Board Effects on Performance in Emerging Industries: The Case of Biotechnology

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BOARD EFFECTS ON PERFORMANCE IN EMERGING INDUSTRIES:

THE CASE OF BIOTECHNOLOGY

by

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BOARD EFFECTS ON PERFORMANCE IN EMERGING INDUSTRIES:

THE CASE OF BIOTECHNOLOGY

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This study was designed to determine if the size and composition of the boards of directors is related to aftermarket performance of initial public offering firms (IPOs) in industries in the early stages of their life cycle. The importance of studying firm performance during the founding period has been emphasized in past research, but actual investigation has been rare. In addition, research on IPOs and the biotechnology industry (the focus of this study) in the literature of strategic management has been sparse.

Based upon resource dependency theory, this study investigated factors associated with the size and composition of the board of directors at the time of the IPO and their effect on subsequent aftermarket performance. Specifically, this dissertation investigated the relationship between the
effect of the size of the board, its expertise (e.g., finance and science), and the percentage of outside directors at the time of the IPO on the subsequent market valuation of these firms. The study examined 80 public biotech companies from the years 1980-1987.

The results of the study supported resource dependency theory by finding significant relationships between the size and composition of the board and aftermarket IPO performance of the biotech firms. Specifically, biotech firms which had a larger number of outside directors with financially related backgrounds had significantly better aftermarket IPO performance. Also, firms which had a larger percentage of outside directors had significantly better aftermarket IPO performance. Results also showed a negative significant relationship between the size of the board and aftermarket IPO performance.

In addition, no significant relationships were found between aftermarket IPO performance and (1) the number of outside directors who were university scientists, and (2) the interaction between the number of outside directors with financially related backgrounds and outsiders who were university scientists. Finally, positive significant relationships were found between organizational size and
initial offering size with aftermarket IPO performance.

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CHAPTER 1

INTRODUCTION

The focus of this research project is to determine if there is a relationship between the size and composition of boards of directors and aftermarket performance of initial public offering firms (IPOs) in emerging industries. The
importance of this research has been exemplified by Zahra and Pearce (1989), who stated that past research on boards of directors has concentrated on the Fortune 500 population, not specific industries. While past studies on the Fortune 500 have contributed extensively to our knowledge of boards of directors, Zahra and Pearce proposed that past researchers have neglected to examine the effect of boards in the following areas: 1) smaller, medium size, and non-profit businesses and 2) specific industries.

The goal of this study is to fill a gap in past research by focusing on the effect of boards of directors in emerging industries. Several emerging industries (e.g., software, microwave telecommunications, fiber optics, robotics, and biotechnology) have been receiving increasing attention in the media. One emerging industry which has received a lot of press recently is biotechnology (see Faulkner, 1986; Yoxen and Di Martino, 1989; Shamel, 1990; Burns, 1991; Hall and Strimpel, 1991; Kupor, 1991; Rau, 1991; Teitelman, 1991; Burrill and Lee, 1991,1992; Hamilton, Smith, Smith, and Weber, 1992).

Despite all of the recent literature being written on biotechnology, virtually no empirical literature in strategic
management has been focused on the industry. This study will attempt to fill a gap in previous research by empirically investigating the effect of the board of directors on performance in the biotechnology industry.

The central research question explored in the study was: What is the effect of board characteristics on performance in emerging industries? The specific research questions addressed in this study were:

1. Is there a relationship between the size of the board members and aftermarket IPO performance of firms in emerging industries?

   In accordance with the theoretical basis for this study, resource dependency theory, research questions 2-4 investigated the relationships between outside directors and aftermarket IPO performance.

2. Is there a relationship between the number of outside board members with financially related backgrounds and aftermarket IPO performance of firms in emerging industries?

3. Is there a relationship between the number of outside board members who are university scientists and aftermarket IPO performance of firms in emerging industries?
4. Is there a relationship between the interaction between the number of outside board members with financially related backgrounds and outsiders who are university scientists with aftermarket IPO performance of firms in emerging industries?

5. Is there a relationship between the percentage of outside directors on the board and aftermarket IPO performance of firms in emerging industries?

The research project investigated the relationships between board characteristics and performance for the entire population of public biotechnology companies from 1980-1987. Public biotechnology firms were chosen for several reasons; the lack of business research on the industry, to control for industry variations, its introductory stage in the industry life-cycle, the call for more research on IPOs (Marino, Castaldi, and Dollinger, 1989), and the ability to generalize the results to other emerging industries.

Profile of the Biotechnology Industry

Several attempts have been made to define what the biotechnology industry is, but Burrill and Lee (1992) have come up with the best description of the industry to date:
"The biotechnology industry encompasses a diverse group of companies that range widely in size, technologies used, and markets served. The common thread that binds them is their primary mission: to use biological processes to develop products for human health care, agricultural productivity, animal health, food safety and nutrition, and environmental improvement. Also included are those companies whose primary mission is to supply technology-based research products to other biotech companies."

Biotechnology, broadly defined, includes any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants or animals, or to develop micro-organisms for specific purposes. Although traditional uses of biotechnology are centuries old (e.g., baking and brewing), it is the so-called new biotechnology involving the uses of modern scientific techniques, such as rDNA technology, hybridoma technology, and bioprocess technology, that leads to issues affecting international commercialization of research and products (OTA, 1991).

Biotechnology has recently taken headlines in the business literature. The industry is only 17 years old, with the first public offering, Genentech, occurring in 1980. Since the first public offering, over 250 biotech companies have gone public. Total revenues for the biotech industry as a whole, both public and private companies, are estimated to

The Bush Administration realized the potential of the biotech industry and created the "Biotechnology Initiative" in January, 1992. The plan calls for an increase of federal support for basic biotech research by 7% to $4.03 billion annually. In May, 1992, the Bush Administration adopted a regulatory policy for bioengineered foods which is designed to promote a profusion of new products on the market and is expected to spur investment in agricultural biotech stocks (Ingersoll, 1992).

D. Allan Bromley, the President Bush's science adviser, observed that since World War II, technologies derived from physics, chemistry, and the physical sciences have dominated world economies. However, he predicted the future could veritably be in biotechnology (Hamilton et al., 1992). The next section will discuss the importance of studying public companies.

**Why Study IPO's?**

This study on the size and composition of boards of directors and their relationship to aftermarket IPO
performance will enhance our existing knowledge in strategic management for the following reasons; (1) Performance measures for public biotech companies will be developed; (2) the biotechnology industry is different from other industries and has been underinvestigated, and (3) Sparse research has been performed on initial public offerings in the strategic management area.

This dissertation contributed to the literature in strategic management by providing a means for measuring the performance of public biotech companies and similar industries. Traditional performance measures (e.g., ROE, ROI, Sales) were not used due to unique performance characteristics of the industry. For example, industry characteristics have rendered traditional measures of performance not meaningful: (1) the first biotech firm did not go public until 1980, this limits our ability to track the longitudinal performance of biotech firms, (2) the average time for a product to get to market in the biotech industry is 10-12 years and costs between $100-$269 million, (3) most of the firms in the study do not as yet have any products on the market, and (4) as of 1991, only six public biotech firms have been profitable.
Due to the newness of an emerging industry, typically-used financial measures in board studies (such as ROI, ROE, and ROA) are not likely to provide a true indication of a firm's financial results. Therefore, alternative measures of performance had to be developed. Three performance measures were used in this study: two measures of market performance (stock prices) and one measure of technological performance (the number of patents and citations over a four year period following a firm's initial offering).

There are a number of advantages to using stock prices: (1) stock prices represent the only direct measure of stockholder value, (2) stock prices are readily available for all publicly traded companies, (3) stock prices are believed to be fully specified; that is they are not limited to a specific aspect of performance such as sales growth or profits, but rather reflect all relevant information aspects of performance, (4) stock prices are reported objectively, (5) stock prices have been shown to see through managers attempts to manipulate reported accounting measures (Lubatkin and Shrievess, 1986), and (6) stock prices are an estimate of future potential, not just past performance.

The other measure of aftermarket IPO performance in this
The study was technological performance. Patents and citations were used to calculate this performance measure. Patent and citation information provide a unique planning resource for managing a firm's technology or product development and for systematically evaluating its competitive position to other companies in a market area (Ashton and Sen, 1988). Narin, Carpenter, and Woolf (1984) claim that patents and their citations are a valid reflection of technological productivity and communication. Furthermore, Carpenter, Narin, and Woolf's (1981) study provides strong evidence that patent citation data can be used as technological indicators of development. They claim that high citation rates on patents are associated with the patents of innovative and important products. The number of patents and citations a firm has should be an indication of future product development which might have a relationship with how the market values biotech companies.

A more in-depth analysis of stock prices, patents, and citations as performance measures will be discussed in the theoretical background and methodology sections.

The biotechnology industry also provides strategic management scholars with a unique opportunity to study firms
in the introductory stage of their market life-cycle. The results of this study assisted future researchers in determining how biotech boards differ from boards in industries at other stages of the industry life-cycle. Furthermore, this study gave future researchers an opportunity to see how boards in the biotech industry differ from boards in industries that are not as heavily regulated by the government.

Finally, past research on IPOs in the biotechnology industry has been mostly of the descriptive nature, occurring in magazines and newspapers like Barrons, Fortune, Chemical and Engineering News, Business Week, Forbes, and The Wall Street Journal. Previous research in the biotechnology industry has been performed in two areas: (1) scientific and (2) commercial-business. Researchers have investigated the scientific side of biotechnology more extensively, leaving business academicians with an opportunity to study biotechnology IPOs.

Research on IPOs, especially biotech IPOs, by strategic management scholars has been neglected. However, academicians in the field of Finance have investigated various aspects of IPOs. Some of the topics which the
Finance researchers have focused on are: (1) abnormal returns earned by investors at the offering price (Reilly and Hatfield, 1969; McDonald and Fisher, 1972; Reilly, 1973; Logue 1973; Block and Stanley, 1980; Neuberger and LaChapelle, 1983); (2) IPO returns on a risk adjusted basis (Ibbotson, 1975); and (3) underpricing of IPOs (Smith, 1986; Tinic, 1988; Ritter, 1991).

This study contributed to our knowledge of IPOs in emerging industries by forming a database on the IPOs from the years 1980-1987. Furthermore, the results found in this study assisted us in understanding the relationship between the size and composition of the board and aftermarket performance of initial public offerings in the biotechnology industry.

The Founding Period

As an emerging industry, the biotechnology industry is in its infancy stage. With the first public offering occurring in 1980, the industry is only 17 years old. This study investigated all of the biotechnology IPOs between the years 1980-1987 (80) and the four years following their initial
This study, which utilized resource dependence theory, looked at how biotech firms, at the time of their initial offering, searched their environment for these critical resources to enhance their aftermarket IPO performance. Resource dependence theory states that outside directors on the board provide valuable scarce information and/or resources which might enhance the performance of the organization.

The importance of studying the origins of organizations has been written about by Stinchcombe (1965), who emphasized the significance of the founding period. Stinchcombe (1965) argued that events surrounding the creation of a new organization have a long-lasting effect on its subsequent development. The founding of the organization has an especially influential effect on the structure, processes, and strategy the organizations develops and continues to exhibit over time (Boeker, 1988). Based on Stinchcombe's research on origins, we apply his findings to emerging industries; specifically, the initial offering period within the biotechnology industry.

Stinchcombe (1965) also talked about the relevance of "imprinting." Stinchcombe argues that organizations, at the
time they are founded, have incorporated elements of the larger societal structure of the period into their basic structures. That is, the social conditions present at the time of founding become imprinted into the newly founded organizations. According to Boeker (1988), the factors which influence the organization during its founding period, will affect the organization throughout its existence.

It is based upon Stinchcombe's (1965) premise of the founding period, that we investigated the effect of the board of directors on the aftermarket IPO performance of biotech firms. We defined the founding period, or organizational birth, in this study as the initial offering date of the organization. Singh, Tucker, and House (1986) used a similar time period as their founding period, the year of formal incorporation. They assumed that formal incorporation reflected a strong commitment by the founder(s) to build and maintain an ongoing organization.

Based on Stinchcombe's (1965) imprinting hypothesis, we argued that firms in emerging industries will search their environment for valuable resources (e.g., boards of directors) to enhance the long-term performance of the organization. In addition to the "imprinting"
hypothesis generated by Stinchcombe (1965), he also emphasized that young organizations have a higher propensity to die than old organizations. Stinchcombe termed this occurrence, "liability of newness." He stated that this liability of newness occurs because younger organizations face the following barriers to entry that may make movement into a new domain prohibitive:

(1) product differentiation, (2) technological barriers, (3) licensing, (4) barriers of entry due to vertical integration, (5) illegitimate acts by competitors, and (6) experiential barriers to entry.

Other researchers (Aldrich and Auster, 1976; Aldrich and Pfeffer 1976; Aldrich, Rosen, and Woodward, 1986) have discussed the propensity of new organizations to die. Aldrich and Auster (1976) state that new organizations face difficulty in the acquisition of resources which may lead to the dissolution of the organization.

To accommodate for the lack of resources in an organization, Selznick (1949), proposed the creation of a boards of directors as an important way in which organizations attempt to co-opt important external constituencies to enhance the survival of the firm.
According to Selznick (1949), organizations have the capacity to develop distinctive competencies, then draw upon actors external to the organization to support these central tasks through co-optation. Through co-optation, organizations have the ability to extract critical external resources which might enhance the survival of the firm.

According to corporate law, all publicly held corporations must have a board of directors (Wang, 1991). Based on this legality, we examined the relationship between the size and composition of the board of directors, at the time of the initial offering, to their aftermarket performance. We concluded that a specific board size, a larger number of outsiders from the functional areas of finance and science (e.g., chemistry, life sciences, medicine), and a larger percentage of outside directors will enhance the aftermarket performance of these public companies. A more in-depth analysis of the variables and hypotheses will be provided in the methodology section.

RESEARCH METHODOLOGY OVERVIEW

Sample
In an effort to control for industry variations, a single industry was used, biotechnology. This will be referred to as the biotech industry. Since the first public offering in the biotech industry in 1980, Genentech, over 250 companies have gone public. A literature review has revealed that there were 52 IPOs issues from January 1983 through September 1987. Due to the low number of IPOs, all public offerings in the biotech industry between 1980-1987 were used in this study (Post 1987 firms were excluded because aftermarket performance was measured for 4 years after the IPO). The number of public offerings during this period was 80; however the final sample size was only 60 firms. Twenty firms were eliminated due to acquisitions, mergers, and/or bankruptcies.

A database of the 60 public biotech companies was developed through the following sources: Disclosure Inc., Securities and Exchange Commission (SEC), an extensive literature search, and the International Biotechnology Association (IBA).

Past studies on boards of directors have focused on the Fortune 500 as the basis for their respective study samples (Kesner et al., 1986; Kesner, 1987; Kerr and Bettis, 1987;
Kesner, 1988). While the Fortune 500 provides a large, homogeneous sample within various industries, it negates the focus on specific industries. By focusing on the biotech industry, it is the hope of this researcher that more future studies will continue to focus on specific industries.

The typical sample size for studies relating to boards of directors ranged from 50-150 firms. This study was well within the range of the sample size of past studies.

**Method**

A multivariate analytical approach—i.e., multiple regression and correlational analysis—was the statistical approach used to establish the various relationships identified in the research questions. The assessment of the relationship between the size and composition of the board of directors and aftermarket IPO performance was determined. Additional detail is presented in the review of the methodology used in this dissertation, in Chapter 3. The data sources used in this study will be discussed next.
Data sources used for this study were comprised of several sources. First of all, a database was developed for public companies in the biotech industry. These sources were listed earlier. Secondly, four sets of proxy statements for each company were used to collect data on the board of directors and organizational age. These were for four consecutive years after going public. The proxies were then collected from the companies, the SEC, and Disclosure Inc. Thirdly, prospecti from the SEC, Disclosure, or the companies were used for information on the initial offering size. Fourthly, Standard and Poor's Stock Reports were used to collect data on the stock prices of the firms. Fifthly, data on patents and citations were gathered from the Dialog database (U.S. Patent and Trademark Office of Classification). Finally, annual reports were collected for information on the size of the firms.

DEFINITION OF THE VARIABLES
Independent Variables

There were five independent variables in this study: (1) size of the board (SOB); (2) outside directors with financially related backgrounds (FL); (3) outsider directors who are university scientists (US), (4) the interactive effect between outside directors on the board who have financially related backgrounds and outsiders who are university scientists (FL x US); and (5) the percentage of outside directors on the board (I/O). The information used in calculating these numbers was obtained from the firms' annual proxy statements filed with the SEC. Four sets of proxy statements were obtained, the initial offering year and the subsequent 3 years.

The size of the board of directors was measured by counting the number of individuals on the board of directors. In addition, the functional backgrounds of outside members of the board of directors were then analyzed. The following outsider functional backgrounds were analyzed: financially related individuals and university scientists.

Financially related outsiders consisted of any individual coming from an investment or commercial bank, venture capital firm, or any other financially related firm. University scientists was comprised of individuals who are on
the faculty at a university and have a background in the sciences (e.g., medicine, biology, chemistry, biochemistry, genetics). Measurement of the functional backgrounds of outside directors was done through the following procedures. First, the number of outsiders with financial backgrounds and university scientists were summed up separately for two final figures. The first figure, the number of outsiders with financially related backgrounds, was used as our measure of the second independent variable. The second figure, the number of outsiders who were university scientists, was used as our measure of the third independent variable. Finally, both of the numbers obtained from the second and third independent variables were multiplied for our fourth independent variable, the interaction between outside directors with financial backgrounds and university scientists.

The final independent variable was the percentage of outsider directors on the board. This was measured by counting up all of the outside members of the board and dividing by the total size of the board. A final ratio was calculated. To be included as an insider director one of the following criteria must have been met: (1) retired from
the company, (2) currently or previously employed by the company, and (3) be related to someone in the company. All other directors were assumed to be outsiders.

Finally, an outsider must have been on the board for at least three of the four years in the study to be considered part of the board.

**Dependent Variable**

The dependent measure used in this study was aftermarket IPO performance (IPO). Multiple measures (e.g., market and technological performance) were used to assess the aftermarket IPO performance of the biotech firms in the study. Since only 6 public biotech companies have reached profitability, measurement of performance was the most difficult aspect of this study. Regular accounting ratios (e.g., ROE, ROI) could not be used due to the lack of profitability of these firms. As stated earlier, the following characteristics of the industry contributed to our measurement problems: (1) the infancy of the industry, (2) the lack of profits in the industry—only 6 companies have reached profitability, (3) the lack of existing products on the market, (4) and the amount of time it takes for a product
to get to market, 12 years. Therefore, measurement of performance was extremely difficult. Market performance was measured through stock prices and technological performance was measured by counting patents and citations. A more in-depth review of the measures of the dependent variables will be discussed in the methodology chapter.

Other Variables

Other likely variables affecting the criterion variable in this study, although not the focus of the study, include: (1) organizational size (OS), as measured by the average number of employees within the firm over a four year period; (2) organizational age (OA), the total number of years the firm has existed since its founding; and (3) initial offering size (IOS), the total dollar amount at the time of the initial offering of the firm.

Figure 1.1 (on the next page) depicts the multiple regression problem where the five independent variables (size of the board, outside board members with functional backgrounds in finance and science), and percentage of outside directors on the board mutually and simultaneously
influence a dependent variable (aftermarket IPO performance) given the existence of three control variables (organizational size, organizational age, and initial offering size). Additional information about the variables in this study can be found in the methodology section within Chapter 3.
LIMITATIONS

Four major limitations were prevalent in this study. First, since Genentech, the first biotech firm, did not go public until 1980, this limited our ability to track the
performance of the biotech firms over decades. Since the average time for a product to get to market in the biotech industry is between 10-12 years, and costs $100-$269 million, most of the firms in the study did not have any products on the market. In addition, as of 1991, only six public biotech firms had been profitable. Therefore, measurement of the performance variable was very difficult. Past, popular financial measures used in board studies such as ROI, ROE, ROA were not a true indication of a firm's financial disposition. Since we used stock prices over a long period of time in this study, other factors could have contributed to the performance of these firms.

Secondly, in regards to the technological performance measure in this study, patent statistics as an indication of economic analysis has been critiqued by Griliches (1990). He asserts that patents differ greatly in their technical and economic significance. Many of them reflect minor improvements of little economic value. Some of them, however, prove extremely valuable. Thus, the weighting of patents becomes a problem. This study attempts to overcome these hurdles by calculating an index based on the number of
patents and the number of times each patent was cited.

Thirdly, there are only about 80 firms which have gone public during the period of this study, 1980-1987. Several of these firms (20) dropped out due to bankruptcies, buyouts, and/or mergers. Thus, leaving us with a very small n, which limited our statistical analyses.

Finally, since we were performing research on the biotech industry, this limited our ability to generalize the results across other industries. We can attempt to generalize the results to emerging industries, however, there is no guarantee that the findings will be indicative for all types of emerging industries.

CONTRIBUTIONS

This study made five contributions to the existing literature in strategic management. First of all, it provided researchers with a database on public biotech companies from the years 1980-1987. This will enhance our ability to continue research on the biotech industry.

Secondly, this dissertation provided a means of measuring the performance of public biotech companies. This could
provide very useful information to researchers and practitioners, especially investors and analysts.

Thirdly, past research has called for studies on the functional backgrounds of boards of directors. This study attempted to enhance our ability to learn about the relationship between outsiders' functional backgrounds with aftermarket IPO performance in the biotech industry.

Fourthly, this study investigated whether a relationship existed between the percentage of outside directors on the board of directors and aftermarket IPO performance in the biotech industry.

Finally, we examined the relationship between the size of the board and aftermarket IPO performance to see if an inverted U effect existed. Previous researchers have called for the investigation of this phenomena.

**DISSERTATION OVERVIEW**

The second chapter of this dissertation provides a literature review of the following areas: the biotechnology industry, resource dependency theory, size of the board, functional backgrounds of the board, inside versus outside
directors, performance, and a critique of previous research.

