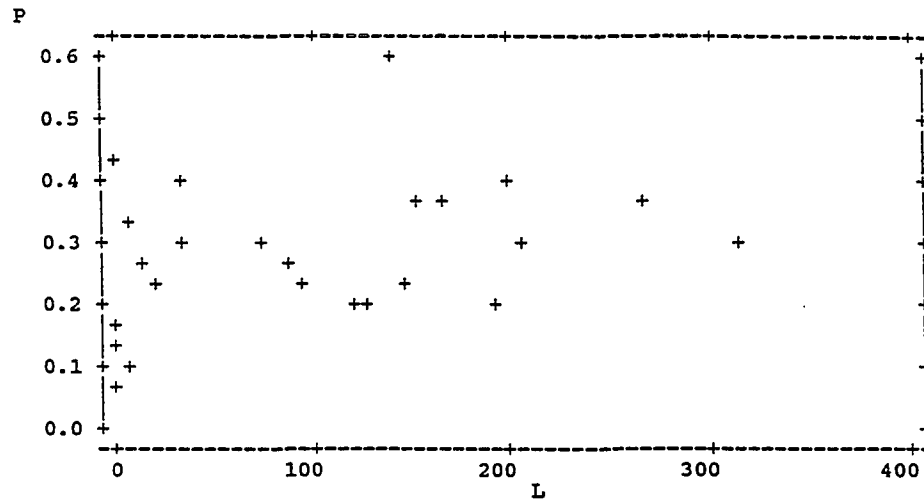


LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT

PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 2830



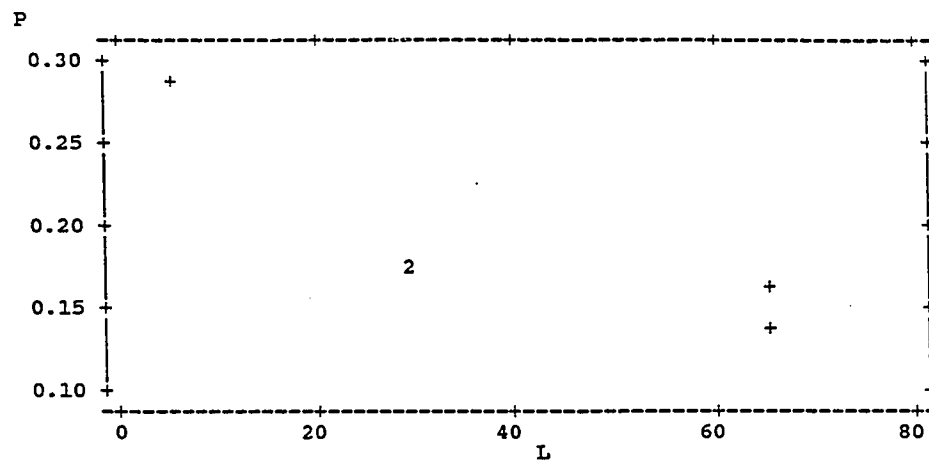
LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT



PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3510

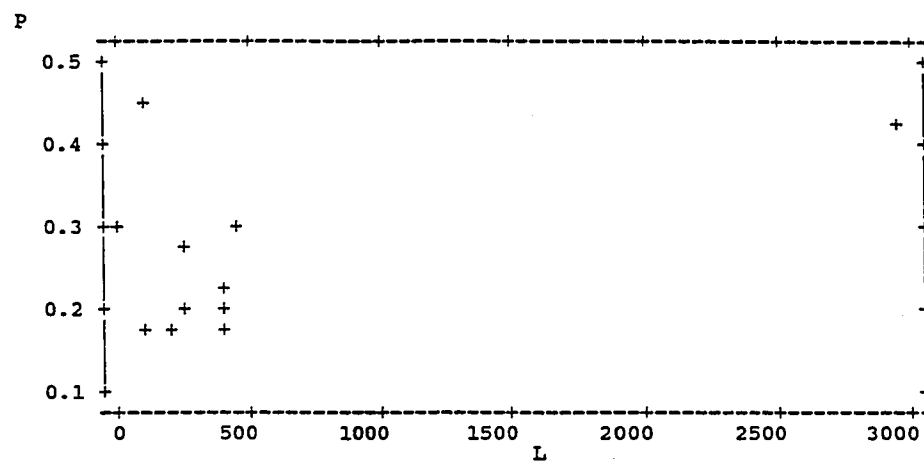


LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT

PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3573A

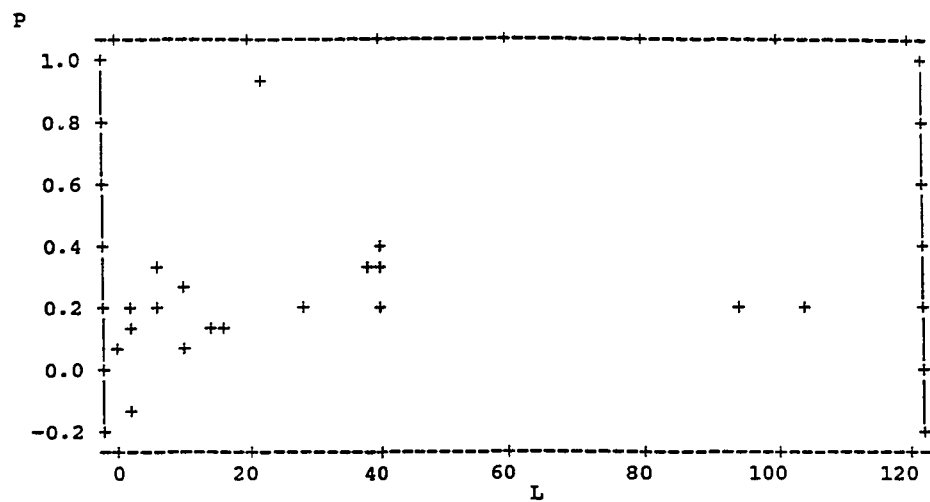


LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT

PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3573B

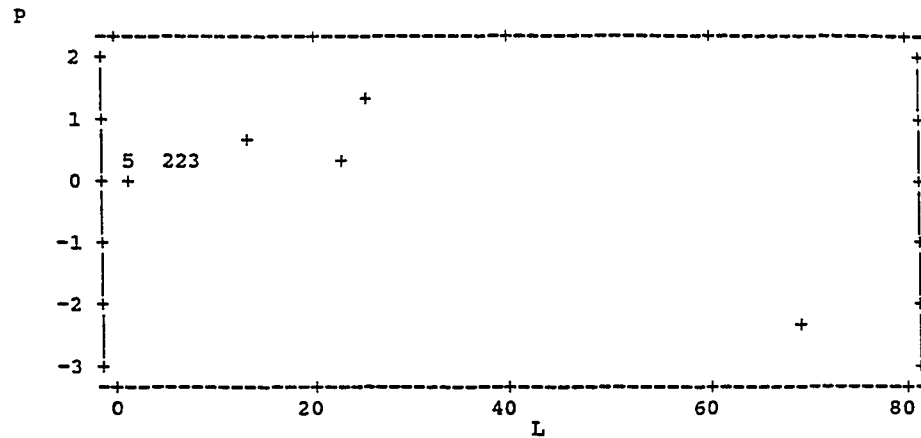


LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT

PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3573C

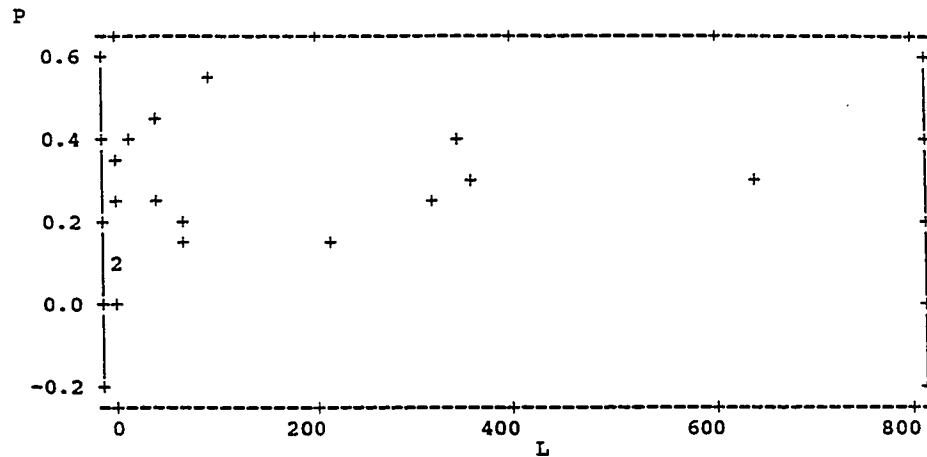


LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT

PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3651

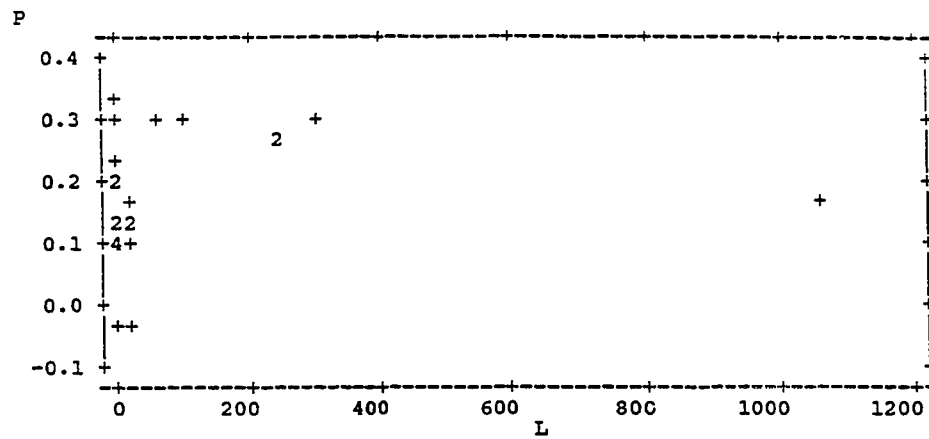


LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT

PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3661

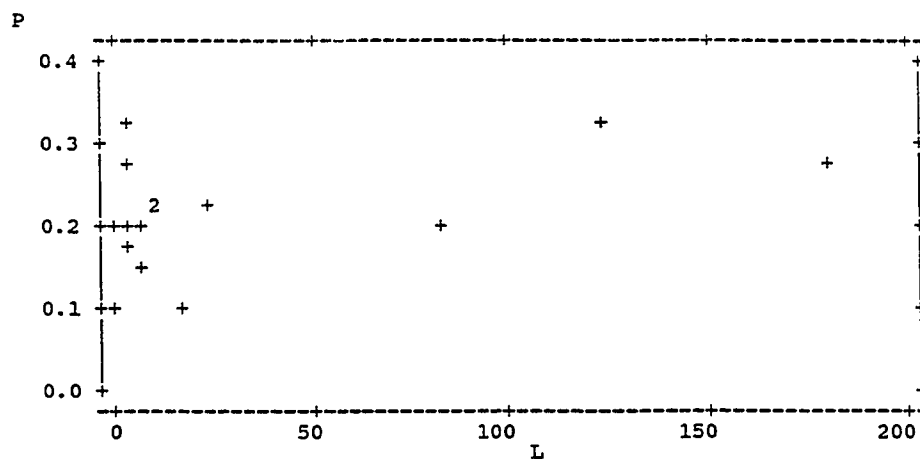


LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT

PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3662

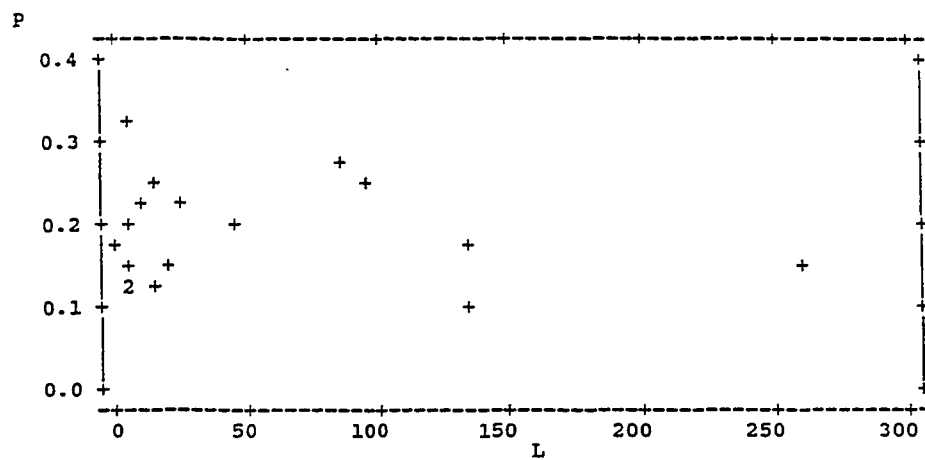


LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT

PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3674



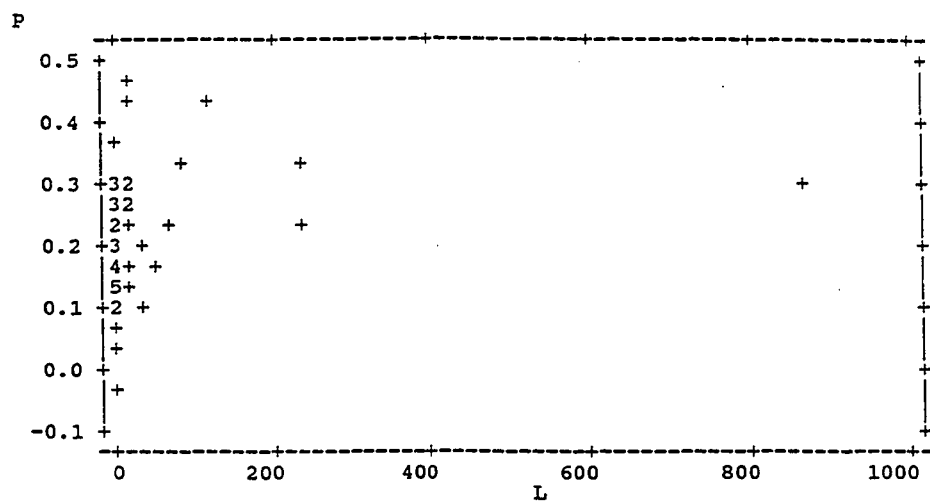
LEGEND:

P = ROI

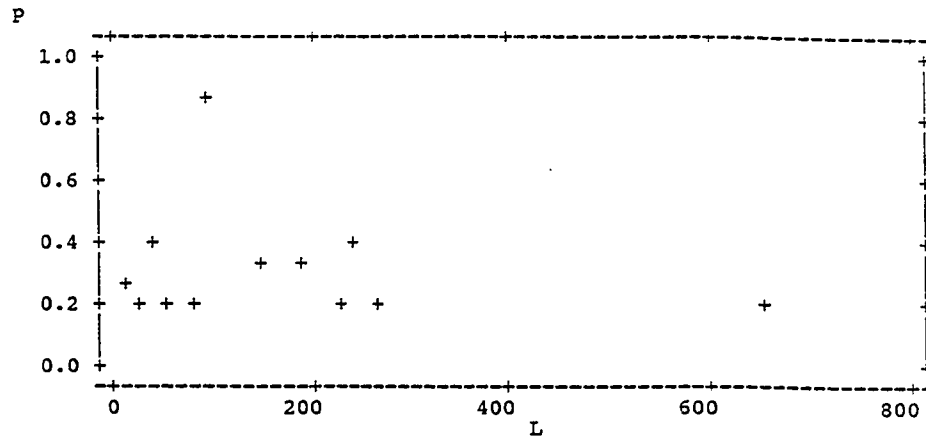
L = R&D DOLLAR INVESTMENT



PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3679



PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3721

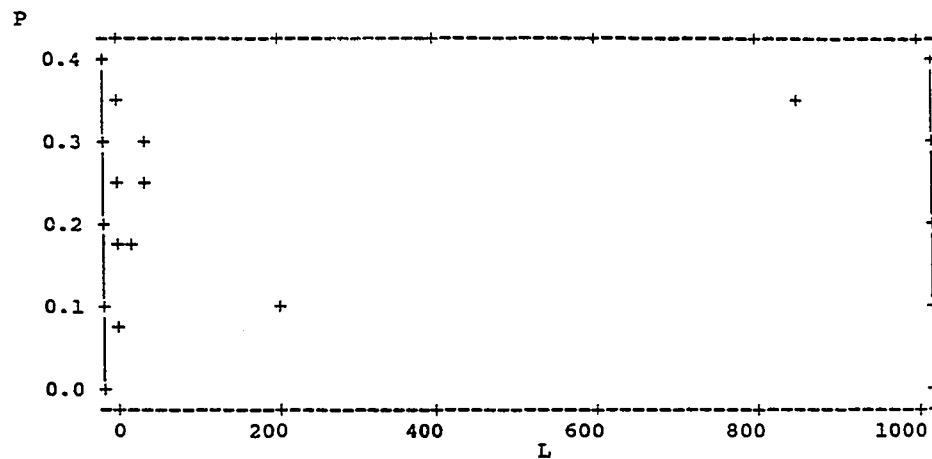


LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT

PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3728

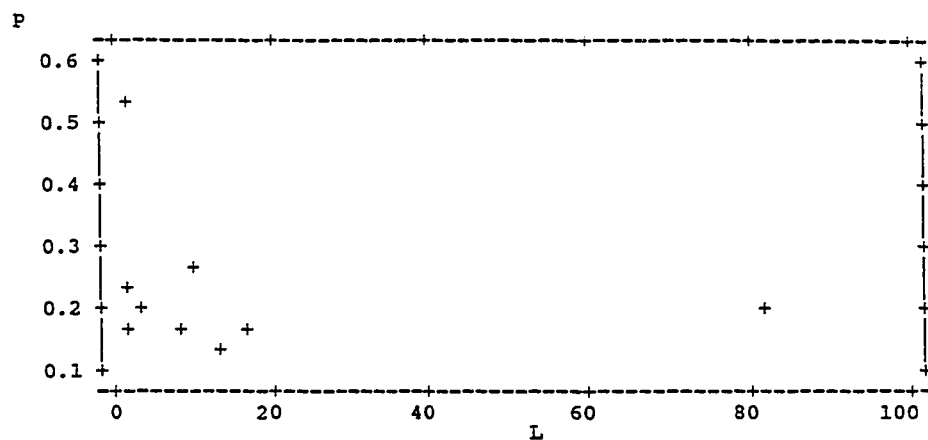


LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT

PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3811

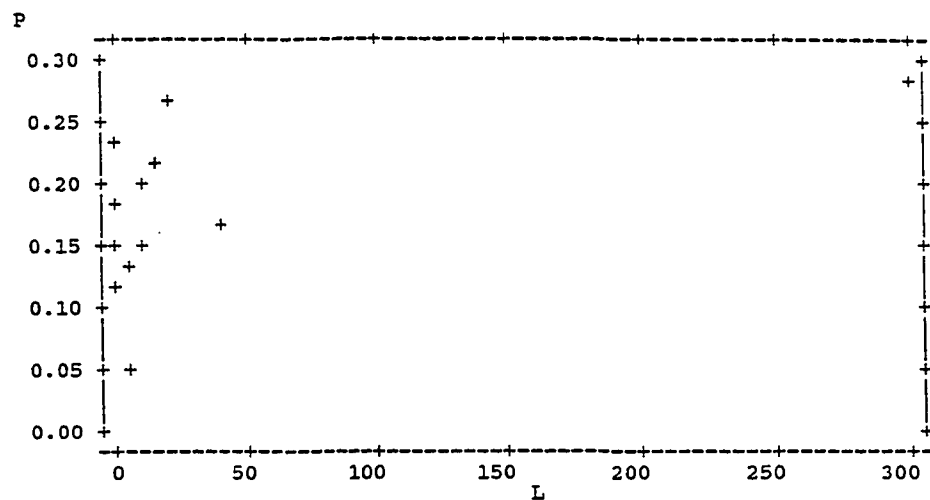


LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT

PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3820

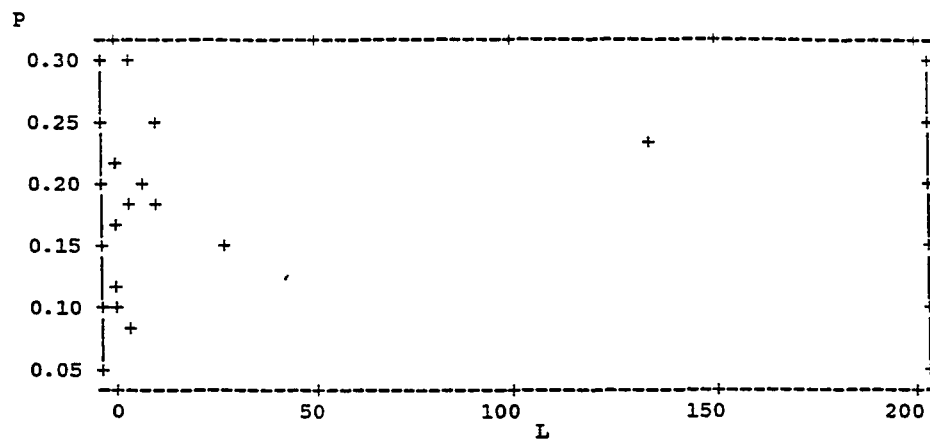


LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT

PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3825

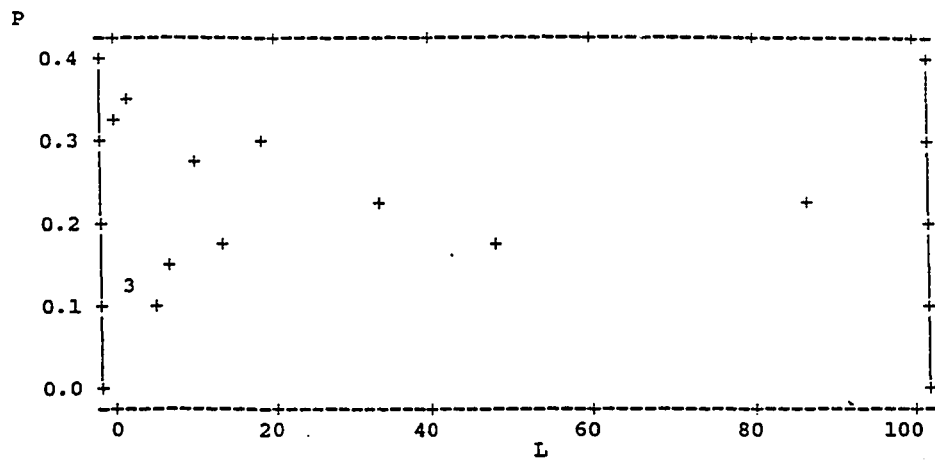


LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT

PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3841

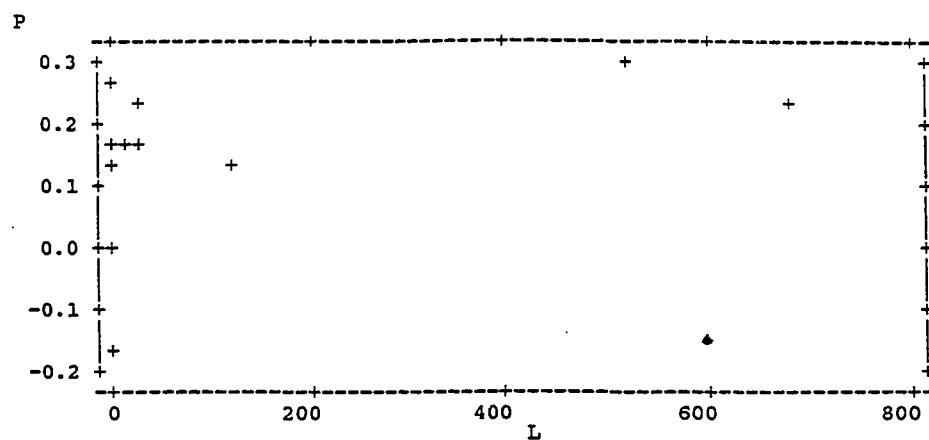


LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT

PLOT OF ROI VS R&D DOLLAR INVESTMENT  
BY INDUSTRY  
SIC 3861



LEGEND:

P = ROI

L = R&D DOLLAR INVESTMENT