Chapter 3 contains the research methodology, including the research questions and variable descriptions, the research hypotheses, the research model, the multiple regression model, and subject companies.

The research findings will be presented in Chapter 4. The chapter will include the descriptive statistics, Pearson correlations, tests of the models, tests of the hypotheses, post hoc tests, and a summary.

Chapter 5, the final chapter, contains a summary of the dissertation along with implications, directions for future research, limitations, and a conclusion.
CHAPTER 2

REVIEW OF THE LITERATURE

This chapter will review the characteristics of emerging industries, using the biotechnology industry as an example. The theoretical foundation for this study, resource dependency theory, will also be examined. In addition, previous theoretical perspectives on boards of directors will be examined. A review of characteristics of emerging industries is provided next.

CHARACTERISTICS OF EMERGING INDUSTRIES
Porter (1980) came up with the concept of an emerging industry. He defined an emerging industry as a group of firms producing products that are close substitutes for each other. Porter states that emerging industries are newly formed or re-formed industries that have been created by technological innovation, shifts in relative cost relationships, emergence of new consumer needs, or other economic or sociological changes that elevate a new product or service to the level of a potentially viable business opportunity.

Emerging industries have the following characteristics in common: strong technological uncertainty, strategic uncertainty, high initial costs but steep cost reduction, many embryonic companies and spin-offs, first time badly informed buyers, and state intervention (subsidy, etc.) (Calori, 1985).

The following emerging industries have receiving increasing attention: fibre optics, microwave telecommunications, software, high definition television (HDTV), digital audio tapes (DAT), robotics, cellular
telephones, and biotechnology. The focus of this study is on
the biotechnology industry. A review of the literature on
biotechnology is provided next.

THE BIOTECHNOLOGY INDUSTRY

To familiarize the reader with the biotechnology
industry, the following areas will be discussed:
(1) background, (2) markets, (3) products, (4) governmental
regulation and research and development (R&D), and
(5) previous research.

BACKGROUND

Biotechnology is the use of biological processes to
develop products for human health care, agricultural
productivity, animal health, food safety and nutrition, and
environmental improvement. The biotechnology industry

encompasses a diverse group of companies that range in size,
technologies used, and markets served. Also included are
those companies whose primary mission is to supply
technology-based research products to other biotech companies (Burrill and Lee, 1992).

The traditional uses of biotechnology can be traced back several centuries with Pasteur's discovery that fermentation involves micro-organisms (Sharp, 1985; Yachinsky, 1985; and Faulkner, 1986). However, the actual roots of biotechnology lie in the discovery of the replication process of deoxyribonucleic acid (DNA) nearly forty years ago by Watson and Crick (1953a, 1953b) and Crick and Watson (1954).

The basic discoveries which led to the development of biotechnology happened in the 1960s and 1970s at academic institutions in the United States and Europe. The two most prominent discoveries which led to the actual birth of contemporary biotechnology are: (1) the discovery of the recombinant DNA (r-DNA) technique in 1973 by Chang and Cohen at Stanford and Boyer and Helling at UCLA and (2) the employment of hybridoma technology to produce monoclonal antibodies in 1975 by Millstein and Kohler in Cambridge.

**Recombinant DNA Technology (r-DNA)**

Recombinant DNA technology (genetic engineering) involves the production of hybrid gene material by joining
of DNA from different organisms together in vitro and then inserting this hybrid material into a host cell. Restriction enzymes are used to cut DNA into segments where specific sequences of nucleotides occur; the DNA sequence is then inserted in the DNA of a plasmid which, in turn, is introduced in host cells (bacteria or yeasts). This recombinant cell becomes the unit producing the desired proteins (Orsenigo, 1989).

In essence, recombinant DNA (r-DNA) technology or genetic engineering is the transfer of genetic information from one living cell to another. A gene which contains the information of a particular protein can be removed from the DNA of one organism, say a human being, and transferred to the DNA of another organism, say a single-celled bacterium. As the bacterium reproduces, it will pass along the genetic information to its offspring. Each of the bacteria will read the human gene and produce the protein it describes. Two human proteins which have been shown to have both anticancer and antiviral activity are: (1) TPA (tissue plasminogen activator), which dissolves blood clots and is useful in
treating heart attacks and (2) EPO (erythropoietin), which stimulates red blood cell production and helps in treating anemia (Fildes, 1990).

Through genetic engineering, future researchers should be able to provide people with a missing gene or replace a defective gene. This will make it possible to cure such diseases as cystic fibrosis, muscular dystrophy and over 2,000 other human genetic disorders.

**Monoclonal Antibody Technology**

The other major technology which led to the development of the biotechnology industry is monoclonal antibody technology (hybridoma technology). Through monoclonal antibody technology, we are able to produce large quantities of special proteins called monoclonal antibodies which are the body's natural defenders against disease-causing bacteria, viruses, and cancer cells. The technology is based on cell-fusion techniques. For example, the fusion of an antibody-producing white blood cell with another cell, such as a cancer cell, will help resist future cancerous growth. The fusion of these cells can be grown in large fermenters.
which can continuously manufacture valuable proteins for use as therapeutic and diagnostic products. Many new, fast accurate diagnostic tests using monoclonal antibodies have been introduced into the market. These tests provide a powerful means for accurately diagnosing many human and animal diseases (Fildes, 1990).

The Commercialization of Biotechnology

After the discoveries of r-DNA and monoclonal antibody technologies in the 1970s, small entrepreneurial companies (e.g., Cetus-1971, Genentech-1976, Genex-1977, Biogen-1978) capitalized on the opportunity to apply these technologies in business. Most of the new businesses started in the United States because risk capital was abundant at that time.

Growth of the industry has continued to proliferate into the 1980s and 1990s. For a review of the significant historical events in the industry see Table 2.1. Currently, there are over 1,200 biotechnology companies, of which over 250 are public. Total revenues for the biotechnology industry as a whole, both public and private companies, are estimated to be $8.1 billion for 1992. Biotechnology
companies are spread throughout the United States, however public companies are concentrated in six major areas: (1) New York Tri State Area (17%); (2) San Francisco Bay Area (14%); (3) Boston Area (13%); (4) Los Angeles/Orange County (7%); (5) Washington D.C. Area 7%; and (6) San Diego Area (7%) (Burrill and Lee, 1992). The commercialization of biotechnology, both in terms of research and the development of products and services has been receiving increasing attention in the 1990s and will continue to receive attention into the 21st century. The promise of this high technology field will proliferate due to its ability to alleviate social problems such as pollution, hunger, disease, and create new sources of wealth for nations. Biotechnology is emerging as one of the most significant scientific leaps forward in human history. The markets,

<table>
<thead>
<tr>
<th>Event</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watson &amp; Clark's replication of DNA</td>
<td>1953</td>
</tr>
<tr>
<td>The first biotech firm was founded, Cetus</td>
<td>1971</td>
</tr>
<tr>
<td>First cloning of a gene (genetic engineering)</td>
<td>1973</td>
</tr>
</tbody>
</table>
First monoclonal antibodies produced (hybridoma technology) 1975
DNA sequencing discovered 1976
Genentech was founded in the U.S. & was the first firm to exploit rDNA technology 1976
Methods for reading DNA sequence using electrophoresis discovered 1977
U.S. Supreme Court rules that micro-organisms can be patented 1980
The first biotech company goes public, Genentech--sets Wall Street record for fastest price per share increase ($35 to $89 in 20 minutes) 1980
United Kingdom & Germany target biotechnology for R&D 1980
Gene synthesizing machines developed 1981
Over 80 new biotech firms formed by end of year 1981
Japan targets biotechnology (MITI declares 1981 "The Year of Biotechnology") 1981
First rDNA animal vaccine approved for use in Europe 1982
First rDNA pharmaceutical product (human insulin) approved for use in the U.S. and the U.K. 1982
First markings for inherited diseases found in genes 1983
First artificial chromosome 1983

TABLE 2.1 (CONTINUED)

MAJOR HISTORICAL EVENTS IN THE BIOTECHNOLOGY INDUSTRY
<table>
<thead>
<tr>
<th>Event</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>New biotech firms raise $500 million in U.S. public markets</td>
<td>1983</td>
</tr>
<tr>
<td>Technique for DNA fingerprinting discovered</td>
<td>1984</td>
</tr>
<tr>
<td>First genetically engineered vaccine</td>
<td>1984</td>
</tr>
<tr>
<td>Genetic markings found for kidney disease and cystic fibrosis</td>
<td>1985</td>
</tr>
<tr>
<td>FDA approves the first genetically engineered vaccine (Hepatitis B)</td>
<td>1986</td>
</tr>
<tr>
<td>IPOs in the biotech industry virtually cease for 2 years after Dow Jones Average plunges a record 508 pts.</td>
<td>1987</td>
</tr>
<tr>
<td>FDA enacts accelerated regulatory process for products combating terminal diseases</td>
<td>1988</td>
</tr>
<tr>
<td>First U.S. patent on an animal-transgeneic mouse engineered to contain cancer genes</td>
<td>1988</td>
</tr>
<tr>
<td>Gen-Probe is first U.S. biotech company purchased by a Japanese company (Chugai Pharmaceuticals)</td>
<td>1989</td>
</tr>
<tr>
<td>Bioremediation gains attention, as microbe-enhanced fertilizers are used to battle the Exxon Valdez oil spill</td>
<td>1989</td>
</tr>
<tr>
<td>Cystic Fibrosis gene discovered</td>
<td>1989</td>
</tr>
<tr>
<td>Authors of Megatrends 2000, John Naisbitt &amp; Patricia Aburdene state that biotechnology will be as important as the computer</td>
<td>1990</td>
</tr>
<tr>
<td>FDA approves recombinant renin, an enzyme used to produce cheese; first bioengineered food additive to be approved</td>
<td>1990</td>
</tr>
<tr>
<td>First human gene therapy</td>
<td>1990</td>
</tr>
</tbody>
</table>
### TABLE 2.1 (CONTINUED)

**MAJOR HISTORICAL EVENTS IN THE BIOTECHNOLOGY INDUSTRY**

<table>
<thead>
<tr>
<th>Event</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mycogen is first company to begin large-scale testing of genetically engineered biopesticide, following EPA approval</td>
<td>1990</td>
</tr>
<tr>
<td>Roche Holding Ltd. acquires a 60% stake in Genentech for $2.1 billion</td>
<td>1990</td>
</tr>
<tr>
<td>Biotech companies sell $17.7 billion in new stock, the highest 5-month total in history</td>
<td>1991</td>
</tr>
<tr>
<td>Chiron Corp. acquires Cetus Corp. for $660 million in the largest merger yet between two biotech companies</td>
<td>1991</td>
</tr>
<tr>
<td>EPA approves the first genetically engineered biopesticide for sale in the U.S.</td>
<td>1991</td>
</tr>
<tr>
<td>39 biotech companies go public raising $1.2 billion</td>
<td>1991</td>
</tr>
<tr>
<td>85 public biotech companies raised $3.7 billion in U.S. stock offerings</td>
<td>1991</td>
</tr>
<tr>
<td>More than 100 genetically engineered drugs are in clinical trials, a dozen more are on the market, and 20 others are awaiting FDA approval</td>
<td>1991</td>
</tr>
<tr>
<td>Over 250 public and 900 private biotech firms exist</td>
<td>1992</td>
</tr>
<tr>
<td>Bush Administration unveils its &quot;Biotechnology Initiative,&quot; a plan to increase federal support for biotech research by 7% to $4.03 billion annually</td>
<td>1992</td>
</tr>
<tr>
<td>FDA enacts plan to speed biotech products to market; the plan is expected to save thousands of lives and a billion of dollars</td>
<td>1992</td>
</tr>
<tr>
<td>Regulatory policy passed for bioengineered foods</td>
<td>1992</td>
</tr>
</tbody>
</table>
which is designed to promote a profusion of new products on the market and increase investment in agricultural biotech stocks 1992

Total revenues for the biotechnology industry, both public and private, are estimated to be $5.8 billion 1992

**TABLE 2.1 (CONTINUED)**

<table>
<thead>
<tr>
<th>Event</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Bush Administration estimates sales in the biotech industry to be $50 billion by the year 2000</td>
<td>1992</td>
</tr>
<tr>
<td>Total revenues for the biotech industry are estimated to be $8.1 billion</td>
<td>1993</td>
</tr>
</tbody>
</table>
products, governmental regulation, and research and development process within the biotech industry will be discussed next.

MARKETS, PRODUCTS, GOVERNMENTAL REGULATION, AND R&D

Three factors which are important to the existence of biotechnology companies are: (1) the markets they serve, (2) their products, and (3) governmental regulation and research and development (R&D). These will be discussed next.

Markets

Biotechnology companies' products have been classified
into five markets: (1) human diagnostics, (2) human therapeutics, (3) ag-bio, (4) suppliers, and (5) other.

Burrill and Lee (1991) provide a definition of each market sector. "Human Diagnostics" focus on clinically important tests which are highly accurate and suited to the site where they will be used, whether it is a sophisticated urban reference laboratory or a rural clinic. Generally, these are subject to approval by the U.S. Food and Drug Administration.

"Human Therapeutics" are pharmaceutical products subject to extensive testing and clinical trials in regulatory environments administered by the FDA, and, if applicable, certain foreign regulatory agencies. The biotechnology industry is currently addressing therapeutic challenges ranging from cardiovascular disease, cancer, AIDS, chronic inflammatory diseases, and wound healing.

"Ag-bio" companies focus on plant genetics and the development of microbial pesticides and herbicides in order to improve yields of major crops, develop new strains, and prevent spoilage. Also included in this category are companies applying innovative technology (diagnostic kits,
enzymes, etc.) in the processing of agriculturally-based food products.

"Suppliers" have carved out a distinct niche in the overall market for lab instrumentation and supplies for life-science research by developing instruments and chemistries specifically suited to biotechnology.

"Other" consists of animal health care, transgenic animals (for research or biologic-products production purposes), and technologies that improve the nutritional characteristics of animal foods and that make the production of these foods more efficient. Bioremediation products are included within this designation as well. These market segments are developing vigorously and in time may command separate groupings. Their potential is enormous.

Table 2.2 (on the next page) shows the percent of public biotech companies which were profitable within each market

\[ \text{TABLE 2.2} \]

\begin{tabular}{|l|l|}
\hline
Profitable Cos. & Projected Sales ($M) \\
\hline
\end{tabular}
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic</td>
<td>26%</td>
<td>33%</td>
<td>2250</td>
<td>4800</td>
<td>9200</td>
<td>15%</td>
</tr>
<tr>
<td>Therapeutic</td>
<td>9%</td>
<td>13%</td>
<td>1050</td>
<td>1700</td>
<td>2500</td>
<td>9</td>
</tr>
<tr>
<td>Ag-bio</td>
<td>0%</td>
<td>8%</td>
<td>70</td>
<td>375</td>
<td>1400</td>
<td>35</td>
</tr>
<tr>
<td>Supplier</td>
<td>33%</td>
<td>56%</td>
<td>95</td>
<td>400</td>
<td>1300</td>
<td>30</td>
</tr>
<tr>
<td>Other</td>
<td>56%</td>
<td>44%</td>
<td>10</td>
<td>100</td>
<td>250</td>
<td>38</td>
</tr>
</tbody>
</table>

Source: Ernst & Young Annual 1992 Biotech Report and Consulting Resources Corp.

segment and the projected increase in sales within each area.

According to the table, the highest percentage of public companies that were profitable in 1991 were in the "other" market sector followed by the supplier and then the diagnostic sector. The projection of future sales shows the "other" market sector leading again with an annual increase in sales of 38% through 2002. This is followed closely by the agricultural market, 35%, and supplier market, 30%.

Products

The development of products is one of the most important factors which contributes to the financial success of biotech
firms. In a recent interview, Denise Gilbert, a biotechnology analyst with Smith Barney, Harris Upham, Inc., stated that publicly held biotech firms have more than 100 drugs in human trials and over 400 products in some stage of development. Burrill and Lee (1992) report that over 120 new biologics are in clinical trials and more than 20 are awaiting regulatory approval. Gilbert continues:

"The potential is staggering! By the year 2000 $50 billion worth of biotech products should be on sale around the globe" (Wall Street Week, 1992). Table 2.3 gives a list of products, targeted diseases, and approval date for products which have been approved by the Food and Drug Administration (FDA). Currently, only 37 products have been approved by the FDA in the biotech industry. A minute number, considering all the attention the industry has received.

For most of its history, the biotechnology industry has been built on the promise of products and sales of the future. Some companies are now turning that into reality, as they come to the marketplace with the following products:

* Genentech's t-PA ($210 million in sales in 1990) now has been joined and surpassed by Amgen's EPO ($320 million). Amgen's Neupogen achieving an astonishing $50 million in sales its first month out, may well outstrip both of its
competitors.

* Amgen may become the first biotechnology company to rank in the Fortune 500.  (If Amgen's fiscal 1992 EPO sales match 1991's, and Nuepogen maintains its momentum, Amgen

### TABLE 2.3

**PRODUCTS APPROVED BY THE FDA IN THE BIOTECH INDUSTRY**

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Indication(s)</th>
<th>Date of Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humulin</td>
<td>Diabetes</td>
<td>10/82</td>
</tr>
<tr>
<td>(Human Insulin)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protropin</td>
<td>Human growth hormone deficiency in children</td>
<td>10/85</td>
</tr>
<tr>
<td>(Human growth hormone)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intron A</td>
<td>Harry cell leukemia</td>
<td>6/86</td>
</tr>
<tr>
<td>(Interferon-alpha2b)</td>
<td>Genital warts</td>
<td>6/88</td>
</tr>
<tr>
<td></td>
<td>AIDS-related Kaposi's sarcoma non-A, non B Hepatitis</td>
<td>11/88</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2/91</td>
</tr>
<tr>
<td>ORTHOCLONE OKT3</td>
<td>Kidney transplant rejection</td>
<td>6/86</td>
</tr>
<tr>
<td>(Muromonab CD3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roferon-A</td>
<td>Hairy cell leukemia</td>
<td>6/86</td>
</tr>
<tr>
<td>(Interferon alpha-2A)</td>
<td>AIDS-related Kaposi's sarcoma</td>
<td>6/88</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RECOMBIVAX HB</td>
<td>Hepatitis B prevention</td>
<td>7/86</td>
</tr>
<tr>
<td>(Hepatitis B vaccine)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humatrope</td>
<td>Human growth hormone deficiency in children</td>
<td>3/87</td>
</tr>
<tr>
<td>(Human growth hormone)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activase (t-PA)</td>
<td>Acute myocardial infarction</td>
<td>11/87</td>
</tr>
<tr>
<td>(Tissue plasminogen activator)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pulmonary embolism</td>
<td>6/90</td>
</tr>
</tbody>
</table>
### TABLE 2.3 (CONTINUED)

**PRODUCTS APPROVED BY THE FDA IN THE BIOTECH INDUSTRY**

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Indication(s)</th>
<th>Date of Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>TheraCys</td>
<td>CIS of the urinary bladder</td>
<td>5/90</td>
</tr>
<tr>
<td>(BCG live)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actimmune</td>
<td>Chronic Granulomatous Disease</td>
<td>12/90</td>
</tr>
<tr>
<td>(gamma interferon)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procrit</td>
<td>Anemia associated with AZT/AIDS</td>
<td>12/90</td>
</tr>
<tr>
<td>(erythropoietin)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AlphaNine</td>
<td>Hemophilia B</td>
<td>12/90</td>
</tr>
<tr>
<td>(Factor IX)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TICE BCG</td>
<td>CIS of the urinary bladder</td>
<td>12/90</td>
</tr>
<tr>
<td>(BCG vaccine)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hibTITER</td>
<td>Haemophilus influenza type b</td>
<td>12/90</td>
</tr>
<tr>
<td>(conjugate vaccine)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PedvaxHIB</td>
<td>Haemophilus influenza type b</td>
<td>12/90</td>
</tr>
<tr>
<td>(conjugate vaccine)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ipol</td>
<td>Poliovirus immunization</td>
<td>1/91</td>
</tr>
</tbody>
</table>
(Vaccine, inactivated)

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Indication(s)</th>
<th>Date of Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intron A</td>
<td>Hepatitis C</td>
<td>2/91</td>
</tr>
<tr>
<td>(alpha interferon)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neupogen</td>
<td>Adjunct to Chemotherapy</td>
<td>2/91</td>
</tr>
<tr>
<td>(G-CSF)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leukine</td>
<td>Bone marrow transplant</td>
<td>3/91</td>
</tr>
<tr>
<td>(GM-CSF)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceredase</td>
<td>Type I Gaucher's disease</td>
<td>4/91</td>
</tr>
<tr>
<td>(glucoerebrosidase)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provisc</td>
<td>Ophthalmic Surgery</td>
<td>10/91</td>
</tr>
</tbody>
</table>
| Nicotine Patch     | Smoking Cessation                    | 11/91
|                    |                                      | 4/92             |
|                    |                                      | 5/92             |

**TABLE 2.3 (CONTINUED)**

**PRODUCTS APPROVED BY THE FDA IN THE BIOTECH INDUSTRY**

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Indication(s)</th>
<th>Date of Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azatin</td>
<td>Biopesticide</td>
<td>1/92</td>
</tr>
<tr>
<td></td>
<td>for Flowers</td>
<td></td>
</tr>
<tr>
<td>Proleukin</td>
<td>Renal Cancer</td>
<td>5/92</td>
</tr>
<tr>
<td>Intrin A</td>
<td>Hepatitis A</td>
<td>7/92</td>
</tr>
<tr>
<td>OncoScint CR</td>
<td>Colorectal Cancer</td>
<td>12/92</td>
</tr>
<tr>
<td>OncoScint OV</td>
<td>Ovarian Cancer</td>
<td>12/92</td>
</tr>
</tbody>
</table>
may well exceed the *Fortune* list cut-off, last at $546 million).

A discussion of governmental regulation and the research and development process in the biotechnology industry is next.

**Governmental Regulation and R&D**

The biotech industry is currently in its introductory
stage of its industry life-cycle. Biotechnology is a fast growing, still-emerging industry that is 17 years into what will probably be a 50 to 60-year life-cycle (Shamel, 1990). However, as of 1991, only six public biotech firms have reached profitability.

The cause for the red ink in most companies is the long process of getting a product to market. The Pharmaceutical Manufacturers Association (PMA) found that of the 23 new drugs approved by the FDA in 1989, it took an average of six years and four months of government-monitored human testing, following by another three years of administration review. In addition, most drugs require one or two years of pre-clinical studies before they are tested in human beings. This adds up to 10 to 12 years for an average drug to move from the lab to the patient (Burrill and Lee, 1991).

This extended period of time before a product reaches the marketplace can be attributed to the industry's impact on life and the quality of life. This has caused the biotechnology industry to be one of the most highly regulated industries in the U.S. It is also subject to intense government scrutiny
because of its economic potential, its pricing structure, growing environmental and ethical issues, and the concern over health care spending (Burrill and Lee, 1992).

The biotechnology industry is unique due to its diversified product mix (e.g., human and animal drugs, agricultural microorganism, and pesticides). Therefore, governmental regulations and R&D process differ for most products. For instance, Table 2.4 (on the next page) gives the specific governmental agency which must review a firm's application for a specific biotechnology product. According to the table, depending on a biotechnology company's product, it will have to deal with a specific governmental agency (e.g., FDA, EPA, USDA).

Similar to governmental regulations, the research and development process is unique to different products. We will look at human drugs or biologics as an example. The FDA employs a three-tier system of testing to ensure that new drugs and biologics are safe and efficacious before being brought to market. When a new drug is identified in a research and development program, it must undergo preclinical testing in animals to assess safety and biological activity. This data is used to support an Investigational New Drug
application (IND), which is submitted to the FDA in order to commence with human clinical studies.

| TABLE 2.4 |
| PRODUCT-SPECIFIC REGULATION OF BIOTECHNOLOGY |

<table>
<thead>
<tr>
<th>Food and Drug Administration (FDA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Drugs</td>
</tr>
<tr>
<td>Human Biologics</td>
</tr>
<tr>
<td>Medical Devices</td>
</tr>
<tr>
<td>Animal Drugs</td>
</tr>
<tr>
<td>Human Foods and Food Additives</td>
</tr>
<tr>
<td>Animal Feeds</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>U.S. Department of Agriculture (USDA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal Biologics</td>
</tr>
<tr>
<td>Animal Pathogens</td>
</tr>
<tr>
<td>Plant Pests</td>
</tr>
<tr>
<td>Transgenic Plants</td>
</tr>
<tr>
<td>Engineered Agricultural Microorganisms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental Protection Agency (EPA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pesticides</td>
</tr>
<tr>
<td>New Chemicals</td>
</tr>
<tr>
<td>Miscellaneous Environmental Uses of Microorganisms</td>
</tr>
</tbody>
</table>

Source: David J. Glass (1990) in Ono's The Business of Biotechnology

Clinical tests proceed in three phases: (1) In Phase I, the drug is tested in a small number of healthy human
volunteers, mostly to measure its safety, pharmacological effects, and how it is metabolized; (2) In Phase II, a larger group of patients actually suffering from the targeted disease are tested. This phase is designed to begin measuring the drug's effectiveness and to determine side effects. These tests are usually carried out at university or governmental medical centers; and (3) Phase III studies test the efficacy of the drug in 1000 to 3000 patients in many locations, and these trials must also show a low incidence of adverse effects.

After these trials, if the drug performs as expected, the sponsor must file a New Drug Application (NDA) with the FDA's Center for Drug Evaluation and Research, or in the case of a biologic, a product license application (PLA) with the Center for Biologics Evaluation and Research. These applications include all the data developed during the clinical trials. FDA approval of an NDA or PLA gives the sponsor clearance to sell the drug for the indications approved (Glass, 1991). New drug applications are usually approved within about two years, and the entire regulatory
process can take seven to twelve years and cost over $235 million.

The aforementioned process is the reason why most biotech firms do not have any products on the market and have yet to reach profitability. The Pharmaceutical Manufacturer's Association reports that the odds are 4,000 to 1 that a drug will not make it to market. Early on in the development process, most fail toxicity or efficacy tests, or are found to be impossible to produce in the manner and quantities that patients need. The next section will discuss the previous research in the biotechnology industry.

**Past Research**

Several books and reports have been published on the biotech industry. Probably the most informative and up to date information can be found in Ernst and Young's annual report on the biotechnology industry written by G. Steven Burrill and Kenneth B. Lee (1991, 1992). Although these reports change as rapidly as the industry itself, Burrill and Lee provide detailed information on the industry based on an annual survey and interviews with key executives in the
biotechnology industry. Some of the topics covered in the reports are product development, sales, government issues, financial information, corporate strategies (e.g., strategic alliances), key business and competitive issues, and an overview of the industry. In addition, the reports contain several charts, graphs, and future trends for the industry.

Another key book called *Biotechnology in a Global Economy*, is published by the U.S Government's Office of Technology Assessment (1991). The book is an in-depth look at the scientific and commercial aspects of the biotech industry. It has in-depth information on financing, federal funding, commercial activity, regulations, industrial policy, environmental applications, intellectual property protection, science and technology policies, and a summary of activity in the pharmaceutical, agricultural, and chemical industries.

Most of the books which have been published on the biotech industry have been scientific. However, there are a few books which have concentrated on the business side of biotechnology. Ono (1991) developed a book which includes 19 articles from 23 specialists within the industry. Some of the articles on the biotech industry in Ono's book include:

Some other recent books which have been written on the business aspects of biotechnology are Daly's (1985) *The Biotechnology Business*, Orsenico's (1989) *The Emergence of Biotechnology*, and Yoxen and Di Martino's (1989) *Biotechnology in Future Society*.

Daly's (1985) investigation of the biotechnology industry includes: background; applications; companies in the U.S., Japan, and Europe; characteristics of the emerging industry; role of governments; case studies; strategies; and keys to success. Orsenico's (1989) book concentrates on the history, trends, government activity, and patterns of industrial innovative activities. Yoxen and Di Martino's (1989) book discussed the different scenarios and options available for the biotechnology industry in Europe.

There have only been a few academic research articles
investigating the following business aspects in the biotechnology industry: strategies of new biotechnology firms (Smith and Fleck, 1988); inter-firm technological collaboration of Japanese biotechnology firms (Roberts and Mizouchi, 1989); strategic challenges in commercializing biotechnology (Fildes, 1990); positioning and innovation (Hamilton, Vila, and Dibner, 1990); and international cooperation (Shan and Hamilton, 1991).

Smith and Fleck (1988) did an in-depth case study analysis of 6 biotech firms investigating how the firms developed. They found that new biotechnology firms tend to develop in three alternative ways: (1) Remain a small or medium size company manufacturing products or undertaking research for other larger companies and possibly selling their "own brand" of diagnostic kits; (2) Become a full fledged pharmaceutical company developing a portfolio of several products at different stages of development. To reach this size, the company must not only grow very rapidly, but go through a series of organizational and cultural changes; (3) Merge with or be taken over by a larger company. This strategy allows the smaller firm possible access to new funding, distribution channels, and new products.
Roberts and Mizouchi (1989) analyzed the inter-firm collaborative strategies of Japanese biotechnology firms.

Drawing upon one of the hottest issues in strategic management, strategic alliances, Roberts and Mizouchi expect three trends to emerge from the inter-firm collaboration strategies in the Japanese biotechnology industry: (1) A stable not increasing amount of research will be contracted out to U.S. start-ups. The fact that R&D research costs in the U.S. are cheaper due to the devaluation of the U.S. dollar; (2) Japanese firms will increase their technology licensing with foreign companies. This will give the Japanese access to world-wide distribution channels at a reduced cost; (3) There will be an increase in the acquisition of Japanese domestic pharmaceutical companies and seed firms. These strategies are expected to be used until the Japanese biotech industry catches up with the United States.

Fildes (1990) discussed the strategic challenges which will face the biotechnology manager in the future. The first internal strategic challenge will be the ability to manage their technical excellence by attracting, motivating, and retaining the best and brightest people in
the industry. The second challenge is the balance between the budget and R&D. A focus must be maintained on the development of new products as cost effective as possible. The final internal challenge is the timely acquisition of downstream capabilities. A company must grow from the R&D department to the marketplace and the sales force must be hired at the appropriate time.

According to Fildes (1990), the biggest external strategic challenge facing the biotechnology industry will be the ability to raise future financing. Lately, public biotech companies have not had any problems with raising capital. However, Wall Street analysts are skeptical of the earnings reports and future of many of these new public biotech upstarts. The second external challenge will be the regulatory environment. Most of the areas in the biotechnology industry are heavily regulated by the Food and Drug Administration. Finally, the biotechnology industry is very competitive. There are hundreds of small companies in the U.S., Europe, and Japan racing to develop the same products.

Hamilton et al., (1990) surveyed 320 senior biotech
executives on their strategic choices used for innovative activities. The empirical study tested three strategic choices: (1) innovation processes--R&D, manufacturing, and marketing activities needed for technology commercialization; (2) external alliances--decisions to pursue innovative activities with external agents; and (3) timing--timing associated with innovation activities and external alliances. The findings of the study indicate that emerging firms in the wake of a revolutionary technological advance exhibit rapid and significant shifts in strategic priorities.

The final article investigating the biotech industry was Shan and Hamilton's (1991) "Country--Specific Advantage and International Cooperation." They investigated a sample of domestic and international cooperative relationships formed by Japanese firms in the commercialization of biotechnology. The findings indicate that country-specific advantages influence international cooperative relationships in the biotech industry. For instance, the country-specific advantage of R&D in the U.S. has led several Japanese biotech firms into collaborative agreements with biotech firms in the U.S. The results of the study indicate that interfirm
cooperation has implications for the international competitiveness of both firms and nations in the biotech industry.

BOARD RESEARCH

Research on the effect of boards of directors on corporate financial performance has proliferated for the past five decades. Diverse disciplines such as management, sociology, economics, and finance have investigated this topic with contradictory findings.

Zahra and Pearce (1989) reviewed the empirical research published on the contributions of boards of directors on corporate financial performance. According to Zahra and Pearce, management, finance, economics, and sociology scholars contributed four prominent theoretical perspectives on boards and corporate financial performance: 1) Legalistic Approach, 2) Class Hegemony, 3) Agency Theory, and 4) Resource Dependency Theory. These four approaches differ in their views of what directors do, which board attributes
influence company performance, and which criteria should be used to assess board contribution to company performance.

The following is a brief review of three of the four theoretical perspectives which look at the effect of boards of directors on corporate performance. The final theoretical perspective, resource dependency theory, is the focus of this study. An in-depth review of the literature on the resource dependence perspective will also be provided.

**The Legalistic Perspective**

The "legalistic approach" suggests that boards of directors contribute to the performance of their firms by carrying out their legally mandated responsibilities. Advocates of this approach posit that corporate laws vest considerable powers in directors to enable them to fulfill their roles.

According to this approach, boards are responsible for corporate leadership without actual interference in day-to-day operations, which are the duties of the chief executive officer (CEO) and senior executives (Zahra and Pearce, 1989). It views the role of the board as including responsibility for
selecting and replacing the CEO, representing the interests of the firm's shareholder's, providing advice and counsel to top management, and serving as a control mechanism by monitoring managerial and company performance (Ewing, 1979; Mueller, 1981; Vance, 1983; Mattar and Ball, 1985; Carpenter, 1988).

Class Hegemony Perspective

The "class hegemony" approach, rooted in Marxist sociology (Mills, 1956; Nichols, 1969; Ratcliff, 1980), views boards as a means of perpetuating the powers of the ruling capitalist elite. The theory states that board membership is a shared commitment among the ruling capitalists to control social and economic institutions, hence wealth.

Previous researchers imply that only the most influential, prestigious individuals are invited to serve on the boards. By this exclusion of other social groups, the values and interests of the ruling capitalists are protected. Thus, the envisioned task of the board is to coordinate actions by the firms they serve and more importantly, to ensure capitalist control of societal institutions (Zahra and Pearce, 1989).
Agency Theory

Deeply rooted in economics and developed in the domain of finance, "agency theory" was formed from the literature on property rights (see Coase, 1937, 1959, 1960; Alchian, 1965, 1968; Alchian and Demsetz, 1972; Jensen and Meckling, 1976). Agency theory emerged in the 1970's as a powerful means of examining the conflicting relationship between owners and managers. Jensen and Meckling (1976) define an agency relationship as follows, "a contract under which one or more persons (the principal(s)) engage another person (the agent) to perform some service on their behalf which involves delegating some decision making authority to the agent."

Agency theory assumes that principals and agents have different self-interests and they try to enhance their own utility. Principals (e.g., shareholders) tend to be profit oriented because they have a stake within the firm, whereas agents tend not to be profit oriented. Another assumption of agency theory is that principals and agents have different attitudes towards risk. Agents tend to be more risk averse because they are unable to diversify their jobs. Principals
have a more liquid position due to their ability to liquify their holdings within the firm. This difference has led researchers to believe that principals and agents have conflicting goals which leads to different attitudes towards risk and self-interests.

"Agency theory" is among the most recognized approaches to studying boards of directors. Agency theory argues that agency relationships should be the focal point in analyzing and studying corporate governance. Boards perform the critical function of monitoring and rewarding top executives to ensure the maximization of shareholders' wealth (Zahra and Pearce, 1989).

Fama (1980) stated, the board's most important role is to scrutinize the highest decision makers in the firm. Fama and Jensen, 1983b) asserted that boards can fulfill the monitoring function because they have the power to hire, fire, and compensate the top-level managers and to ratify and monitor important decisions.

Board contribution to organizational performance occurs by reducing agency cost arising from noncompliance of executives with established goals and procedures, by
articulating shareholders' objectives and focusing the attention of key executives on company performance, and through strategic decision making and control (Mizruchi, 1983).

Resource Dependency Theory

The final theoretical approach to understanding the effect of the board of directors on corporate performance is "resource dependency" theory. Resource dependency theory is the prime theoretical base for this dissertation.

Resource dependency theory is deeply rooted in sociology (Selznick, 1949), built upon open systems theory (Katz & Kahn, 1966) and contingency theory (Lawrence & Lorsch, 1967). Resource dependency theory emerged in the 1970s as a new perspective on how organizational environments affect, constrain, and control organizations and how organizations deal with these external constraints and controls (Pfeffer & Salancik, 1978).

The following research provided the base for the formulation of the resource dependency perspective. Lawrence and Lorsch (1967) found that organizational effectiveness
depends upon a differentiation of activities that is consistent with environmental uncertainties. Burns and Stalker (1961), Emery and Trist (1965), Thompson (1967), Neghandi and Reimann (1973), and Osborn and Hunt (1974) suggest that organizations search their environment more in a complex environment. According to the sociological approach to understanding organizations, organizations cannot exist as self-contained entities isolated from their environments (Parsons, 1956; Selznick, 1949). Therefore, they must rely upon their environment for resources to enhance performance. According to resource dependency theory, firms scan the environment to extract resources to enhance the firm's legitimacy in society and to help it achieve its goals of efficiency and improved performance (Pfeffer, 1972, 1973; Price, 1963; Provan, 1980; Zald, 1967). Resource dependency theory (Aldrich and Pfeffer, 1976; Pfeffer and Salancik, 1978; Pfeffer, 1987) proposes that a firm's survival is contingent on its ability to gain control over critical environmental resources.

Resource dependency theory views organizations from the perspective of power. Organizations are seen as complex
systems of coalitions who compete with each other for scarce resources. According to Mintzberg (1983), Pfeffer (1981), and Pfeffer & Salancik (1978), power and influence are important and permanent facts of organizational life. Resource dependency theory proposes that organizations try to influence, control, or even create the environment (Pfeffer, 1981; Pfeffer & Salancik, 1978).

The resources in the environment lay at the heart of resource dependency theory. Organizations need these resources in order to survive in the competitive environment. Thus, much competition arises from other organizations for the scarce resources which may be undependable.

Pfeffer (1981) describes the success of an organization as maximizing its power for obtaining needed external resources. Pfeffer (1981) and Pfeffer & Salancik (1978) state the following assumptions of the resource dependency perspective on how organizations work to achieve power: (1) to exist in an environment which contains scarce and valued resources that are essential to organizational survival and (2) to acquire control over resources that minimize their dependence on other organizations and to acquire control over
resources that maximize the dependence of other organizations on themselves. The major theme of the resource dependence theory is that the links among organizations are characterized as a set of power relations which originate from the exchange of resources. Facing external constraints and control, organizations attempt to change their dependence relationships and to maximize their power by decreasing their own dependence or by increasing the dependence of other organizations on themselves. (Wang, 1991).

In this study, we look at how firms, in the emerging industry of biotechnology, extract these critical external resources through their board of directors. Through this co-optation, we hypothesize that biotech firms which extract more critical external resources (e.g., financiers and university scientists) will have better aftermarket IPO performance. We assume the extraction of these critical external resources, will assist the firm in its effort to overcome their "liability of newness" (Stinchcombe, 1965).

Resource Dependency Theory and Boards

The resource dependence perspective views boards as vehicles through which organizations "co-opt, or partially
absorb, important external organizations with which they are interdependent" (Pfeffer, 1972: 222). According to Pfeffer, co-optation is likely to be used by business organizations "when total absorption is (1) legally prescribed, (2) impossible due to resource constraints, or (3) when partial inclusion is sufficient to solve the organization's problems of dealing with the external organization" (1972:22).

Resource dependence calls for outside directors on the board as a means of achieving co-optation. These outside directors provide important information or resources for the organization. One of the first people to look at the resource value of outsiders on the board was Selznick in his (1949) study of the Tennessee Valley Authority. He concluded that an organization, which is faced with strong opposition, could partially neutralize their situation by bringing in representatives of hostile groups onto the organization's governing boards.

Burt (1980) found previous research which suggested that outsiders absorbed from such external groups as customers, suppliers, and competitors enable firms to facilitate resource exchange agreements and reduce both vertical and
horizontal external constraints. For example, in the case of the biotechnology industry, we have hypothesized that firms having a higher number of outside directors with functional backgrounds in the finance industry and scientists at universities will perform better than other firms. Essentially what we are saying is, these firms will have access to privatized information and resources from the environment more than other firms.

Resource dependency theory is based upon the premise of power. It is this power that a board has which enables it to search the environment, both internal and external, to achieve the goals of the firm, such as effective corporate performance. Powerful boards are considered necessary for organizational effectiveness in regards to the resource dependence perspective because they provide useful contacts, thus strengthening the link between corporations and their environments (Bazerman and Schoorman, 1983; Castaldi and Wortman, 1984; Pfeffer, 1972, 1973; Provan, 1980; Zald, 1967, 1969).

In summary, scholars have studied the effects of boards on corporate performance using resource dependency theory.
Past research has revolved around the theme that boards which fit the firm's external environment or aid in absorbing uncertainty enhance company performance. The next three sections review the previous research on the independent variables used in this study.

Size of Boards and Corporate Performance

Corporate board size has remained the same during the past half century. Past studies have found boards which ranged from very small (5 or 6) to very large (30 plus).

Gordon (1945) found that the average size of corporate boards has remained the same (between 12 and 14) for the past 50 years. A more recent study by Heidrick and Struggles, Inc. (1986), found the average board of Fortune 500 companies to be 13.7 members.

Research on the size of boards and its relationship to corporate performance has not proliferated to the extent of the insider versus the outsider dimension in the board composition literature. Early research on size of boards, utilized size as a proxy measure of director's expertise (Bacon, 1973; Herman, 1981). It was assumed that larger
boards had directors with diverse skills and educational and industrial backgrounds which would enhance the quality of board decision making. Furthermore, larger boards were associated with enhancing the firm's ability to obtain resources, creating a better image of the company, and diminishing the power of the CEO. Hence, there existed a universal tendency towards a positive relationship between the size of the board of directors and corporate performance.

In a study of 57 hospitals in a large midwestern state, Pfeffer (1973) examined the functions of hospital boards of directors. He found that the size of the board of directors was related to the requirements for successful linkage with the environment and with the function of the board.

Helmich (1974) found that the size of the board was associated with effective CEO succession patterns, a requisite for effective corporate performance. When the board was large, directors were in a position to avoid inbreeding by selecting competent outside executives to lead the firm. Helmich's conclusions urged stability in determining board size to create parallel internal stability in corporate leadership, another important predictor of
company performance (Zahra and Pearce, 1989).

Provan (1980) studied 46 nonprofit human service agencies within the same community. He found that larger boards provided a stronger access to funding for the nonprofit organizations. In essence, he stated that larger boards provided access to previously scarce resources which enhanced the effectiveness of the organization.

In a study of 21 pairs of successful versus unsuccessful retailing firms, Chaganti, Mahajan, and Sharma (1985) found that non-failed firms tended to have bigger boards than failed firms. The average board size of the non-failed firms was between 10-15.

From a list of 100 randomly selected Fortune 500 companies, Zahra and Stanton (1988) found that larger board size was conducive to effective corporate financial performance (e.g., profit margin on sales and log profits). Overall, past research findings would tend to indicate a relationship between larger boards and enhanced corporate

TABLE 2.5

SUMMARY OF MAJOR BOARD SIZE–CORPORATE PERFORMANCE STUDIES
<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>Independent Variables</th>
<th>Dependent Variables</th>
<th>Sample Size</th>
<th>Analytical Approach</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pfeffer Board composition (1973)</td>
<td>Size</td>
<td>Percent increase in budget between reflected sources of funding.</td>
<td>57 hospitals</td>
<td>Correlation</td>
<td>Board size and performance positively related.</td>
</tr>
<tr>
<td>Chaganti Board were</td>
<td>Firm bankruptcy</td>
<td>21 pairs of T-test</td>
<td>Smaller boards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mahajan &amp; Size Sharma</td>
<td>successful/failing retail firms</td>
<td>Board size was related with financial performance.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zahra &amp; Board not Stanton Size (1988)</td>
<td>ROE</td>
<td>100 Fortune 500</td>
<td>Canonical</td>
<td>Board size was related with financial performance.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EPS</td>
<td>1980-83</td>
<td>correlation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DPS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Net sales-to-equity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Profit margin on sales</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Log profits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
performance. For a review of the major studies see Table 2.5. However, caution must be used in interpreting the past research. Hiner (1968) has argued that there is an optimum number of directors on the board which is conducive to corporate performance. Zahra and Pearce (1989) hypothesized the possibility of a non-linear (inverted U) relationship between board size and corporate performance. They propose that as the size of the board reaches a certain point, performance is optimal. The following are some possible explanations for this phenomena.

Social psychologists and organizational behavior scholars have focused on such group issues. Group size has
been shown to affect group processes and outcomes (Bettenhausen, 1991). As groups increase in size, a major problem which might affect their performance level is "groupthink" (Janis, 1972). According to Janis, groupthink is "a deterioration of mental efficiency, reality testing, and moral judgement that results from in-group pressures."

Essentially, groupthink results from the pressures on individual members to conform and reach consensus. Committees (e.g., boards) that are suffering from groupthink are so bent on reaching consensus that there is no realistic appraisal of alternative courses of action in a decision, and deviant, minority, or unpopular views are suppressed (Luthans, 1989).

Furthermore, as group size increases, the possibility of "risky shift" (Stoner, 1961) might increase. The risky shift phenomena states that groups may make more risky decisions than individual members under loss conditions. The results of these decisions could lead to decreased levels of performance. Social loafing (Latane, Williams, and Harkins, 1979) is another possible explanation for the proposed inverted U effect on boards. According to social
loafing, a decrease in performance occurs under group conditions when participants feel their outputs cannot be compared to those of others. In our study, we might suspect that as board size increases, the possibility for social loafing might increase, unless board members outputs are evaluated individually. If board members individual contributions can not be measured, this could lead to decreased output by members on the board and possible decreased performance levels by the firm.

Other possible explanations for the inverted U effect are: (1) a decrease in communication between individuals, (2) political problems, and (3) conflicts which arise due to the formation of smaller groups on the board (e.g., dyads, triads).

One of the goals of this study is to determine if a non-linear (inverted U) relationship does exists between the size of the board and aftermarket IPO performance of these biotech firms. The next section will discuss the past research on functional backgrounds of board members.

Functional Backgrounds of Board Members

Functional backgrounds of directors have been

There is a need to study the performance effects of variation among board members (Morck, Shleifer, and Vishny, 1988; Kosnik, 1990). Despite the importance given to the composition of the board and corporate performance in past research, there has been only a slight amount of empirical evidence dealing with the functional backgrounds of directors. A summary of the research is provided.

One of the earliest studies to look at the functional aspect of board members was Vance (1968). He developed a model of 10 important board characteristics: membership contact, owner's equity, percentage of patronage, corporate interlocks, asset impact, image, director economic sophistication, specific economic service, management expertise, and technical expertise. He tested the model and found that special interest groups and reliance on expertise of outside directors were associated negatively with performance (Vance, 1978).

Pfeffer (1972) looked at the functional backgrounds of
the outsiders on the board in 80 non-financial institutions. He hypothesized that as an organization has greater needs for external financing, access to the capital market, and legal assistance, particularly in a regulated environment, it will be more likely to have a greater proportion of outsiders who are representatives from financial institutions and law firms. He found that organizations who have a high debt/equity ratio (suggesting dependence upon lenders) had a high proportion of outside directors, from financial institutions, on their board.

Pfeffer and Salancik (1978) argued that firms needed to establish appropriate links with political, financial, or competitive collaborators to deal with the external uncertainties facing the organization. Hence, they argue for the acquisition of specific functional deficiencies within the organization.

In a study attempting to determine the functional backgrounds of boards of directors in the nation's 1,300 largest firms, Heidrick and Struggles (1981) found that 64.9% were business executives, 6.0% were attorneys, 8.9%
were teachers or educational administrators, and 4.5% were consultants. Mills (1985) reported the percentage of functional backgrounds of non-executives in Fortune 500 companies in 1982: 37% commercial bankers, 24% investment bankers, 62% attorneys, 50% academics, and 27% ex-government officers.

Baysinger and Butler (1985) investigated the functional backgrounds (e.g., financiers, consultants, lawyers, and interdependent decision makers) of boards of directors in 266 firms from 1970-1980. They found no significant relationship between the composition of the board and performance. However, they found that firms with a higher percentage of independent directors in the early part of the decade ended up with superior performance, on average, later in the period. In essence, they propose a lagged performance effect by these independent directors. Furthermore, firms that started with above average performance and remained above average, had far fewer than a majority of independent directors and ended with fewer than a majority of independent directors.

Kesner (1988) examined the occupation, type, tenure, and
gender in relationship to the director's membership on four board committees, the audit, nominating, compensation, and executive committees. Results showed strong evidence that the members of these committees are more likely to be outsiders, come from business occupations, and have longer tenure than nonmembers.

Sebora, Kesner, and D'Aveni (1990) looked at the composition of the board and its relationship to tender offers from 1984-1986. Findings indicate the presence of a greater variety of experts in the areas of finance, law, and academics on the board, the more likely it is to resist a takeover offer.

Overall, previous research on the functional backgrounds of boards of directors and corporate performance has been sparse. Previous empirical studies have contradicting findings: (1) Pfeffer (1972) found a significant positive relationship between higher debt/equity ratios and outside directors from financial backgrounds and (2) Vance (1978) found a reliance on the expertise of outside directors was associated with negative performance. No major conclusions can be drawn from the results of previous studies. However,
we expect that firms which rely on outside directors with specific functional expertise will outperform those which are deficient of these types of directors.

Although it is difficult to make any global concluding remarks at this time on research of the functional backgrounds of board members, board activists have generally recommended that companies recruit outside directors on the basis of their functional expertise, specialized knowledge, or links with certain stakeholders (Bacon and Brown, 1975; Waldo, 1985). Through a heterogeneous board, it is thought that the quality of board decisions will be enhanced, thus, leading to increased corporate performance.

**Inside Versus Outside Directors**

Research on the insider versus outsider-corporate performance link has been conducted over the past four decades (see Zahra & Pearce (1989) for an extensive review). Agency and resource dependency theorists, legalistic scholars, and anti-class hegemony activists have all investigated the insider versus outsider-corporate performance link with contradictory findings. Table 2.6 summarizes most of the
major insider versus outsider-corporate performance studies.

Past studies utilizing resource dependency and agency theories have emphasized the importance of outside directors on the board (Pfeffer, 1972; Baysinger and Butler, 1985; Kesner, Victor, and Lamont, 1986; Kosnik, 1987; Singh and Harianto, 1989). Agency and resource dependency theories state that an increased number of outsiders on the board will enhance the performance of the firm. However, Vance (1955, 1964, 1968) has shown that having a majority of insiders on the board leads to better performance. In summary, previous empirical evidence has provided contradictory results.

According to Table 2.6, several authors have researched the relationship of insiders versus outsiders with various aspects of corporate performance. Some of the performance criteria used in past studies include: golden parachutes (Cochran, Woods, and Jones, 1985; Singh and Harianto, 1989); greenmail (Kosnik, 1987); illegal acts (Kesner et al., 1986); bankruptcy (Chaganti, Mahajan, and Sharma, 1985); shareholder suits (Kesner and Johnson, 1990); financial ratios (Vance,

TABLE 2.6
<table>
<thead>
<tr>
<th>Study</th>
<th>Independent Variables</th>
<th>Dependent Variables</th>
<th>Sample Size</th>
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</thead>
<tbody>
<tr>
<td>Vance</td>
<td>Insiders vs. Outsiders</td>
<td>Sales</td>
<td>200</td>
</tr>
<tr>
<td>Regression (1955)</td>
<td>Insiders were positively associated with Equity performance.</td>
<td>Net income</td>
<td>(1925-1950)</td>
</tr>
<tr>
<td>Vance</td>
<td>Insiders vs. Outsiders</td>
<td>Sales</td>
<td>103</td>
</tr>
<tr>
<td>Regression (1964)</td>
<td>Insiders were positively related to performance.</td>
<td>Net income</td>
<td>(1925-1963)</td>
</tr>
<tr>
<td>Pfeffer</td>
<td>Deviation</td>
<td>Income/sales</td>
<td>80</td>
</tr>
<tr>
<td>Spearman (1972)</td>
<td>Firms that deviated from ideal Income/equity</td>
<td>more poorly. insider-ratio</td>
<td></td>
</tr>
<tr>
<td>Schmidt</td>
<td>Insiders vs. Long-term debt</td>
<td>No relationship</td>
<td>80 chemical companies</td>
</tr>
<tr>
<td>Regression (1975)</td>
<td>Outsiders were positively related to Dividends</td>
<td>companies performance.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Current ratio</td>
<td>(1962-1971)</td>
<td></td>
</tr>
</tbody>
</table>
Schmidt   Outsiders'    ROE             156 industrial   Chi-square   No relationship
(1977)    financial    Long term    firms    Z-statistics between outsiders'
affiliation    debt    ratio affiliation and Net working capital
performance. per sale dollar

Baysinger Number of   ROE             266 companies
Cross-lagged Firms having more outsiders
& Butler outsiders in 1970 & 1980
regression in 1970 outperformed their

<table>
<thead>
<tr>
<th>TABLE 2.6 (CONTINUED)</th>
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<tr>
<td>SUMMARY OF MAJOR INSIDE VS OUTSIDE-CORPORATE PERFORMANCE STUDIES</td>
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<tr>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Study</td>
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<td>-------</td>
</tr>
<tr>
<td>Analytical Approach (year)</td>
</tr>
<tr>
<td>Kesner</td>
</tr>
<tr>
<td>Victor &amp; Lamont</td>
</tr>
<tr>
<td>Lamont</td>
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<td>Kesner</td>
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<tr>
<td>Kesner (1987)</td>
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<tr>
<td>Kosnik</td>
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<tr>
<td>Kosnik (1987)</td>
</tr>
<tr>
<td>Zahra &amp; Stanton</td>
</tr>
<tr>
<td>Schellenger &amp; Wood</td>
</tr>
<tr>
<td>Tashakori</td>
</tr>
<tr>
<td>Singh &amp; Harianto</td>
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</table>

<table>
<thead>
<tr>
<th>Kesner &amp; Proportion</th>
<th>Shareholder</th>
<th>56 pairs of T-test</th>
<th>Fewer outsiders were on Johnson of suits companies boards that were sued.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1990) outsiders</td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>


In terms of the operationalization of the independent
variable, insider versus outsider, three approaches have been used:

(1) Number of Outsiders: The association between the overall number of outsiders and corporate performance has been used by (Vance, 1955, 1964, 1968). His findings indicated that boards which had fewer outside directors were associated with superior performance.

(2) Outsider Dominance: Researchers proposing this approach state that simply increasing the number of outside directors is not sufficient to reform a board. They argue that a majority of outsiders is necessary to command power to challenge the chief executive officer's (CEO's) dominance.

In operational terms, researchers measured the power of outsiders by emphasizing either outside proportion or dominance. Proportion was calculated by dividing the number of outside directors to board size. In contrast, "dominance" denoted the existence of a large majority of outside directors on the boards, and was treated as a dichotomous variable (outsider vs insider controlled) (Zahra & Pearce, 1989).

Kesner et al., (1986), Kesner (1987), and Zahra and Stanton (1988) used both proportion and dominance in their
operationalizations of insider-outsider and found no significant differences between boards that were dominated by outsiders and those that were not.

(3) Industry Inside-Outside Norm: The final operationalization of the independent variable is the focus of this study. Using resource dependency theory, Pfeffer (1972) found that an ideal ratio of inside-outside directors had a relationship with better performance. This ratio was unique to each industry and any deviations from this ratio had a negative effect on corporate performance. For example in an emerging industry like biotechnology, one might expect a disproportionate number of outsiders to reduce the uncertainty in a firm's operations and to secure critical resources and information.

In analyzing the findings of Table 2.6, out of the 15 studies reviewed, eight studies found no relationship between insiders versus outsiders and corporate performance. The other studies were either positively or negatively related to corporate performance. A brief summary of some of the major findings will be presented next.
Research on the association between the board of directors and corporate performance initiated with Vance (1955, 1964). He found that boards with fewer outsider directors were associated with superior company performance. Schmidt (1975, 1977) found no relationship between the ratio of insiders to outsiders and various forms of financial performance (e.g. ROE).

Kesner, Victor and Lamont (1986), Kesner (1987), Zahra and Stanton (1988) found no significant differences between boards that were dominated by outsiders and those that were not. Baysinger and Butler (1985) found that firms having more outsiders in 1970 outperformed their counterparts in 1980. However, the best performing firms did not have a majority of outsiders. Cochran et al., (1985) and Singh and Harianto (1989) examined the relationship between the proportion of outsiders and the firm's adoption of golden parachutes. Golden parachutes "involve a renegotiation of top-management compensation contracts to include very sizeable payments to be made in the event of a takeover" (Singh and Harianto, 1989: 7). They found that the higher the proportion of outsiders on the firm, the more likely the
firm would adopt golden parachutes. Schellenberger et al., (1989) found no relationship between the financial measures of ROE and ROA and the proportion of outsiders. And finally, Kesner and Johnson (1990) found no relationship between the proportion of outsiders and shareholder suits.

As stated initially in this section, the previous findings are inconclusive. Overall, the results of past studies suggest that inside directors, not outside directors, are related to corporate performance. However, the prevailing consensus from the resource dependence perspective has emphasized the importance of increasing the outside dominance on the boards which will enhance corporate performance. Thus, the dilemma remains in the studies of this phenomenon.

PERFORMANCE

The measurement of organizational performance (Child, 1974, 1975; Thorelli, 1977; and Lenz, 1981) has been questioned by several researchers (Cameron and Whetton, 1983; Hofer, 1983; Chakravarthy, 1986; Lubatkin and Shriever, 1986; Venkatraman and Ramanujam, 1986). Although the importance of the performance concept is widely
recognized (Yuchtman and Seashore, 1967; Steers, 1975, 1977; Campbell, 1977; Goodman and Pennings, 1977; Connolly, Conlon and Deutsch, 1980) the treatment of performance in research settings is perhaps one of the thorniest issues confronting the academic researcher today (Venkatraman and Ramanujam, 1986).

The performance dimension is at the heart of research in strategic management. Two major problems have confronted strategic management scholars on measuring performance: (1) how to measure an organization's performance and (2) when to measure an organization's performance. These issues will be addressed next.

Measurement of Performance

Historically, strategy research has defined performance by some accounting-based index such as assets, and/or sales growth. Each of these measures, however, captures only one dimension of performance (Dalton, Tador, Stendolin, Fielding, and Porter, 1980; Ford and Schellenberger, 1982). Measurement problems associated with accounting-based measures are as well documented as those of hybrid measures
(e.g., price/earnings) which incorporate both accounting and market-based measures (Hong, 1977; Lev and Sundar, 1979; Rappaport, 1983). Chakravarthy (1986) states the following problems with measures of performance based in accounting: (1) scope for accounting manipulation, (2) undervaluation of assets, (3) distortions due to depreciation policies, inventory valuation and treatment of certain revenue and expenditure items, (4) differences in methods of consolidating accounts, and (5) differences due to lack of standardization in international conventions. Furthermore, traditional measures of performance are not necessarily correlated with the value of the firm (Beaver, Kettler, and Scholes, 1970; Gonedes, 1973) and record only the history of the firm. Hofer (1983: 45) discusses the difficulties of all of the traditional performance measures in organizational research. For instance, in analyzing the performance measure ROI, he asks "how should investment be defined?"
Previous studies on the size of the board and corporate performance have used performance measures such as percent increase in budget (Pfeffer, 1973), amount of intra-agency funding (Provan, 1980), firm bankruptcy (Chaganti et al., 1985), and ROE, EPS, net sales-to equity, profit margin on sales (Zahra and Stanton, 1988). Previous studies on the functional background of boards and corporate performance used performance measures such as debt to equity (Pfeffer, 1972) and return on stockholder's capital (Vance, 1978). Finally, past studies on inside versus outside directors and corporate performance have used performance measures such as sales, net income, and equity (Vance, 1955, 1964), debt and current ratio (Schmidt, 1975, 1977), bankruptcy (Chaganti et al., 1985), golden parachutes (Cochran et al., 1985; Singh & Harianto, 1989), ROE (Cochran et al., 1985; Zahra & Stanton, 1988; Schellenger et al., 1989), number of illegal acts (Kesner et al., 1986), greenmail (Kosnik, 1987), and shareholder suits (Kesner & Johnson, 1990).

The difficulty in this study was the lack of profits within the biotechnology industry. As stated earlier, only 6
firms have reached profitability, thus traditional accounting measures (e.g., ROI, ROE) could not be used. Due to the nature of the industry, multiple measures of performance will be used. Aftermarket IPO performance will be measured under two constructs: (1) Market Performance and (2) Technological Performance. These will be discussed next.

Market Performance

To determine the aftermarket IPO performance of biotech firms, two performance measures utilizing stock prices were developed. There are a number of advantages to using stock prices: (1) stock prices represent the only direct measure of stockholder value, (2) stock prices are readily available for all publicly traded companies, (3) stock prices are believed to be fully specified; that is they are not limited to a specific aspect of performance such as sales growth or profits, but rather reflect all relevant information aspects of performance, (4) stock prices are reported objectively, and (5) stock prices have been shown to see through managers attempts to manipulate reported accounting measures (Lubatkin and Shriives, 1986).
Stock price, as a measure of corporate performance, has been used by Vance (1978). He measured corporate performance through the return on stockholder's capital (ROSC). ROSC was compiled by taking the average price of a share of common stock plus the dividends for that year.

Dalton and Kesner (1985) also used stock market price over an extended period of time in a CEO succession study. They looked at the monthly, closing, stock price of companies over a three year period in determining the stock market reaction prior to successions. Stock prices have been used regularly in the executive succession literature (see Salancik and Pfeffer, 1980; Weiner and Mahoney, 1981; Dalton and Kesner, 1985; Beatty and Zajac, 1987; Worrell and Davidson, 1987; and Friedman and Singh, 1989).

Technological Performance

The other measure of aftermarket IPO performance in this study was technological performance. Patents and citations will be used to calculate this performance measure. A patent is a document, issued by an authorized governmental agency, granting the right to exclude anyone else from the
production or use of a specific new device, apparatus, or process for a stated number of years (17 in the U.S. currently) (Griliches, 1990). A patent is cited (also called a citation) if it is listed as a reference on the cover page of a later, follow-on patent document.

Patent and citation information provide a unique planning resource for managing a firm's technology or product development and for systematically evaluating its competitive position to other companies in a market area (Ashton and Sen, 1988). Narin, Carpenter, and Woolf (1984) claim that patents and their citations are a valid reflection of technological productivity and communication. Furthermore, Carpenter, Narin, and Woolf's (1981) study found that outstanding new products were 2.5 times as frequently cited as randomly chosen control patents from the same time frame. That is, patents associated with outstanding new products were rather highly cited (Narin, Noma and Perry, 1987).

The use of patents and citations as a measure of a firm's technological performance has been studied by Narin et al., (1984). They state that a company's technological performance can be quantified through bibliometrics-the
counting, classification and analysis of publications and citations. Several researchers have investigated the patent-citation relationship (e.g., Reisner, 1963; Gerson, 1972; Ellis, Hepburn, and Oppenheim, 1978; Narin, Noma, and Perry, 1987; and Buderi, Carey, Gross, and Miller, 1992). Narin et al., (1987) studied links between citations/patent data and several indicators of corporate financial performance in 17 US pharmaceutical companies. They found positive meaningful correlations between the citations/patent data and indicators of financial performance (e.g., change in net pre-tax profits).

Buderi et al., (1992) and CHI Research Inc., studied 197 of the world's top companies in 14 industries. They developed a measure derived from the number and quality of patents (based on citations/patent) to develop a measure of technological performance. From their results, a list of the most technologically innovative companies in the world was developed.

**Time Period**

Similar to the difficulty of how to measure performance,
is the dilemma of what time period should be used. Researchers have stressed the importance of measuring strategic outcomes over an extended period of time because of the lagged manifestation and impact of strategic moves on firm performance (Lubatkin and Shrieves, 1986; Gomez-Mejia, Tosi, and Hinkin, 1987; Fowler and Schmidt, 1988; and Keats and Hitt, 1988). However, many board researchers have neglected the lag effect of board variables, such as board composition, on organizational performance (Zahra and Pearce, 1989).

This study attempts to overcome the deficiency of previous studies by measuring the performance of public biotech firms over a four-year period (4 years following the initial offering). The advantages of using a four year period to measure corporate performance are: (1) A four-year period is relatively long enough to minimize the influence of short-term irregularities. Thus, providing better and more reliable long-term indicators than annual measures; and (2) Lubatkin and Shrieves argue that it is inappropriate to use short-term horizons to study strategic acts, "because the flow of information regarding strategic events cannot be dated
precisely (1986: 508).

Previous studies on the size and composition of the board and corporate performance have neglected the strategic lag effects on performance. However, Pfeffer's (1973) study on hospitals looked at the relationship between the size of the board and the amount of new programs developed over a five-year period. He found that the size of the board was related to the requirements for successful linkage with the environment and with the board. A critique of previous research is provided next.

 Critique of Previous Research

The first major limitation of past research on the relationship between board size and corporate performance has been the neglect of researchers to realize the possibility of a non-linear (inverted U) relationship. Past studies have implied that there is a relationship between larger board size and enhanced corporate performance. Researchers have yet to determine if an inverted U relationship does indeed exist between the size of the board and corporate performance.
Research on the relationship between the functional backgrounds of outsiders on the board and corporate performance has been virtually extinct. Previous empirical studies have contradicting findings: (1) Pfeffer (1972) found a significant positive relationship between higher debt/equity ratios and outside directors from financial backgrounds and (2) Vance (1978) found a reliance on the expertise of outside directors was associated with negative performance. In our study, we expect that a reliance on outsiders with expertise in specific functional areas would enhance corporate performance.

A major limitation of previous research on the insider versus outsider dimension is the operationalization of the independent variable. Some authors have used the ratio of insiders to outsiders, the proportion and dominance of outsiders, and the number of outsiders. The diverse measurements of the predictor variable may lead to differing results. For instance, the number of outsiders on the board may not be the same as the ratio of outsiders on the board.

Another limitation on the insiders versus outsiders phenomenon is the performance criteria used. Past research
on insiders does not reflect the contributions of outsiders according to previous theories. In addition, most studies have emphasized the financial performance measures versus the market based measures when looking at these relationships.

Other critiques of past research on the size and composition of boards and corporate performance include: (1) a focus on the Fortune 500 population, while neglecting non-profit medium, and smaller organizations, and (2) a lack of specific industry studies, and (3) a lack of studies which investigate the relationship between board size and composition and the time-lag effect on corporate performance.

Finally, academic research dealing with the business aspect of biotechnology has been sparse. Most of the research has been of a descriptive nature, with only a few academic articles existing. Past researchers have neglected the investigation of the relationship between boards of directors and corporate performance in the biotechnology industry.
CHAPTER 3

RESEARCH METHODOLOGY

This research project was designed to investigate the research issues and questions presented in the preceding chapters. The study looked at the relationship between the
size and composition of the boards of directors and aftermarket performance of initial public offerings in the biotechnology industry. The specific research questions addressed in this study were:

1. Is there a relationship between the size of the board of directors and aftermarket IPO performance of firms in emerging industries?

2. Is there a relationship between the number of outside members with financial related backgrounds and aftermarket IPO performance of firms in emerging industries?

3. Is there a relationship between the number of outside members who are university scientists and aftermarket IPO performance of firms in emerging industries?

4. Is there a relationship between the interaction of outside members with financially related backgrounds and outsiders who are university scientists with aftermarket IPO performance of firms in emerging industries?

5. Is there a relationship between the percentage of outside directors on the board and aftermarket
IPO performance of firms in emerging industries?

The research hypotheses are delineated subsequent to the presentation of the variables and their definitions. Given the aforementioned research questions, the following variables were employed in this study:

INDEPENDENT VARIABLES: The following variables on the size and composition of the board were investigated:

- Size of the Board (SOB)
- Outsiders on the Board (OOB):
  - Financially Related Individuals (FL)
  - University Scientists (US)
  - Financially Related Individuals x University Scientists (FL x US)
- Percentage of Outsiders (I/O)

DEPENDENT VARIABLES: Aftermarket IPO Performance (IPO)

- Market Performance (MP1 & MP2)
- Technological Performance (TP)

CONTROL VARIABLES: Organizational Size (OS)

- Organizational Age (OA)
- Initial Offering Size (IOS)
Variable Selection Criteria

When constructing a predictive model for this study, the selection of variables involved an extensive literature search and discussions with a leading biotech analyst and several researchers in the field of biotechnology.

Due to the sparse amount of business research on biotech firms, Denise Gilbert, a leading biotech analyst at Smith Barney, Upham Harris was contacted. She was asked the following question, "How do you value biotech firms when they don't have any profits or products on the market?" She stated that Smith Barney looks at the following factors in placing a value on biotech firms: (1) products, (2) proprietary products, (3) markets served, (4) strategies, and (5) the top management team.

The focus of the study is on part of the top management team, the boards of directors. The independent variables which were selected for this study (e.g., size of the board and percentage of outside directors on the board) were based on previous research done by Pfeffer (1972) and several other board researchers. The control variables in this study (e.g., organizational size, organizational age, and initial
offering size) were also integrated into the study. A more in-depth examination of these variables is given in the theoretical background and the measures of the variables sections.

The most difficult aspect in developing a predictive model for this study was determining how to measure the performance of the biotech firms. Currently, there are no performance measures for these firms. Therefore, an extensive literature review of performance measures used in the fields of finance and strategic management was conducted. Cutting-edge researchers in biotechnology at the University of Washington and Harvard University were also contacted to determine appropriate performance measures.

After an extensive review of the performance literature, two performance measures were integrated into this study. The first performance measure used stock prices. The second performance measure, number of patents and citations, was adopted from the dissertations in progress at the University of Washington and Harvard University. Patents and citations should reflect the proprietary product issue which Denise Gilbert used to value biotech companies. Previous
researchers (Carpenter et al., 1981) have stated that high citation rates on patents are associated with the patents of innovative and important products.

Upon further examination of Gilbert's valuation technique, other valuation factors were investigated. The first two factors, products and proprietary products were introduced into the study as a measure of technological performance, patents and citations. Due to lack of availability of data on products in the research stages, the actual number of products could not be used in this study.

In regards to Gilbert's third valuation factor, markets served, problems arose. While a firm may say that the target market for a specific product may be $20 billion, the actual sales of the product may be $10 million. Furthermore, the difficulty arises as to what specific markets are being targeted if one does not have access to all of a firm's products in the their research stages.

Finally, Gilbert looks at the strategies used by biotech firms. It is assumed that all of the biotech firms will be using a differentiation strategy in trying to come out with products which are unique to the marketplace. In addition,
to gain access to specific strategies being used by the companies (e.g., distribution channels) one would have to go inside these organizations and interview key individuals within the firms.

In summary, multiple sources were used to determine the variables which were selected for inclusion in this study: (1) an extensive literature review; (2) a leading biotech analyst; and (3) leading researchers in the field biotechnology.

Independent Variables

The size of the board of directors was measured by counting the number of individuals on the board of directors. In addition, the functional backgrounds of outside members of the board of directors were then analyzed. The following outsider functional backgrounds were examined: financially related individuals and university scientists.

Financially related outsiders consisted of any individual coming from an investment or commercial bank, venture capital firm, or any other financially related firm. University scientists was comprised of individuals who are on
the faculty at a university and have a background in the sciences (e.g., medicine, biology, chemistry, biochemistry, genetics).

Measurement of the functional backgrounds of outside directors was done through the following procedures. First, the number of outsiders with financial backgrounds and university scientists were summed up separately for two final figures. The first figure, the number of outsiders with financially related backgrounds, was used as our measure of the second independent variable. The second figure, the number of outsiders who were university scientists, was used as our measure of the third independent variable. Finally, both of the numbers obtained from the second and third independent variables were multiplied for our fourth independent variable, the interaction between outside directors with financial backgrounds and university scientists.

The final independent variable was the percentage of outsider directors on the board. This was measured by counting up all of the outside members of the board and dividing by the total size of the board. A final ratio was calculated. To be included as an insider director one of the
following criteria must have been met: (1) retired from
the company, (2) currently or previously employed by the
company, and (3) be related to someone in the company. All
other directors were assumed to be outsiders.

Finally, an outsider must have been on the board for at
least three of the four years in the study to be considered
part of the board.

**DEPENDENT VARIABLES**

The dependent variable used in this study was
aftermarket IPO performance (IPO). Multiple measures (e.g.,
market and technological performance) were used to measure
the aftermarket IPO performance of the biotech firms in the
study. Since only 6 public biotech companies have reached
profitability, measurement of performance was the most
difficult aspect of this study. Regular accounting ratios
(e.g., ROE, ROI) were not used due to the lack of
profitability of these firms. The problems as stated
earlier: (1) the infancy of the industry, (2) the lack of
profits in the industry, (3) the lack of existing products on
the market, (4) and the amount of time it takes for a product
to get to

market, 10-12 years. Therefore, measurement of performance was extremely difficult.

**Market Performance**

Stock prices have been determined to be one of the measures of performance for this study. Cochran and Wood (1984) argued that although there is no consensus as to what constitutes the proper measure of financial performance, such measures fall into two broad categories: (1) an investor return and (2) an accounting term. Due to the unique nature of the companies in this study, accounting measures were not used. Therefore, two measures of stock prices were used as a measure of market performance.

The first measure was the average quarterly stock price over a four year period. The following process will be used to calculated the stock prices of the public companies in the first measure of market performance: (1) a measure of the stock price at the date of the public offering was taken, (2) a stock price measure every quarter for 4 years was recorded, (3) a percentage increase or decrease was calculated for each
quarter from the previous quarter, and (4) all of the percentages from the 16 quarters were averaged for a final average % quarterly return.

To control for risk, variance was calculated for each quarter. The final performance measure consisted of a ratio of average quarterly increase or decrease divided by the variance.

\[
\text{Average Quarterly Return} \quad \frac{\text{Average Quarterly Increase or Decrease}}{\text{Variance of Returns}} = \text{Performance Ratio}
\]

This method of valuing a stock's performance is common in the field of finance. Levy and Sarnat (1972) and Johnson (1978) discuss the valuation of an individual stock versus its risk. They state that the risk-return relationship for any stock is formulated in terms of the expected return divided by the variance of the returns.

The second stock price measure of market performance controlled for industry effects by taking the percentages obtained from the first measure and subtracting the industry
average percentages. The following process was used to calculate these numbers: (1) all of the percentages from the first market performance measure were tabulated, (2) an industry average was calculated by adding up all of the biotech firms' percentages (minus the firm we are looking at) and dividing by the number of firms that went public in that year, and (3) a final percentage was calculated by subtracting the industry average from the individual firm's percentage. The following formula was used to calculate the market valuation of the biotech firms for the second measure of market performance:

\[
\text{RET} = \frac{\sum_{i}^{n-1} \text{RET}_i}{\sum_{j}^{n-1} \text{VAR}_j} - \frac{\sum_{i}^{n-1} \text{VAR}_i}{\sum_{j}^{n-1} \text{VAR}_j} = \text{Performance Ratio}
\]

Previous researchers have used similar methods of controlling for industry effects. In their studies of
IPO's, Brown and Warner (1980; 1985) and Ritter (1991) controlled for industry effects by using the CRSP Value Weighted Index (Amex-NYSE and NASDAQ indexes). Tinic (1988) used the Standard and Poor's Composite Index (S&P) to control for industry effects in his study of IPO's. These indexes were not used in this study due to the confounding effects of other industries on the overall results. In addition, a specific biotechnology index had not been developed during the period in this study. Therefore, the most appropriate manner to control for the movements within the industry, was to control for the biotech companies themselves.

Technological Performance

Previous researchers (Carpenter et al., 1981) have empirically proven that patents receiving high citation rates are associated with the patents of innovative and important products. In addition, the usage of patents and citations has recently been used as an indicator of technological performance (see Buder et al., 1992).

This study, similar to Buder et al., (1992), used the
number of patents and citations as a measure of technological performance. The following process was used to determine technological performance: (1) the number of patents and their identification # were obtained for four years after each firm's initial offering, (2) the number of citations for each patent were obtained for each patent, (3) a final number was obtained by multiplying each patent by the number of times it was cited over the four year period, (4) the numbers from step three were added for a numerical measure of technological performance, (5) all of the numbers from step four were added together and divided by the total sample size for an average number of citations x patents, (6) a citation index (C/I) was then formed by taking the average number of patents x citations for each company (which was 3) and equivocating that with 1. Afterwards, for every increase or decrease of 1, 10% was added or subtracted from the base index of 1. For instance, a firm with a patent x citation measure of 5 would have an index of 1.2., finally (7) the citation index (C/I) was multiplied by the total number of patents over the four year period in the study for a final measure of technological
performance (TP).

Patents which are awaiting approval will not be included in this study. There are two reasons for not including them in the study. First of all, the data on patents awaiting approval was not available. Secondly, since these patents have not been approved, they have no citations. Therefore, a value of their technological performance can not be obtained according to the formula used in this study.

Control Variables

Other likely variables affecting the criterion variable in this study, although not the focus of the study, include: (1) organizational size (OS), (2) organizational age (OA), and (3) initial offering size (IOS).

Organizational researchers have suggested that larger organizational size is associated only with increases in the pool of resources available for organizational use (Gooding & Wagner, 1985). It has been proposed that larger organizations are more likely to possess the resources necessary to acquire control over environmental entities that mediate critical resources (Aldrich & Pfeffer, 1976; Pfeffer & Salancik, 1978). Larger organizations are thought to have
access to more critical resources which might enhance the survivability of the firm.

Despite the previous conclusions, the organizational size-performance relationship has reported contradictory findings. Gooding and Wagner (1985) performed a meta-analysis on the organizational size-performance relationship and found difficulty in analyzing the results due to the different operationalizations of the variables.

Previous studies have operationalized organizational size by the following measures: (1) number of employees (e.g., Marriott, 1949; Glisson & Martin, 1980), (2) log of the number of employees (e.g., Evers, Bohlen, & Warren, 1976) which might reflect the degree to which the availability of human resources facilitates or constrains performance, (3) physical capacity measures (e.g., number of beds in a hospital; Hrebinik & Alutto, 1973), and (4) financial assets (e.g., Weiner & Mahoney, 1981) reflects the discretionary resources that are available to attract additional members or balance productivity.

The operationalization of performance also might be an important difference among size-performance studies which
might moderate findings. Some of the measures used have been: (1) absolute output (e.g., net revenues produced; Evers, Bohlen & Warren, 1976), (2) Compustat indices (Weiner & Mahoney, 1981), and (3) organizational records (Glisson & Martin, 1980). Inconsistencies across previous studies, therefore might arise out of the differences in the operationalizations of the variables. In this study, organizational size (OS) will be operationalized as the average number of employees over the four year period following the firm's initial offering.

The organizational age-performance link is thought to be another important control variable in this study. Zahra and Pearce (1989) have critiqued previous research on boards of directors and performance for their lack of controlling for intra-industry differences, such as organizational size and age. This study will control and measure organizational age by: (1) determining the founding year of the organization and (2) counting the number of years the firm has been in existence during the study.

Older organizations might have an advantage over newer firms by having more: (1) information and resources, (2)
patents, and (3) experience. Established relationships with key individuals might give older firms an advantage in obtaining critical information and resources over newer firms. In addition, older organizations might be further along in their R&D activities.

Since it takes an average of 10-12 years for a product to get to market in the biotechnology industry, older firms might have an advantage over newer firms by having products already in the pipeline. Finally, older firms might have gained invaluable experience in management activities (e.g., obtaining quality employees, functioning as a team, learning from mistakes).

The initial size of the offering is also thought to be important control variable in the study. Larger initial offerings might give firms increased resources to perform research and obtain top researchers and executives. Since the biotech industry is very capital intensive, the amount of money raised at the initial offering might be an important variable contributing to the performance of the firm. The initial offering size will be compiled from the following sources: (1) **Standard and Poor's Stock Reports** and (2)
prospecti from the SEC and the companies. The next section will discuss the research hypotheses.

### RESEARCH HYPOTHESES

**Size of the Board and Corporate Performance**

The main conclusion from previous research on the relationship between the size of the boards and corporate performance was, "larger boards would enhance corporate performance." Despite this conclusion, Hiner (1968) and Zahra and Pearce (1989) argue that there is an optimum number of directors on the board which is conducive to corporate performance. Zahra and Pearce (1989) hypothesize the possibility of a non-linear (inverted U) relationship between board size and corporate performance. They propose that as the board reaches a certain number, corporate performance will be maximized.

Given the mixed messages in the previous research findings, the present study will examine the following relationship between the size of the board and corporate performance:
H1: There will be a positive linear relationship between the size of the boards of directors of public biotech firms and their aftermarket performance.

Functional Backgrounds and Corporate Performance

According to resource dependency theory, boards are vehicles through which organizations co-opt, or partially absorb, important external organizations with which they are interdependent (Pfeffer: 222). Resource dependence views outsiders on the board of directors as a means of achieving co-optation. Through these outside directors, organizations can gain important information or resources.

Previous research on the functional backgrounds of boards of directors and corporate performance has been sparse and inconclusive. In this study, we hypothesize that public biotech firms which have a greater number of outsiders on the board of directors with functional backgrounds in finance and science (e.g., university professors in medicine, chemistry, life sciences) will have better aftermarket performance.
It is thought that biotech firms which have a larger number of outsiders on the board who are financiers will have better performance due to their experience and connections within the financial industry. Since the average amount of time for a product to get to market is 10-12 years, and only 6 firms have reached profitability in the biotech industry, financial hurdles must be overcome. By having outsiders from the with functional backgrounds in finance, firms might have better access to vital information and resources which could enhance the firm's future profitability. The previous rationale leads to our hypothesis:

H2: Public biotech firms with a greater number of outside board members with financially related backgrounds will have better aftermarket performance.

We also argue that biotech firms which have an increased number of outside board members who are university scientists will have better aftermarket IPO performance. Outside scientists could provide the firm with: (1) valuable research techniques, information, and/or data, (2) information on
experienced workers, and (3) the ability to review other scientists work.

The ability of outside university scientists to review others work has been exemplified in the literature on board professionalism. March and Simon (1958:70) state: "To the extent that a job is professionalized, techniques and standards of performance are defined by the other members of the profession." Thompson (1967:113) notes "Because such occupations rest on specialized skills, there is basis for contention that assessment standards should be established and performance evaluated by peers in the occupation....."

Professionalism is characterized by the accumulation of specific, often unique, knowledge over a long period of time (e.g., scientists) (Sebora, 1992). By having a larger number of outside board members who are scientists, they can review the work of other scientists within the firm. Thus, leading to our third hypothesis:

**H3: Public biotech firms with a greater number of outside board members who are university scientists will have better aftermarket**
performance.

The next hypothesis to be tested combines hypotheses 2-3. This hypothesis was developed to examine the interaction between outsiders with functional backgrounds in finance and science.

H4: There will be a positive significant relationship between the interaction of outside board members with financially related backgrounds and outsiders who are university scientists with aftermarket IPO performance.

Insider Versus Outsider and Corporate Performance

Research on the insider versus outsider-corporate performance link has been conducted over the past four decades (see Zahra & Pearce, 1989) for an extensive review). Agency and resource dependency theorists, legalistic scholars, and anti-class hegemony activists have all investigated the insider versus outsider-corporate performance link with contradictory findings.
Past studies utilizing resource dependency and agency theories have emphasized the importance of outside directors on the board (Pfeffer, 1972; Baysinger and Butler, 1985; Kesner, Victor, and Lamont, 1986; Kosnik, 1987; Singh and Hariano, 1989). Agency and resource dependency theories state that an increased number of outsiders on the board will enhance the performance of the firm. However, Vance (1955, 1964, 1968) has shown that having a majority of insiders on the board leads to better performance. In summary, the past empirical evidence has concluded contradictory results.

In congruence to resources dependency theory, this study hypothesizes that firms in the biotech industry will tend to extract critical resources from their environment. Since the industry is in its introductory stage, we assume that firms that have a larger percentage of outsiders in specialized areas (e.g., finance and science) might have a relationship with better corporate performance. Thus, leading to our final hypothesis:

H5: Public biotech firms which have a greater percentage of outside directors will have
better aftermarket IPO performance.

The next section will review the data sources which were used in the study.

**DATA SOURCES**

Data sources used for this study were comprised of several sources. First of all, a database needs was developed for public companies in the biotech industry. These sources were listed earlier. Secondly, four sets of proxy statements for each company were used to collect data on the board of
directors and organizational age. These were for four consecutive years after going public. The proxies were collected from the companies, the SEC, and Disclosure Inc. Thirdly, prospecti from the SEC, Disclosure, and/or the companies was used for information on the initial offering size. Fourthly, *Standard and Poor's Stock Reports* was used to collect data on the stock prices of the firms. Fifthly, data on patents and citations was gathered from the Dialog database (U.S. Patent and Trademark Office of Classification). Finally, annual reports were collected for information on the size of the firms.

**EXPERIMENTAL DESIGN**

The design of this study was cross-sectional in nature. The size and composition of the board and aftermarket IPO performance measures were collected the year the firm went public and 4 subsequent years after the firms' initial public offering. Statistical tests were run on the performance measures and the variables comprising the size and composition of the board, along with the control variables.
A multivariate analytical approach—i.e., multiple regression and correlational analysis—was the statistical approach used to establish the various relationships identified in the research questions. Descriptive statistics were also run on the variables. The assessment of the relationship between the independent and control variables and aftermarket IPO performance was run on the statistical procedures of SPSSx.

THE GENERAL MODEL

A general multiple regression model was developed to test the hypotheses generated earlier. A definition of the variables is provided:

\[ Y = a_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5 + b_6 x_6 + b_7 x_7 + b_8 x_8 + e \]

DEPENDENT VARIABLE:

\[ Y_1 \] - aftermarket IPO performance (IPO)
INDEPENDENT VARIABLES

\( x_1 \) - size of the board (SOB)

\( x_2 \) - number of financially related outsiders on the board of directors (FL)

\( x_3 \) - number of university scientists who are outsiders on the board of directors (US)

\( x_4 \) - the interaction between the number of financially related outsiders and university scientists on the board of directors (FL x US)

\( x_5 \) - percentage of outside directors on the board (I/O)

CONTROL VARIABLES

\( x_6 \) - organizational size (OS)

\( x_7 \) - organizational age (OA)

\( x_8 \) - initial offering size (IOS)

In the general multiple regression equation, the dependent variable is seen as a linear function of more than one independent variable, where the subscript identifies the independent variables (Lewis-Beck, 1980). In this dissertation, \( Y \) is determined by \( X_1 \) to \( X_8 \).
Multiple regression is a method for studying the effects and the magnitude of the effects of more than one independent variable on a single dependent variable using principles of correlation and regression (Kerlinger, 1986). What multiple regression and correlation does, essentially, is to find the best possible combination of x's (independent variables) given y (dependent variable) and the relations among the variables so that the correlation between the x's and y is a maximum.

For example, in our problem (see Figure 1.1) multiple regression finds the values of $b_1$, $b_2$, $b_3$, $b_4$, $b_5$, $b_6$, $b_7$, and $b_8$ that will make the correlation between $x_1$, $x_2$, $x_3$, $x_4$, $x_5$, $x_6$, $x_7$, and $x_8$ together, and $y_1$ as high as possible. The $b$ weights are called regression weights or coefficients and are used with the independent variables in predicting the dependent variable, $y_1$. Through this method, a new variable which is a combination of $x_1$ through $x_8$ is created, $y'$. The multiple correlation between
observed dependent variable \((y_1)\) and the dependent variable predicted from knowledge of \(x_1\) through \(x_8\) can then be predicted. The correlation between \(y'\) and \(y\) creates an ordinary correlation coefficient, "r." Due to the difficulty in computing the coefficient of correlation "r", the product moment technique, or the Pearson coefficient of correlation, will be used. The Pearsonian "r" is equivalent to the ordinary correlation coefficient "r." The Pearson "r" correlations are depicted in Chapter 4.

The technique of multiple regression makes it possible to combine predictor variables and thus to make a better prediction than any "one" predictor variable can do alone (Minium, 1978). Through multiple regression, weights will be applied to each predictor variable so that the weighted total of these variables has the highest possible correlation with the variable we are attempting to predict. The Pearsonian correlation, \(R\), yields the correlation between the variable to be predicted and the best weighted composite predictor variables. In essence, \(R\) is the highest possible correlation between a least-squares linear composite of the independent
variables and the observed dependent variable. The term, \( R^2 \), indicates the portion of the variance of the dependent variable, \( Y \), due to the independent variables. The values of \( R^2 \) run from 0 to 1.00 and the knowledge of the value of the multiple correlation coefficient does not tell us how to make the prediction. However, it does enable us to predict possibilities.

The regression equation estimates what the expected value of \( Y' \) will be when \( X \) has a certain value. It must be reinforced that the predicted value, i.e., \( Y' \), is only an estimate. If the correlation coefficient is high, the actual values will gather closer to the actual predicted value. If the coefficient is low, it is expected that a lot of variation will occur about the actual values of the predicted \( Y' \). If the correlation has a value of 1.0, then the actual value equals the predicted value. A way to measure this predictive error is with the standard error of estimate \( S_{xy} \). The standard error of the estimate is the standard deviation of the distribution of obtained \( Y \) scores about the predicted \( Y \) score. If the correlation is perfect, every value of \( (Y-Y') \)
is zero, and therefore $S_{xy}$ is zero. Therefore, there is no error of prediction.

The following are the assumptions which are necessary for the multiple regression and correlation procedures to work: (1) the distribution of $Y$ scores (for a particular value of $x$) is normal, (2) in using a regression equation to obtain the predicted value for $Y$, a straight line must be the line of best fit, and (3) regardless of the value of $X$ from which the prediction has been made, $S_{xy}$ is taken as the standard deviation of the distribution of obtained $Y$ scores about $Y'$.

**SUBJECT COMPANIES**

In an effort to control for industry variation, companies from a specific industry were chosen. All public companies in the biotechnology industry (80) were chosen from the years 1980-1987. Out of the 80 original companies used in the study, only 60 companies continued to exist throughout the study. Of the remaining 60 companies, only the
The organizational age of CYTRX Corp. was unable to be obtained. The disposition of the remaining 20 companies was not investigated in this study.

Table 3.1 (on the next page) shows population and sample used in the study. Table 3.2 shows the names of the public biotech companies which were used in the study.

TABLE 3.1
POPULATION AND SAMPLE

<table>
<thead>
<tr>
<th>NO. FIRMS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Biotech Firms from 1980-87</td>
<td>80</td>
</tr>
<tr>
<td>Less:</td>
<td></td>
</tr>
<tr>
<td>Companies purchased, merged, or bankrupt</td>
<td>20</td>
</tr>
<tr>
<td>Net sample size</td>
<td>60</td>
</tr>
</tbody>
</table>
### TABLE 3.2

**PUBLIC BIOTECH COMPANIES USED IN STUDY**

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>YEAR WENT PUBLIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genentech</td>
<td>1980</td>
</tr>
<tr>
<td>Enzo Biochem</td>
<td>1981</td>
</tr>
<tr>
<td>Cetus</td>
<td>1981</td>
</tr>
<tr>
<td>Collaborative Research</td>
<td>1981</td>
</tr>
<tr>
<td>Genetic Systems Corp.</td>
<td>1981</td>
</tr>
<tr>
<td>Hybritech</td>
<td>1981</td>
</tr>
<tr>
<td>Interferon Sciences</td>
<td>1981</td>
</tr>
<tr>
<td>Monoclonal Antibodies</td>
<td>1981</td>
</tr>
<tr>
<td>Ribi Immunochem Research</td>
<td>1981</td>
</tr>
<tr>
<td>Viratek</td>
<td>1981</td>
</tr>
<tr>
<td>COMPANY</td>
<td>YEAR WENT PUBLIC</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Centocor</td>
<td>1982</td>
</tr>
<tr>
<td>Genex</td>
<td>1982</td>
</tr>
<tr>
<td>Molecular Genetics</td>
<td>1982</td>
</tr>
<tr>
<td>Amgen</td>
<td>1983</td>
</tr>
<tr>
<td>Applied Biosystems</td>
<td>1983</td>
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<td>Biogen</td>
<td>1983</td>
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<td>Biotechnica International</td>
<td>1983</td>
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<tr>
<td>Biotechnology Development</td>
<td>1983</td>
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<tr>
<td>Bio-Technology General Corp.</td>
<td>1983</td>
</tr>
<tr>
<td>California Biotechnology</td>
<td>1983</td>
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<tr>
<td>Cambridge Bioscience</td>
<td>1983</td>
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<tr>
<td>Chiron Corp.</td>
<td>1983</td>
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<tr>
<td>Damon Biotech</td>
<td>1983</td>
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<tr>
<td>Immunex</td>
<td>1983</td>
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<tr>
<td>Immunomedics</td>
<td>1983</td>
</tr>
<tr>
<td>IMRE Corp.</td>
<td>1983</td>
</tr>
<tr>
<td>Life Technologies</td>
<td>1983</td>
</tr>
<tr>
<td>Molecular Biosystems</td>
<td>1983</td>
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<td>Nova Pharmaceuticals</td>
<td>1983</td>
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<tr>
<td>Synbiotics</td>
<td>1983</td>
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<tr>
<td>Enzon Inc.</td>
<td>1984</td>
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<tr>
<td>Immucor</td>
<td>1985</td>
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<tr>
<td>Xytronyx</td>
<td>1985</td>
</tr>
<tr>
<td>Alpha 1 Biomedicals</td>
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<tr>
<td>Applied Microbiology</td>
<td>1986</td>
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<tr>
<td>Calgene</td>
<td>1986</td>
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<td>Cytogen</td>
<td>1986</td>
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<tr>
<td>CYTRX</td>
<td>1986</td>
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<tr>
<td>DNA Plant Technology</td>
<td>1986</td>
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<tr>
<td>Genetics Institute</td>
<td>1986</td>
</tr>
<tr>
<td>Gynex</td>
<td>1986</td>
</tr>
<tr>
<td>Hana Biologics</td>
<td>1986</td>
</tr>
<tr>
<td>Hemacare Corp.</td>
<td>1986</td>
</tr>
</tbody>
</table>
Oncogence Science 1986
Syntro Corp. 1986
Repligen 1986
Synergen 1986
T Cell Sciences 1986
The Liposome Co. 1986
Vestar 1986
Xoma 1986
Agouron Pharmaceuticals 1987
Celgene Corp. 1987
Crop Genetics 1987
Genzyme Corp. 1987
Immucel Corp. 1987
Liposome Corp. 1987
Mycogen 1987
Unigene Labs 1987
This chapter is divided into four sections. The first section discusses the sample characteristics which are delineated by the descriptive statistics and Pearson correlations. In the second section, the results of the tests of the five hypotheses are reported. The third section reports all of the post hoc tests used in the relationship between board size and composition with aftermarket IPO performance. Finally, a summary of the analyses and results is presented.

DESCRIPTIVE STATISTICS

Table 4.1 shows the descriptive statistics of the sample and each variable used in the study. The data sample consisted of 59 to 60 public biotech companies depending on the variable used. As the independent variables shown in Table 4.1 indicate, the average size of the board (X1) in the study was 7.2 directors, ranging from 2 to 15. The average number of outside directors with the following functional backgrounds was: financially related outsiders (X2) 1.35,
university scientists (X3) .83, and the interaction between

### TABLE 4.1
DESCRIPTIVE STATISTICS

<table>
<thead>
<tr>
<th>Variables</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Independent variables:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X1 SOB</td>
<td>60</td>
<td>7.20</td>
<td>2.38</td>
<td>2 - 15.00</td>
</tr>
<tr>
<td>X2 FL</td>
<td>60</td>
<td>1.35</td>
<td>1.35</td>
<td>0 - 4.00</td>
</tr>
<tr>
<td>X3 US</td>
<td>60</td>
<td>.83</td>
<td>1.03</td>
<td>0 - 4.00</td>
</tr>
<tr>
<td>X4 FL x US</td>
<td>60</td>
<td>.97</td>
<td>1.74</td>
<td>0 - 8.00</td>
</tr>
<tr>
<td>X5 I/O</td>
<td>60</td>
<td>.59</td>
<td>.15</td>
<td>0 - .70</td>
</tr>
<tr>
<td>X6 OS</td>
<td>60</td>
<td>144.90</td>
<td>191.29</td>
<td>4 -1159.00</td>
</tr>
<tr>
<td>X7 OA</td>
<td>59</td>
<td>7.34</td>
<td>2.33</td>
<td>0 - 14.00</td>
</tr>
<tr>
<td>X8 IOS</td>
<td>60</td>
<td>.27</td>
<td>21.34</td>
<td>.001 - 120.17*</td>
</tr>
</tbody>
</table>

| **Dependent variables:** |    |       |       |         |
| A. Market Performance  |    |       |       |         |
| Y1 MP1                | 60 | 40.17 | 77.91 | -142 - 333 |
| Y2 MP2                | 60 | -1.87 | 69.97 | -184 - 273 |

| B. Technological Performance |    |       |       |         |
| Y3 TP                  | 60 | 5.26  | 13.35 | 0 - 77.7 |

* In millions
financially related outsiders (X2) and university scientists (X3), X4, was .97. The average percentage of outside directors (X5) was 59%. This is a little lower (7-11%) than previous board studies (see Cochran et al., 1985; Kesner et al., 1986; and Wang, 1991).

The average size of each biotech firm (X6) was 145 employees, varying from 4 to 1159 employees. The average age (X7) of each firm was 7.34 years, with the ages varying from 0 to 14 years. The initial offering size (X8) for each firm ranged from $1,000 to $120 million, with an average offering size of $270,000.

Three measures of the dependent variable, aftermarket IPO performance were analyzed (Market Performance: Y1, Y2; and Technological Performance: Y3). The first measure of market performance, Y1, was the average quarterly stock return divided by the variance of the returns over a four
year period for each biotech firm. The average quarterly stock return for each firm was 40.17%, with ranges between -142% and 333%.

The second measure of market performance, Y2, controlled for industry effects. To obtain this measure, the industry average percentages were subtracted from Y1. The following process was used to calculate these numbers: (1) all of the percentages from the first market performance measure, Y1 were tabulated, (2) an industry average was calculated by adding up all of the biotech firms' percentages (minus the firm we are looking at) and divided by the number of firms that went public in that year, and (3) a final percentage was calculated by subtracting the industry average from the individual firm's percentage increase or decrease. A dramatic change in the numbers was seen with the average percentage increase in stock price over the four year period at -1.87% with the range varying between -184% and 273%. The final measure of performance, technological performance (Y3), looked at the number of patents and citation a firm had over
a four year period. The average measure of technological performance was 5.26, varying from 0 to 77.7.

The Pearson correlations of the variables are given in Table 4.2. A description and discussion of all of the variables was given in Chapter 3. Briefly, variables 1-3 represent the dependent variables, market and technological performance. Variables 4-8 represent the independent variables including the size of the board, the functional backgrounds of outsiders, and the percentage of outside directors. Finally, variables 9-11 comprise the control variables (e.g., organizational size, age, and initial offering size). The sample size of the correlations was 60 except for organizational age, where it was 59. The significant relationships are depicted in Table 4.2.

The next step was the investigation of the possibility of

<p>| VARIABLES |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 11 |</p>
<table>
<thead>
<tr>
<th></th>
<th>MP1</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>MP2</td>
<td>.82**</td>
</tr>
<tr>
<td>3.</td>
<td>TP</td>
<td>-.05</td>
</tr>
<tr>
<td>4.</td>
<td>SOB</td>
<td>.02</td>
</tr>
<tr>
<td>5.</td>
<td>FL</td>
<td>.28*</td>
</tr>
<tr>
<td>6.</td>
<td>US</td>
<td>.03</td>
</tr>
<tr>
<td>7.</td>
<td>FL x US</td>
<td>.20</td>
</tr>
<tr>
<td>8.</td>
<td>I/O</td>
<td>.03</td>
</tr>
<tr>
<td>9.</td>
<td>OS</td>
<td>.25*</td>
</tr>
<tr>
<td>10.</td>
<td>OA</td>
<td>-.02</td>
</tr>
<tr>
<td>11.</td>
<td>IOS</td>
<td>-.04</td>
</tr>
</tbody>
</table>

* significant at .05
** significant at .01
All N = 60 except OA = 59

Muticollinearity between the variables. Collinearity is a concept that expresses the relationship between two (collinearity) or more variables (muticollinearity). Two variables are said to exhibit complete collinearity if their correlation coefficient is 1 and complete lack of collinearity if their correlation coefficient is 0 (Hair, Anderson, and Tatham, 1987). Upon analysis of the Pearson correlation table, the existence of muticollinearity was not apparent due to the low correlations between the variables.

**TESTS OF MODELS**
This section will discuss the results of the models developed in the study. A more in-depth analysis of the findings will be expanded upon in the summary section. To test the 5 hypotheses in the study, three multiple regression full models were run. Tables 4.3, 4.4, and 4.5 depict the results using full model multiple regression. Tables 4.3 and 4.4 look at the market measures of performance and Table 4.5 examines technological performance. The primary reason for running full model multiple regression, was to see how all of the variables interact with each other and relate to performance.

Market Performance 1 (MP1)

Table 4.3 depicts the results of the full model multiple regression used to determine the best fit model for the dependent variable, Market Performance 1 (MP1). The table presents the results of the full model multiple regression of Market Performance (MP1, i.e., Y1) on size of the board (SOB, i.e., X1 ), financially related outsiders (FL, i.e., X2 ), university scientists (US, i.e., X3 ), the interaction between
financially related outsiders and university scientists (FL x US, i.e., $X_4$), percentage of outside directors (I\O, i.e., $X_5$), organizational size (OS, i.e., $X_6$), organizational age (OA, i.e., $X_7$), and initial offering size (IOS, i.e., $X_8$).

Given the results of the full model regression, Table 4.3, the related equation is as follows:

**TABLE 4.3**  
FULL MODEL MULTIPLE REGRESSION OF MP1

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Coeff.</th>
<th>Std. Error</th>
<th>Student's T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>22.3747</td>
<td>64.3187</td>
<td>.348</td>
</tr>
<tr>
<td>SOB</td>
<td>-1.5056</td>
<td>5.2151</td>
<td>-.289</td>
</tr>
<tr>
<td>FL</td>
<td>14.9569</td>
<td>14.0810</td>
<td>1.062</td>
</tr>
<tr>
<td>US</td>
<td>5.9933</td>
<td>17.7270</td>
<td>.338</td>
</tr>
<tr>
<td>OS</td>
<td>0.1547</td>
<td>0.0741</td>
<td>2.089</td>
</tr>
<tr>
<td>OA</td>
<td>-3.4220</td>
<td>5.4639</td>
<td>-.627</td>
</tr>
<tr>
<td>IOS</td>
<td>3.4201</td>
<td>0.6604</td>
<td>-1.556</td>
</tr>
<tr>
<td><strong>Cases Included</strong></td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Missing Cases</strong></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Degrees of Freedom</strong></td>
<td>50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Overall F Statistic     1.462 * Significant P Value at .05
Adjusted R squared       .060 Overall P Value:       .1952
R squared                .190

\[
Y = 22.375 - 1.506 (X_1) + 14.957 (X_2) + 5.993 (X_3) + 3.420 (X_4) + 55.053 (X_5) + .155 (X_6) - 3.422 (X_7) + 3.420 (X_8)
\]

The regression results indicated that the only variable which was significantly related to MP1 \(Y_1\) was OS \((X_6)\). Results of the full model of MP1 were not significant with a \(P = .1952\) which accounted for only 19% of the variance in market performance 1.

In the model, the \(R^2\), the coefficient of determination or how well the regression equation accounts for the variation in the dependent variable, was relatively low at .19. The possible values of the measure \(R^2\) range from a +1 to 0 (Lewis-Beck, 1980). If \(R^2\) were equal to 1, the independent variables would completely account for the variation in market performance 1, the dependent variable. If this were to occur, all of the observations would fall directly on the regression line. Therefore, knowing X would enable the prediction of Y without error.
If \( R^2 \) is 0, the independent variables account for no variation in the dependent variable. Therefore, since the previous model had an \( R^2 \) equal to .19, we are not explaining very much of the variance in the dependent variable, market performance.

Ideally, researchers want a high \( R^2 \) because it explains a large variance in the dependent variable and can assist in the accuracy of future predictions. However, caution must exist in the interpretation of the results. A high \( R^2 \) does not necessarily mean a causal explanation has been found between the independent and dependent variables. It can only be said that a statistical explanation for the change is evident in the independent variables to explain changes in the dependent variables. Caution must also be used in the interpretation of a \( R^2 \). For instance, researchers can increase their \( R^2 \) by increasing the number of independent variables used in the study until their number equal \( n-1 \), then \( R^2 \) equals 1. This perfect explanation is of course utter nonsense, and amounts to no more than a mathematical necessity, which occurs because the degrees of freedom have been exhausted. Therefore, rather than entering variables...
primarily to enhance $R^2$, the analyst must be guided by theory in deciding which variables to include; this process was followed in the selection of variables for this dissertation (Henricks, 1991).

**Market Performance 2 (MP2)**

Table 4.4 depicts the results of the full model multiple regression used to determine the best fit model for the dependent variable, market performance 2 (MP2). The table presents the results of the full model multiple regression of market performance (MP2, i.e., $Y_2$) on the previously mentioned independent and control variables. Given the results of the full-model regression, Table 4.4, the related equation is as follows:

$Y = 15.990 - 1.400 (X_1) + 19.286 (X_2) - 3.906 (X_3) + 8.760 (X_4) - 20.514 (X_5) + .108 (X_6) - 3.405 (X_7) - 1.146 (X_8)$

The regression results indicated that the only variable which was significantly related to MP2 ($Y_2$) at the alpha .05 level was IOS ($X_8$). Two variables FL ($X_2$) and OS ($X_6$) were significant with MP2 at the .10 level.
Results of the full model of MP2 were significant with a $P = .0089$ which accounted for 32% of the variance in market performance 2.

**TABLE 4.4**

FULL MODEL MULTIPLE REGRESSION OF MP2

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Coeff.</th>
<th>Std. Error</th>
<th>Student's T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>15.9898</td>
<td>52.8052</td>
<td>.303</td>
<td>.7633</td>
</tr>
<tr>
<td>SOB</td>
<td>-1.4004</td>
<td>4.2816</td>
<td>-.327</td>
<td>.7450</td>
</tr>
<tr>
<td>FL</td>
<td>19.2860</td>
<td>11.5604</td>
<td>1.668</td>
<td>.1015*</td>
</tr>
<tr>
<td>US</td>
<td>-3.9056</td>
<td>14.5537</td>
<td>-.268</td>
<td>.7895</td>
</tr>
<tr>
<td>FL x US</td>
<td>8.7595</td>
<td>8.4691</td>
<td>1.034</td>
<td>.3060</td>
</tr>
<tr>
<td>I\O</td>
<td>-20.5142</td>
<td>59.9751</td>
<td>-.342</td>
<td>.7338</td>
</tr>
<tr>
<td>OS</td>
<td>.1079</td>
<td>.0608</td>
<td>1.774</td>
<td>.0821*</td>
</tr>
<tr>
<td>OA</td>
<td>-3.4051</td>
<td>4.4858</td>
<td>-.759</td>
<td>.4514</td>
</tr>
<tr>
<td>IOS</td>
<td>-1.1455</td>
<td>8.4691</td>
<td>-2.113</td>
<td>.0396**</td>
</tr>
</tbody>
</table>

Cases Included 60
Missing Cases 1
Degrees of Freedom 50
Overall F Statistic 2.943
Adjusted R squared .211
R squared .320

* Significant P Value at .10
** Significant P Value at .05

Technological Performance (TP)

Table 4.5 depicts the results of the full model multiple regression used to determine the best fit model for
the dependent variable, technological performance (TP).

Table 4.5 (on the next page) presents the results of the full model multiple regression of technological performance (TP, i.e., Y3) on the previously mentioned independent and control variables. Given the results of the full model regression, Table 4.5, the related equation is as follows:

\[
Y = 14.154 - 1.674 (X_1) + 3.095 (X_2) + 1.928 (X_3)
- 1.291 (X_4) - 22.721 (X_5) + .004 (X_6) + .635 (X_7)
+ .198 (X_8)
\]

The regression results indicated that the only variable

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Coeff.</th>
<th>Std. Error</th>
<th>Student's T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
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<td>10.3526</td>
<td>1.367</td>
</tr>
<tr>
<td>.1777 SOB</td>
<td>-1.674</td>
<td>.8394</td>
<td>-1.994</td>
</tr>
<tr>
<td>.0516**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FL</td>
<td>3.0951</td>
<td>2.2664</td>
<td>1.366</td>
</tr>
<tr>
<td>.1782</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>1.9227</td>
<td>2.8532</td>
<td>.674</td>
</tr>
<tr>
<td>.5035</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FL x US</td>
<td>-1.2911</td>
<td>1.6604</td>
<td>-.778</td>
</tr>
<tr>
<td>.4405</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I\O</td>
<td>-22.721</td>
<td>11.7583</td>
<td>-1.932</td>
</tr>
<tr>
<td>.0590*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OS</td>
<td>.0037</td>
<td>.0119</td>
<td>-.315</td>
</tr>
</tbody>
</table>
which was significantly related to TP (Y3) at the alpha = .05 level was SOB (X1). IOS (X8) and I\O (X5) were significant with TP at the .10 level. Results of the full model of TP were significant with a P = .0245 which accounted for 28% of the variance in technological performance.

TESTS OF HYPOTHESES

Test of H1

The first hypothesis (H1) stated that there would be a positive linear relationship between the size of the board of directors and aftermarket IPO performance. As discussed
in Chapter 3, the size of the board was defined as the total number of directors on the board. In order to get an average size of the board over the four year period, all of the directors on the board were added over the four year period in the study and divided by four.

To test for the relationship depicted in H1, three full multiple regression (see Tables 4.3, 4.4, & 4.5) models were run. Results of the full models indicated that there was no significant relationship between the size of the board and the two measures of market performance (MP1 & MP2). However, the size of the board and technological performance had a negative significant relationship at the alpha .05 level. The p values for the full model multiple regressions were: (1) MP1 $p \leq .774$; (2) MP2 $p \leq .745$; and (3) TP $p \leq .0516$.

Test of H2

Hypotheses 2-5 were based on the central arguments of resource dependency theory. The second hypothesis stated that there would be a positive association between the number of outside directors with financially related backgrounds and aftermarket IPO performance. In this study, financially related outsiders (FL) were defined as individuals who worked
for an investment or commercial bank, venture capital firm, or any other financially related firm. The number of financially related individuals was measured by adding up all of the outside directors, with the previously mentioned characteristics, on the board over the four year period in the study. To be included in the study, an outside director must have been on the board for at least three out of the four years in which the study took place.

Results of the full model multiple regression show that FL was not significant with aftermarket IPO performance at the alpha .05 level. However, FL was significant with MP2 at the .10 level. P values for the full model regressions were: (1) MP1 p <= .2932; (2) MP2 p <= .1015; and (3) TP p <= .1782.

Test of H3

The third hypothesis, also based on resource dependency theory, stated that there would be a positive association between the number of outside directors who are university scientists and aftermarket IPO performance. As discussed in Chapter 3, university scientists (US) were defined as any
individual who was on the faculty at a university with a background in the sciences (e.g. medicine, biology, chemistry). The variable US was measured by counting up all of the outside directors who were university scientists, over the four year period during the study. To be included in the study, a university scientist must have been on the board for at least three out of the four years.

Results of the full model multiple regression models show that variable US was not significant with aftermarket IPO performance. P values for the full model regressions were: (1) MP1 $p \leq .7367$; (2) MP2 $p \leq .7895$; and (3) TP $p \leq .5035$.

**Test of H4**

Based on resource dependency theory, hypothesis 4 suggests a positive relationship between the interaction of outside directors who have financially related backgrounds and outsiders who are university scientists (FL x US) with aftermarket IPO performance. The definitions and measures of the variables were explained in the previous two sections.
Results of the full model multiple regressions show that FL x US was not significantly associated with aftermarket IPO performance. P values for the full model regressions were: (1) MP1 p <= .7416; (2) MP2 p <= .3060; and (3) TP p <= .4405.

**Test of H5**

In congruence to resource dependency theory, the final hypothesis, H5, examined the percentage of outside directors on the board (I/O). Previous researchers have emphasized the importance of outsiders on the board (Pfeffer, 1972; Baysinger and Butler, 1985; Kesner et al., 1986). In accordance with resource dependence theory, this hypothesis states that an increased number of outsiders on the board will have a positive association with better aftermarket IPO performance.

Results of the full model multiple regressions show that I/O was not significantly related with aftermarket IPO performance at the .05 level. P values for the full model regressions were: (1) MP1 p <= .4546; (2) MP2 p <= .7338; and (3) TP p <= .0590. However, it must be noted that I/O had a negative significant relationship with TP at p <= .1.
POST HOC TESTS

The Durbin-Watson (Durbin and Watson, 1951, 1971) test for autocorrelation (where the error terms associated with different observations are correlated, thereby violating the regression assumption) was used for all of the models. The Durbin-Watson statistic was used to test whether the random errors about the regression line exhibit such autocorrelation (Henricks, 1991).

Autocorrelation can occur if the data has some natural sequence to it. For instance, positive autocorrelation results when large positive errors tend to be followed by large positive errors. Negative autocorrelation, which is less common, occurs when large errors tend to be followed by large errors of the opposite sign. The Durbin-Watson statistic will be close to 2 if there is no positive or negative autocorrelation.

Results of the Durbin-Watson statistic for the full models were the following: (1) MP1 = 1.546; (2) MP2 = 2.072; and (3) TP = 2.452. Based on these findings, there was no evidence that autocorrelation affected any of the results in
the models which were used in this study.

The last post hoc test used was to test for the nonlinear (inverted U effect) between the size of the board and aftermarket IPO performance. Recognizing the limitations of visual inspection on two dimensional diagrams, a number of polynomial regression models (e.g., second-degree and third-degree polynomials) were developed to test for this effect. For example, a second-degree polynomial model indicates that the response variable, $y$, is a quadratic function of the independent variable, $x$. These nonlinear relationships were explored in all of the models presented in Tables 4.3, 4.4 and 4.5. However, none of the models were significant at the .10 level.

**SUMMARY**

The results of the statistical analyses of full model multiple regressions in this study differ in the type of variable which was significantly related to aftermarket IPO performance. For a summary of the significant relationships see Table 4.6. The following variables were significantly related with the dependent variables at the alpha .10 level:
TABLE 4.6
SUMMARY TABLE OF SIGNIFICANT RELATIONSHIPS

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variable</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Performance (MP1)</td>
<td>Organizational Size (OS)</td>
<td>.0418 **</td>
</tr>
<tr>
<td>Market Performance (MP2)</td>
<td>Financially Related Outsiders (FL)</td>
<td>.1015 *</td>
</tr>
<tr>
<td></td>
<td>Organizational Size (OS)</td>
<td>.0821 *</td>
</tr>
<tr>
<td></td>
<td>Initial Offering Size (IOS)</td>
<td>.0396 **</td>
</tr>
<tr>
<td>Technological Performance (TP)</td>
<td>Size of Board (SOB)</td>
<td>.0516 **</td>
</tr>
<tr>
<td></td>
<td>Percentage of Outsiders (I/O)</td>
<td>.0590 *</td>
</tr>
<tr>
<td></td>
<td>Initial Offering Size (IOS)</td>
<td>.0682 *</td>
</tr>
</tbody>
</table>

* p < .10
** p < .05
(1) MP2 & financially related outsiders (FL, X2); (2) MP2 & organizational size (OS, X6); and (3) TP & percentage of outside directors (I/O, X5). The following variables were significantly related with the dependent variables at the alpha .05 level: (1) MP1 & organizational size (OS, X6); (2) MP2 & initial offering size (IOS, X8); and (3) TP & size of the board (SOB, X1). Due to the exploratory nature of this dissertation and the small sample size (60), alpha at the .10 level was also deemed to be significant. Therefore, a discussion of both .05 and .10 levels of significance will be examined.

As stated earlier in this chapter, the method which was used to determine the best fit model was full model multiple regression. The overall results relating to the specific hypotheses suggest that: (H1) There is no relationship between the size of the board and market performance.
However, there was a negative significant relationship between the size of the board and technological performance at the .05 level; (H2) there was a positive significant relationship between the number of financially related outsiders (FL) and MP2 at the alpha .10 level; (H3) there was no relationship between the number of outside directors who are university scientists and aftermarket IPO performance; (H4) there was no relationship between the interaction of outside directors who have financially related backgrounds and who are university scientists (FL x US) with aftermarket IPO performance; and (H5) there was no relationship between the percentage of outside (I/O) directors and market performance. However, technological performance and I/O were negatively related to each other at the alpha .10 level.

Hypothesis 1 found a negative relationship between the size of the board and technological performance. This suggests that as the size of the board increases, the technological performance of the firm decreases. This finding undermines previous theoretical research. Previous researchers (Provan, 1980 and Chaganti et al., 1985) found
positive relationships between the size of the board and performance.

Factors which might contribute to the diminished performance level as the board size increases include group dynamics. For instance, Bettenhausen (1991) has found that group size affects group processes and outcomes. For example, as the board size increases the possibility of a decreased level of communication exists between individuals, political problems might arise, or conflicts might arise due to the formation of dyads or triads. A review of Chapter 2 examines the other possible theoretical explanations for this phenomenon: groupthink (Janis, 1972), risky shift (Stoner, 1961), or social loafing (Latane, et al., 1979) might contribute to the decreased level in performance as the size of the board increases.

Hypothesis 2 examined the relationship between financially related (FL) outsiders and aftermarket IPO performance. Of the three measures of performance, only MP2 had a positive significant relationship between FL at the .10 level. The significant finding of this hypothesis is consistent with the major theoretical thrust of this study,
resource dependency theory (Pfeffer and Salancik, 1978, 1981). According to resource dependency theory, firms tend to seek their external environment for individuals to enhance the efficiency and performance of the organization. One way in which firms can enhance the performance of the company is by bringing outside directors (e.g., financially related outsiders) onto their board of directors.

Results of this hypothesis found a positive significant relationship between firms which have a larger number of financially related outsiders and market performance. Possible explanations for this phenomenon might be the high need for capital in order to survive in the biotech industry. As stated previously, several factors have contributed to the biotech industry's heavy reliance on capital: (1) the average amount of time for a product to get to market is 10-12 years, (2) the average cost of a product before it reaches the marketplace is between $100-$269 million, and (3) the biotech industry is in its introductory stage in the industry life-cycle.

By bringing these individuals who specialize in financially related areas onto their boards, biotech firms
might have the advantage of having access to critical information and/or resources. For instance, an individual who is a partner in a venture capital firm, might have access to other possible investors and/or experience about going public.

The third hypothesis investigated the relationship between outside directors who were university scientists (US) and aftermarket IPO performance. No significant relationships were found between all three measures of performance and US. At this period of time in the biotech industry (the introductory stage of the industry life-cycle), the knowledge, experience, information, and/or resources provided by these university professors does not have a significant effect on the performance of these firms.

This finding goes against the main theoretical foundation of the study, resource dependency theory, which states that outside directors will assist in the performance and efficiency of the organization. Essentially what this hypothesis states is that the biotech industry is not just a scientific discipline relying on technologies, science, and data. But, the business aspect of the biotech industry is of vital importance. As stated earlier, Hypothesis 2 found
that firms which had a larger number of outsiders specializing in financially related backgrounds had better aftermarket IPO performance.

Hypothesis 4 examined the relationship between the interaction of outsiders with financially related backgrounds and university scientists with aftermarket IPO performance. No significant relationships were found between these variables. Again, this hypothesis goes against resource dependency theory, which states that firms which have a larger number of the interaction of these outsiders will have better performance. An explanation for this finding was expanded upon in Hypothesis 3. Of the three hypotheses dealing with functional backgrounds of outsiders on the board and aftermarket IPO performance, the most significant finding was the positive significant relationship between financially related outsiders and market performance 2.

The final hypothesis investigated the relationship between the percentage of outside directors and aftermarket IPO performance. A significant negative relationship was found between I/O and technological performance at the alpha .10 level. Simply stated, as the percentage of outside
directors increased, the technological performance of the firm increased. The finding of this hypothesis is in congruence with previous studies utilizing resource dependency theory. Previous researchers have emphasized the importance of outside directors on boards (Pfeffer, 1972; Baysinger and Butler, 1985; and Kesner et al., 1986). Through these outside directors, firms might have a greater access to critical resources and/or information from their environment to enhance performance.

The findings of this hypothesis insinuate that firms which had a larger percentage of outside directors in specialized areas (e.g., finance, science, and attorneys) will have better technological performance. Since technological performance was measured through patents and citations, the possibility remains that these outside directors might be contributing to the performance of the firm through the development of patents and citations. For instance, having a larger percentage of financially related outside directors might enhance the firm's ability to raise capital to invest in R&D, thus contributing to an increase in
patents and citations. Similarly, having a larger percentage of outside directors who are attorneys might assist the firm with strict governmental regulations and the legalities of dealing with patents. Other outside directors might also contribute to the success of technological performance. For instance, even though outsiders from other industries was not investigated in this study, outsiders from other biotech and/or pharmaceutical firms might contribute to the increased level of technological performance.

Other relationships were found to be significant in this study, although they were not the focus of the hypotheses. Positive significant relationship were found between the control variables organizational size (OS) and MP1 & MP2 at the .05 and .10 levels. In addition, initial offering size (IOS) and technological performance (TP) were positively significant at the alpha = .05 level.

Previous researchers have suggested that larger organizational size is associated with increases in the pool of resources available for organizational use (see Gooding and Wagner, 1985). Aldrich and Pfeffer (1976) and Pfeffer and Salancik (1978) proposed that larger organizations are
more likely to possess the resources necessary to acquire control over environmental entities that mediate critical resources. Despite the previous conclusions, the organizational size-performance relationship has reported inconclusive empirical evidence. Gooding and Wagner (1985) performed a meta-analysis on the organizational size-performance relationship and found difficulty in determining a concrete conclusion.

This study found positive significant relationships between organizational size, as measured by the average number of employees over a four year period, and both measures of market performance, MP1 & MP2. Possible explanations for this phenomenon were previously presented by Aldrich and Pfeffer (1976), Pfeffer and Salancik (1978), and Gooding and Wagner (1985).

More specifically, biotech firms with a larger number of employees might have an increased capacity to perform R&D which might enhance the firm's capability to produce products in the pipeline. Investors might place a higher value on firms with an increased amount of products within their pipeline. Furthermore, firms with a larger number of
employees might have access to more critical resources and/or information due to the larger number of individuals with varying backgrounds within the firm. For instance, firms with a larger number of employees might have a greater number of research scientists, attorneys, and/or accountants. Through these individuals, firms might have an increased amount of human capital, information, and/or resources.

The final significant finding in this study was the positive relationship between initial offering size (IOS) and technological performance (TP). A few possible explanations might exist for this phenomenon. For instance, firms with more money at the time of the initial offering might have an increased capacity to hire key employees on the cutting-edge of their fields, invest in R&D, and/or obtain critical equipment and facilities. These activities might contribute to the firm's ability to increase the number of patents and citations. Also, firms which have larger initial offerings might already have a pipeline full of patents and citations which are included in the value of the initial offering.

However, this assertion can not be justified because the number of patents and citations was not investigated before
the initial offering in this study.

Other possibilities for this finding include how the investment bankers value the following firm's activities:

(1) The area in which the firm is doing research. For instance firms may be entering an area of research which has not been previously investigated (e.g., a cure for colitis). This might contribute to a better measure of technological performance due to the lack of competition; and/or (2) future research productivity of the employees. Do the firms have experienced and capable managers and employees within their specific area of research? Investment bankers might place a higher value on the initial offering if the firm has a capable management team to compete within their specific domain.
CHAPTER 5

SUMMARY AND CONCLUSION

Chapter 5 begins with a summary of the study followed by a discussion of the theoretical and methodological contributions of the dissertation. Implications and directions for future research will then be examined followed by a conclusion.

SUMMARY

This section includes a statement of the problem, hypotheses, methodology, and hypothesis test results.

Statement of the Problem

The purpose of this study was to address the following question: What is the effect of board characteristics on performance in emerging industries? In order to answer this
question, three theoretical models using one statistical technique were developed and tested. Specifically, the models raised the following research questions:

1. Is there a relationship between the size of the board of directors and aftermarket IPO performance of firms in emerging industries?

2. Is there a relationship between the number of outside board members with financially related backgrounds and aftermarket IPO performance of firms in emerging industries?

3. Is there a relationship between the number of outside board members who are university scientists and aftermarket IPO performance of firms in emerging industries?

4. Is there a relationship between the interaction of the number of outside board members with financially related backgrounds and university scientists with aftermarket IPO performance of firms in emerging industries?

5. Is there a relationship between the percentage of outside directors on the board and aftermarket IPO performance of firms in emerging industries?
Hypotheses

Based on the literature review, the models of size and composition of the board and aftermarket IPO performance were developed. Table 5.1 (on the next page) depicts the results of the five hypotheses tested. The hypotheses were derived from the models to address the research questions. The first hypothesis stated that there would be a positive association between the size of the board and aftermarket IPO performance. The remaining 4 hypotheses were based on resource dependency.

TABLE 5.1
RESULTS OF THE HYPOTHESES

<table>
<thead>
<tr>
<th>Hypothesis Direction</th>
<th>Relationship</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1  Negative</td>
<td>Effect of Board Size on Technological Performance</td>
<td>*</td>
</tr>
<tr>
<td>H2  Positive</td>
<td>Effect of Outside Financiers on Market Performance 2</td>
<td>*</td>
</tr>
</tbody>
</table>
H3  Effect of Outside University Scientists on Aftermarket IPO Performance

H4  Effect of the Interaction of Outside Financiers and University Scientists on Aftermarket IPO Performance

H5  Effect of the Percentage of Outside Directors on Technological Performance

Positive

* Significant
- Not Significant

theory. The second hypothesis argued that there would be a
positive relationship between the number of financially related outside directors and aftermarket IPO performance. The third hypothesis maintained that there would be a positive association between the number of outside directors who were university scientists and aftermarket IPO performance. The fourth hypothesis argued for a positive association between the interaction between outsiders with financially related backgrounds and university scientists with aftermarket IPO performance. Finally, the fifth hypothesis proposed that firms with a larger percentage of outsiders on the board would have a positive significant relationship with aftermarket IPO performance.

The results of Hypothesis 1, as stated in Chapter 4, indicated there was a negative significant relationship between the size of the board and technological performance. This means that as the size of the board increases, the technological performance of the firm decreases.

Factors which might contribute to the diminished performance level as the board size increases include group dynamic effects. For instance, Bettenhausen (1991) has found that group size affects group processes and outcomes. For example, as the board size increases the possibility of a
decreased level of communication exists between individuals, political problems might arise, or conflicts might arise due to the formation of dyads or triads. Other possible theoretical explanations for this phenomenon include: groupthink (Janis, 1972), risky shift (Stoner, 1961), or social loafing (Latane, et al., 1979). These group dynamic effects might contribute to the decreased level in performance as the size of the board increases.

The results of Hypothesis 2 found a positive significant relationship between the number of financially related outsiders on the board and MP2 at the .10 level. The significant finding of this hypothesis is consistent with the major theoretical thrust of this study, resource dependency theory (Pfeffer and Salancik, 1978, 1981). According to resource dependency theory, firms tend to seek their external environment for individuals to enhance the efficiency and performance of the organization.

Findings of this study indicate that firms which have a larger number of these outsiders, specialized in finance, will have better aftermarket performance. This can be explained by the high need for capital in the biotech
industry in order to survive. By bringing outsiders who specialize in financially related areas (e.g., investment banking, venture capitalists) onto the board of directors, biotech firms might have greater access to critical information and/or resources which are available in the external environment. Although we can not insinuate cause and effect relationships using multiple regression, the possibility remains that by having outsiders specialized in finance on the board might lead to better performance for the firm.

Hypothesis 3 found no relationship between outside directors who are university scientists and all three measures of aftermarket IPO performance; MP1, MP2, and TP. It appears that outside directors who are university scientists do not contribute significantly to the performance of the firms.

At this period of time in the biotech industry (the introductory stage of the industry life-cycle), the knowledge, experience, information, and/or resources provided by these university professors does not have a significant effect on the performance of these firms.
This finding goes against the main theoretical foundation of the study, resource dependency theory, which states that outside directors will assist in the performance and efficiency of the organization. Essentially, what this hypothesis states is that the biotech industry is not just a scientific discipline relying on technologies, science, and data. But, the business aspect of the biotech industry is of vital importance. As stated earlier, Hypothesis 2 found that firms which had a larger number of outsiders specializing in financially related backgrounds had better aftermarket IPO performance.

Hypothesis 4 also found no relationship between the interaction of outside directors with financially related backgrounds and university scientists with all three measures of aftermarket IPO performance. Again, this hypothesis goes against resource dependency theory, which states that firms which have a larger number of the interaction of these outsiders will have better performance. It appears that the mere presence of having a larger number of outside directors with financially related backgrounds and outsiders who are university scientists does not relate to better aftermarket
IPO performance. An explanation for this finding was expanded upon in Hypothesis 3. Of the three hypotheses dealing with the functional backgrounds outsiders on the board and aftermarket IPO performance, the most significant finding was the positive significant relationship between financially related outsiders and market performance 2.

Finally, hypothesis 5 found a positive significant relationship between the percentage of outside directors and technological performance. Firms which had a larger percentage of outside directors on their boards had better technological performance.

The finding of this hypothesis is in congruence with previous studies utilizing resource dependency theory. Previous researchers have emphasized the importance of outside directors on boards (Pfeffer, 1972; Baysinger and Butler, 1985; and Kesner et al., 1986). Through these outside directors, firms might have a greater access to critical resources and/or information from their environment to enhance performance.

The findings of this hypothesis indicate that firms
which had a larger percentage of outside directors in specialized areas (e.g., finance, science, and attorneys) will have better technological performance. Since technological performance was measured through patents and citations, the possibility remains that these outside directors might be contributing to the performance of the firm through the development of patents and citations. For instance, having a larger percentage of financially related outside directors might enhance the firm's ability to raise capital to invest in R&D, thus contributing to an increase in patents and citations. Similarly, having a larger percentage of outside directors who are attorneys might assist the firm with strict governmental regulations and the legalities of dealing with patents. Other outside directors might also contribute to the success of technological performance. For instance, even though outsiders from other industries was not investigated in this study, outsiders from other biotech and/or pharmaceutical firms might contribute to the increased level of technological performance.
Methodology

The population, sample, and measures utilized in this study are summarized in this discussion. The sample of the study was comprised of the entire population of public biotech companies from 1980 to 1987. The final sample was comprised of 60 public biotech companies. Each company, except for CYTRX Corporation, in the sample had complete four-year data from the following sources: annual reports, proxy statements, prospecti, and Standard and Poor's Stock Reports.

This study suggested three classes of aftermarket IPO performance: two measures of market performance and one measure of technological performance. Furthermore, one measure of market performance (MP2) controlled for industry effects. The average board size of the sample was 7.2 directors with a range of 2 to 15. The average number of outside directors with the following functional backgrounds was: financially related outsiders 1.35, university scientists .83, and the average of the interaction of both outside directors was .97. The average percentage of outside directors was 59%.
The average size of each biotech firm was 145 employees, varying from 4 to 1159 employees. The average age of each firm was 7.34 years, with the ages varying from 0 to 14 years. The initial offering size for each firm ranged from $1,000 to $120 million, with an average offering size of $270,000.

Three measures of the dependent variable, aftermarket IPO performance were analyzed (Market Performance: MP1, MP2; Technological Performance: TP). The first measure of market performance, MP1, was the average quarterly return divided by the variance of the returns. The average return for each firm was 40.17%, with ranges between -142% and 333%.

The second measure of market performance, MP2, controlled for industry effects by subtracting the average performance of all the biotech firms which went public during that year. A dramatic change in the numbers was seen with the average percentage increase in stock price over the four year period at -1.87% and the range between -184% and 273%. There was a positive significant correlation between MP1 and MP2 at p <= .001, however there were differences between the measures.
Results of the full model regression of MP2 were significant with a $P = .0089$ which accounted for 32% of the variance in market performance 2. These results were significantly different from the findings in MP1. Market performance 1 was significant with a $P = .1952$ and a $R^2$ of .19. It appears that MP2 is a much better predictor of market performance than MP1, due to its superior $R^2$. Therefore, we must conclude that MP2, which controlled for industry effects, caused us to have a much better predictor of the dependent variable, market performance.

The final measure of performance, technological performance, looked at the number of patents and citation a firm has over the four year period. The average measure of technological performance was 5.26, varying from 0 to 77.7. This measure of performance was weakly correlated with the other measures of performance (MP1 & MP2) at $p = .363$ and $P = .459$, respectively. Furthermore, it explained only 28% of the variance in technological performance, with a $P = .0245$. Therefore, we must conclude that MP2, which explained 32% of the variance in aftermarket IPO performance, was the best dependent measure used in this study.
THEORETICAL IMPLICATIONS

The results of this dissertation indicate that there is a relationship between the size and composition of the board of directors in the biotechnology industry and aftermarket IPO performance. For a summary of the significant board effects on aftermarket IPO performance, see Figure 5.1 on the next page.

The significant findings of this dissertation support the main proposition of resource dependency theory: Firms in emerging industries will scan their environment to extract resources to enhance the firm's legitimacy in society and to help achieve its goals of efficiency and improved performance (Pfeffer, 1972, 1973; Price, 1963, Provan, 1980, Zald, 1967). The resource dependence perspective views boards of directors as vehicles which organizations "co-opt", or partially absorb, important external resources.

Implications of this study indicate that there is a negative significant relationship between the size of the board and technological performance. This phenomenon might
be caused by group dynamic effects, as discussed earlier. Implications of this study, through resource dependency theory, suggest that firms in emerging industries (e.g., the case of biotechnology) which bring a larger number of outsiders with functional backgrounds in financially related areas onto their boards, will have better market performance. Furthermore, the results of this study imply that there is no positive significant relationship between a larger number of outsiders who are university scientists and aftermarket IPO performance. Also, the interaction between outsider directors with financially related backgrounds and outsiders who are university scientists had no positive significant relationship with aftermarket IPO performance.

Other findings in this study imply that a there is a positive significant relationship between the percentage of outside directors with technological performance. This finding also supports resource dependency theory by stating that firms which bring a larger percentage of outside
directors will have better technological performance.

The existence of the inverted U effect (non-linear effect) between the size of the board and aftermarket IPO performance was also tested in this study. Results indicate that there is no exact board size which is related to better performance.

This study also found that firms which had a larger organizational size had better aftermarket IPO performance. Specifically, this study found positive significant relationships between organizational size, as measured by the average number of employees over a four year period, with both measures of market performance, MP1 & MP2.

The significant findings on organizational size and both measures of market performance in this study support previous research by Aldrich and Pfeffer (1976) and Pfeffer and Salancik (1978) who proposed that larger organizations are more likely to possess the resources necessary to acquire control over environmental entities that mediate critical resources.
The final significant finding in this study was the positive relationship between initial offering size (IOS) and aftermarket IPO performance. A few possible explanations might exist for this phenomenon. For instance, firms with more money at the time of the initial offering might have an increased capacity to hire key employees on the cutting-edge of their fields, invest in R&D, and/or obtain critical equipment and facilities. These activities might contribute to the firm's ability to increase their performance level. Also, firms which have larger initial offerings might already have a pipeline full of patents and citations which are included in the value of the initial offering. However, this assertion cannot be justified because the number of patents and citations was not investigated before the initial offering in this study.

The results of this study focused on one emerging industry, biotechnology. However, the findings of this study can be generalized to other emerging industries. We recommend firms in other emerging industries to have the following board characteristics: smaller boards, a larger number of financially related outsiders, a larger percentage
of outside directors, and a larger organizational size and initial offering size. The specific numbers and recommendations will be expanded upon in the next section.

**IMPLICATIONS TO PRACTITIONERS**

Several findings in this study will benefit practitioners in the formation of boards in the biotechnology industry and other emerging industries. First, larger boards were found to have a negative relationship with technological performance. These findings indicate that practitioners must use caution in forming boards which are too large. Larger boards might diminish the firm’s ability to compete in the marketplace due to group dynamic effects. Therefore, we recommend that practitioners limit the size of their board to 4 – 6 directors. Since the average size of a board in this study was 7.2, and larger boards were found to have a negative relationship with technological performance, we determined the ideal size of the board to be between 4 to 6 directors. Secondly, practitioners should emphasize a larger number of financially related outsiders on their boards versus
university scientists. The findings of this study indicate that firms with a larger number of outside directors with financial backgrounds had significantly better market performance.

In this study, the average number of outsiders specializing in finance was 1.35 and the average board size was 7.2. Therefore, the numbers indicate that the average percentage of outside financiers on boards was approximately 19%. Therefore, we recommend that firms in emerging industries comprise their board of at least 2 directors (over 19% of the total board size) specializing in finance. Thirdly, the lack of significance in hypotheses 3 and 4 indicates no relationship between a larger number of outsiders who are university scientists and the interaction of outside directors who are financiers and university scientists with aftermarket IPO performance. The average number of outside university scientists on the boards was .83. In addition, there was no significant relationship between a larger number of these outsiders and aftermarket IPO performance. Therefore, we recommend to practitioners that they can place outside directors who are university
scientists on their boards, however, there is no guarantee that these individuals will contribute to the overall performance of the organization.

The same rationale can be used in analyzing the interaction of outside directors in finance and university scientists with aftermarket IPO performance. The average number of the interaction between these outside directors was .97. Since there was no significant relationship between a larger number of these directors and performance, we don't recommend placing a larger number of both of these individuals on boards. However, we do recommend a larger number of outside financiers (see above).

Fourthly, practitioners in emerging industries should form boards with a majority of outsider directors during the introductory stage of the industry life-cycle. A positive significant relationship was found between a larger percentage of outside directors and technological performance. The average percentage of outside directors in this study was 59%. Therefore, we recommend that firms in emerging industries comprise their boards with at least 60% of outsiders.

Finally, this study found that firms which had a larger
organizational size and initial offering size had better aftermarket IPO performance. The average organizational size of each the firms in the study was 145 employees and the average initial offering size was $270,000.

This indicates that firms which have more than 145 employees and offer more than $270,000 at the time of their initial offering will have better aftermarket IPO performance. Therefore, we recommend that firms in emerging industries build their organizations, through growth, to more than 145 employees. Specifically, emerging firms with more than 145 employees might have an increased capacity to perform R&D which might enhance the firm's capability to produce products in the pipeline. Investors might place a higher value on firms with an increased amount of products within their pipeline. Furthermore, firms with a larger number of employees might have access to more critical resources and/or information due to the larger number of individuals with varying backgrounds within the firm. For instance, firms with a larger number of employees might have a greater number of research scientists, attorneys, and/or accountants. Through these individuals, firms might have an increased amount of human capital, information, and/or
The final significant finding in this study was the positive relationship between initial offering size (IOS) and aftermarket IPO performance (MP2 & TP). Since the average initial offering size was $270,000, we recommend to practitioners to have an initial offering larger than this. Firms with more money at the time of the initial offering might have an increased capacity to hire key employees on the cutting-edge of their fields, invest in R&D, and/or obtain critical equipment and facilities. These activities might contribute to the firm's ability to increase the number of patents and citations. By having an increased thrust in research and development, better equipment, and/or quality personnel, the firm should have an increased number of patents and citations (technological performance).

Through the development of these patents and citations, the firm has the increased capability to develop products in the future. Practitioners must realize the importance of the initial offering period and obtain a substantial amount of money in order to survive during the volatile introductory stage of the industry life-cycle.
In summary, the following recommendations are made to practitioners in emerging industries: (1) a board size between 4-6; (2) at least 2 financially related outsiders (or over 19% of the board); (3) outside directors comprising at least 60% of the board; (4) expand the organization, through growth over time, to over 145 employees; and (5) have an initial offering larger than $270,000.

FUTURE RESEARCH

Several directions exist for future research. First, future research needs to be done on the overall composition of the board of directors in emerging industries, both inside and outside directors along with their functional backgrounds. Is there a relationship between a certain mix of directors' functional backgrounds and corporate performance?

Secondly, board interlocks (the number and/or type of directorships) on boards in the biotech industry need to be investigated. Board interlocks are the directorships which a director serves on in other companies. Is there a
relationship between the types and number of board interlocks and corporate performance of firms of emerging industries? Thirdly, a replication of this study could be performed with other emerging industries to check the validity of the results. For instance, replication studies could be done with emerging industries like robotics, software, microwave telecommunications, fibre optics, digital audio tape (DAT), high definition television (HDTV), and cellular telephones. A comparative study with public companies within the software industry might validate our results and their relationship to firms in emerging industries. In addition, comparative studies could also be performed contrasting how boards differ in other industries and stages of their industry life-cycles. For instance, how does the size and composition of the board of directors in the introductory stage of the biotech industry differ from the growth stage of the pharmaceutical industry? These results might prove to be useful for the future construction of boards in the biotech industry and other emerging industries as they move through their life-cycle.

Fourthly, the measures of aftermarket IPO performance in
this study should be improved in future research. To date, there has been no attempt at measuring the performance of public biotech firms. This study has contributed three measures of aftermarket IPO performance, however researchers should continue to use their creativity to develop new measures of this construct.

Fifthly, further investigation of the role that patents and citations play in the valuation of the performance of biotech firms should be undertaken. Since most of the firms are lacking in products, it appears that technological performance is a valid measure of performance. Future studies need to look at the number of patents and citations throughout the entire existence of the biotech firm's life and its relationship to performance.

Sixthly, other factors which might contribute to the overall performance of firms in emerging industries need to be investigated. For instance, in the biotechnology industry, products could play an important role in the performance of the firm. Future researchers need to examine the firms' products on the market and their pipelines. Is there a relationship with the number and/or types of products
and the markets they serve with performance? Furthermore, the investigation of the control variables used in this study might give more insight into the success of these firms. For example, is there an ideal initial offering size or organizational size which relates to better performance.

Finally, the mere investigation of the functional backgrounds might be fruitless. For instance Wang (1991) exerts that just studying the classifications of directors is inadequate to capture the complex and dynamic nature of the relationship between board composition and corporate performance. According to Wang, in order to understand the true motivations of boards of directors and the relationship between board composition and firms' performance, future researchers should perform more qualitative research. Field studies, such as observing how boards work and interviewing boards of directors, might enhance our understanding, thus help the development of normative board models and theories (Wang, 1991). Through these interviews, we can investigate the areas which board members actively participate (e.g., mergers, acquisitions). Through these findings, we can better understand the functions of a board of directors and
how they contribute to the performance of the firm. In summary, specific studies need to be undertaken to look at the various activities which the board members partake in.

LIMITATIONS

Several major limitations were prevalent in this study:
(1) The first biotech firm did not go public until 1980, this limited our ability to track the performance of the biotech firms over an extended period of time. Furthermore, since the average time for a product to get to market in the biotech industry was 10-12 years and costs $100-$269 million, most of the firms in the study did not have any products on the market. In addition, as of 1991, only six public biotech firms had been profitable. Therefore, measurement of the performance variable was extremely difficult. Past, popular financial measures used in board studies such as ROI, ROE, ROA could not be used. Since we used stock prices over a long period of time in this study, we ran the risk of what is really contributing to the performance of these firms?

(2) In regards to the operationalization of the construct aftermarket IPO performance, a few limitations existed.
First, three measures of aftermarket IPO performance

(2 measures of market performance, MP1 & MP2 and 1 measure of technological performance, TP) were used in this study. Upon analysis of the correlations between the dependent variables, both measures of market performance were significantly correlated. However, technological performance and market performance were not significantly correlated. Therefore, market and technological performance appeared to be measuring different kinds of performance under the same construct, aftermarket IPO performance. Can we make generalizations about the aftermarket IPO performance of the firm using these different measures of performance?

(3) The operationalization of technological performance through patents and statistics has been critiqued by Griliches (1990). He asserts that patents differ greatly in their technical and economic significance. Many of them reflect minor improvements of little economic value. Some of them, however, prove to be extremely valuable. Thus, the weighting of patents becomes a problem. This study attempted to overcome these hurdles by calculating an index based on the number of patents and the number of times each patent was
(4) The operationalization of the percentage of outside directors construct has been criticized in previous research. Previous studies have used different operationalizations of the construct (e.g., number of outsiders, outsider dominance, and percentages). This study found a significant relationship using the operationalization, percentages. However, the possibility remains that using different operationalizations of this construct might result in different findings.

(5) Only 80 firms went public during the period of this study, 1980-1987. Out of these 80 firms only 60 remained in our final sample. Thus, leaving us with a very smaller n which limited our ability to perform certain statistical analyses. Furthermore, the statistical technique used in this study, multiple regression, does not insinuate cause and effect, but mere associations or relationships.

(6) Since we performed research on the biotech industry, this limited our ability to generalize the results across other industries. Just because the results are indicative in the biotech industry does not necessarily mean that they will
be applicable to other industries. However, we can attempt
to generalize the results to other emerging industries.

CONCLUSION

The importance of this study should not be looked upon
as just another board dissertation, but a contribution to the
betterment of mankind. Even though the biotechnology
industry is in its introductory stage, it has already
contributed
immensely to help the world in the cure of critical diseases
(e.g., diabetes, hepatitis, influenza). We have just begun
to see the true potential of this dynamic industry. Several
drugs are in the pipeline to combat the threat of life-
threatening diseases like AIDS, Alzheimer's and Parkinson's
disease and cystic fibrosis.

Business researchers are just beginning to investigate
the biotechnology industry. This study has contributed to
our understanding of one significant aspect of the
biotechnology industry and other emerging industries, the
board of directors. Future studies should continue to
investigate the factors which contribute to the success of firms in emerging industries. From a global perspective, as we continue to explore how these successful companies work, then we can contribute in a positive way to the betterment of mankind all over the world.
REFERENCES


Conference Board.


The Unseasoned Securities Market in the Late 1970s. Financial Management. 9, 4, 30-36.


Gordon, R. (1945). Business Leadership in the Large


Henricks, T. (1991). Directors Control in Large


Papers, Brighton, University of Sussex.


### TABLE 2.6

**SUMMARY OF MAJOR INSIDE VS OUTSIDE-CORPORATE PERFORMANCE STUDIES**

<table>
<thead>
<tr>
<th>Study</th>
<th>Independent Variables</th>
<th>Dependent Variables</th>
<th>Sample</th>
<th>Analytical Approach</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vance</td>
<td>Insiders vs. Outsiders</td>
<td>Sales</td>
<td>200 major manufacturing companies</td>
<td>Regression</td>
<td>Insiders were positively associated with performance. (1955)</td>
</tr>
<tr>
<td>Vance</td>
<td>Insiders vs. Outsiders</td>
<td>Net income</td>
<td>103 major industrial firms</td>
<td>Regression</td>
<td>Insiders were positively related to performance. (1964)</td>
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<tr>
<td>Pfeffer</td>
<td>Deviation from ideal performance</td>
<td>Income/sales income/equity ratio</td>
<td>80 manufact. companies</td>
<td>Spearman correlation</td>
<td>Firms that deviated from ideal ratio performed more poorly. (1972)</td>
</tr>
<tr>
<td>Schmidt</td>
<td>Insiders vs. Outsiders</td>
<td>Long-term debt</td>
<td>80 chemical companies</td>
<td>Regression</td>
<td>No relationship with financial performance. (1975)</td>
</tr>
<tr>
<td>Schmidt</td>
<td>Outsiders' financial affiliation</td>
<td>ROE Long term debt ratio Net working capital per sale dollar</td>
<td>156 industrial firms</td>
<td>Chi-square Z-statistics</td>
<td>No relationship between outsiders' affiliation and performance. (1977)</td>
</tr>
<tr>
<td>Baysinger &amp; Butler</td>
<td>Number of outsiders</td>
<td>ROE</td>
<td>266 companies</td>
<td>Cross-lagged</td>
<td>Firms having more in 1970 &amp; 1980 regression in 1970 outperformed their</td>
</tr>
</tbody>
</table>
Chaganti Proportion Bankruptcy 21 pairs of T-test No relationship between counterparts in 1980.
Mahajan of successful &

Cochran Proportion Golden 406 Fortune Correlation The grant of golden
Woods & of parachutes 500 companies Logit parachutes was negatively
Jones Insiders Excess value ratio regression related to insiders' (1985)
(1985) (market value to Insiders' ratio was
book value) positively related to financial performance.

TABLE 2.6 (CONTINUED)

SUMMARY OF MAJOR INSIDE VS OUTSIDE-CORPORATE PERFORMANCE STUDIES

<table>
<thead>
<tr>
<th>Study</th>
<th>Independent Variables</th>
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</thead>
<tbody>
<tr>
<td>Kesner</td>
<td>Proportion</td>
<td>Number of</td>
<td>384 Fortune 500</td>
<td>Correlation</td>
<td>No relationship between the number of illegal acts committed by the firm. (1986) and outsiders' proportion.</td>
</tr>
<tr>
<td>Victor &amp;</td>
<td>of illegal acts</td>
<td>firms between</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamont</td>
<td>outsiders</td>
<td>1980-1984</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Author(s)</td>
<td>Type of Relationship</td>
<td>Measure of Financial Performance</td>
<td>Sample Size</td>
<td>Correlation Type</td>
<td>Correlation Findings</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------------</td>
<td>---------------------------------</td>
<td>-------------</td>
<td>------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Kosnik (1987)</td>
<td>Proportion of insiders of ROA Fortune 500 companies in 27 industries</td>
<td>ROE EPS</td>
<td>110 companies</td>
<td>Canonical</td>
<td>No relationship</td>
</tr>
<tr>
<td>Zahra &amp; Stanton (1988)</td>
<td>Outsiders' ratio of ROE Fortune 500 companies</td>
<td>EPS  Sales/equity (1980-83)</td>
<td>100 companies</td>
<td>Canonical</td>
<td>Outsiders' ratio was not related to financial performance.</td>
</tr>
<tr>
<td>Schell-enger &amp; Wood &amp; Tashakori (1989)</td>
<td>Proportion of ROA Shareholders' annualized total market ROI</td>
<td>ROE Shareholders' annualized total market ROI</td>
<td>526 companies</td>
<td>Correlation</td>
<td>No relationship</td>
</tr>
</tbody>
</table>
TABLE 4.5

FULL MODEL MULTIPLE REGRESSION OF TP

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Coeff.</th>
<th>Std. Error</th>
<th>Student's T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>14.1541</td>
<td>10.3526</td>
<td>1.367</td>
<td>.1777</td>
</tr>
<tr>
<td></td>
<td>-1.6741</td>
<td>.8394</td>
<td>-1.994</td>
<td>.0516**</td>
</tr>
<tr>
<td>FL</td>
<td>3.0951</td>
<td>2.2664</td>
<td>1.366</td>
<td>.1782</td>
</tr>
<tr>
<td>US</td>
<td>1.9227</td>
<td>2.8532</td>
<td>.674</td>
<td>.5035</td>
</tr>
<tr>
<td>FL x US</td>
<td>-1.2911</td>
<td>1.6604</td>
<td>-.778</td>
<td>.4405</td>
</tr>
<tr>
<td>I\O</td>
<td>-22.7210</td>
<td>11.7583</td>
<td>-1.932</td>
<td>.0590*</td>
</tr>
<tr>
<td>OS</td>
<td>.0037</td>
<td>.0119</td>
<td>-.315</td>
<td>.7540</td>
</tr>
<tr>
<td>OA</td>
<td>.6349</td>
<td>.8795</td>
<td>.722</td>
<td>.4737</td>
</tr>
<tr>
<td>IOS</td>
<td>.1981</td>
<td>.1063</td>
<td>1.864</td>
<td>.0682*</td>
</tr>
</tbody>
</table>

Cases Included           60
Missing Cases             1
Degrees of Freedom       50
Overall F Statistic      2.468
Adjusted R squared       0.168
R squared                0.283

which was significantly related to TP (Y3) at the alpha = .05 level was SOB (X₁). IOS (X₈) and I\O (X₅) were significant with TP at the .10 level. Results of the full model of TP were significant with a P = .0245 which accounted for 28% of the variance in technological performance.
TESTS OF HYPOTHESES

Test of H1

The first hypothesis (H1) stated that there would be a positive linear relationship between the size of the board of directors and aftermarket IPO performance. As discussed