THE IMPACT OF RECEIVING A PATENT ON THE MARKET VALUE OF FIRMS

A THESIS

Presented to

The Faculty of the Department of Economics and Business

The Colorado College

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Arts

By

Joseph D. Miller

May, 2008

THE IMPACT OF RECEIVING A PATENT ON THE MARKET VALUE OF FIRMS

Joseph D. Miller

May, 2008

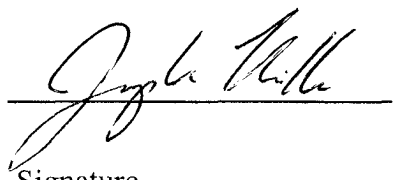
Economics

Abstract

This study addresses the general reaction a firm's stock price has when the firm receives a patent and looks at the implications such reactions have on the Efficient Market Hypothesis. The study introduces the underlying theory and relevant literature to develop the foundation needed to assess these connections. The literature that examines the EMH is unmistakably extensive. Nonetheless, literature that looks at it in relation to patent grants is quite limited. This study uses an event study to examine a sample of 90 patents from 5443 patents that were granted during a five year period (1999-2004) to chemical companies. Through the use of four statistical models which attempt to control for what the price of each security would be if a patent was not granted, the results of this study are able to assess the general reaction of the stock market to the granting of patents to chemical companies. The primary conclusion of this study is that the stock prices of chemical companies do not react to the granting of a randomly selected patent. Specifically, there were no statistically significant abnormal or cumulative abnormal returns found near the time of patent grants. This finding thus enriches the current literature relating to market value and innovation.

KEYWORDS: (Patent Grants, Market Value, Efficient Market Hypothesis)

ON MY HONOR, I HAVE NEITHER GIVEN NOR RECEIVED
UNAUTHORIZED AID ON THIS THESIS



Signature

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

I would first like to first like to thank John Stinespring for his invaluable support and guidance through all stages of my thesis. I would also like to thank Dan Johnson for introducing me to the field of intellectual property and pointing me to the idea of studying the connection between innovation and market values, as well as Eason Jostad for giving me access to his collection of patent data. Lastly, I would like to thank my friends and family for their untiring support from start to finish.

CHAPTER I

INTRODUCTION

It is apparent that the stock market has become a keystone of our economy. Indeed the investment into companies listed on a stock market is a crucial aspect of the financing for corporate and individual endeavors. Moreover, many people dedicate their professional or personal lives to studying the markets in an attempt to understand more fully how the markets move. However, an abundance of literature relating to the stock market suggests that consistently achieving abnormally high returns in the stock market is impossible. The Efficient Market Hypothesis (EMH) asserts that markets are so efficient that above average returns are unachievable because all available information is fully incorporated and reflected in the price of each security. The purpose of this paper is to address the general reaction a firm's stock price has when the firm receives a patent and to look at the implications such reactions may have on the EMH. This study adds to the current literature first by assessing the general reaction of the stock market to the granting of an average, or randomly selected patent. Secondly, it adds to current literature by evaluating whether the reactions that do occur to the granting of patents are accurately and efficiently reflected in the market value of a stock, or if an overreaction occurs.

The basis of this study rests on the fact that patents, like any asset, add value to companies. Patents, which provide twenty years of legal protection for inventions that are original, useful, and non-obvious, are clearly vital for the continued success of

companies[1]. IBM, for example, makes approximately $1.5 billon per year from sharing its patents with other firms[2]. The *American Bar Association Journal* further highlights the value of patents by stating that intellectual property in general "...is becoming more and more crucial to a company's overall operations and financial health.[3]" Thus, when a company receives a patent, the forecast of the firm's expected future earnings should be adjusted. If the stock markets are efficient, when a firm obtains a patent, the increased outlook for earnings should be instantly reflected into the price of the company's stock.

The EMH is one of the most highly debated and studied market behavior theories. If the claims of the EMH hold true and individual investors cannot consistently beat market averages, then devoting time and money attempting to do so is useless. Conversely, if individuals can achieve above average returns in the stock market, such dedication to beating the market could be met with substantial financial reward. With nearly half of American households investing in stocks[4], studies that provide insight into the extent that markets are efficient have substantial ramifications for many. While there exists a vast amount of literature that provides evidence that both supports and refutes the EMH, looking at whether the granting of a patent affects the valuation of different securities is a topic that has only been studied to a limited extent. Previous studies have looked at the influence that patents and innovations have on the profits of companies and the performance of innovative versus non-innovative companies (Mansfield et al. 1971, 1977). Moreover, research has looked at the value of *patent counts* as a measurement of

---

[1] Bronwyn H. Hall, Adam Jaffe, and Manuel Trajtenberg, "Market Value and Patent Citations," *RAND Journal of Economics* 36, no. 1 (2005): 16.
[2] Julie L. Davis and Suzanne S. Harrison, *Edison in the Boardroom: How Leading Companies Realize Value from their Intellectual Assets* (2001): 2.
[3] Donna Suchy, "The Block's New Big Kid," *ABA Journal* 92, no. 4 (2006): 54.
[4] Robert J. Samuelson, "The Market's Echo Chamber," *BusinessWeek* CLI, no. 5 (2008)

R&D success (Hall, Jaffe, and Trajtenberg 2001) and have focused on the market's reaction to product announcements (Channey and Devinney 1992). Furthermore, a study has estimated the private value of patents to specific companies and to their rivals for patents that are readily identifiable (Austin 1993). This thesis attempts to expand upon these studies to shed light on the EMH and enrich the literature relating to innovation and market value.

There are numerous economic theories that lay at the foundation of this study. As mentioned previously, this paper is founded upon the efficiencies of the market and aims to assess the EMH. While there are different levels of the EMH, each return to the concept that consistent above average returns are not obtainable. The basis of the EMH is that stock markets have so many investors who are competing rationally, and reacting to relevant events, that the prices of securities change in an almost instantaneous fashion[5].

While the EMH is a theory that carries much support, another body of literature speaks to the ability to outperform the market because of its inefficiencies and tendency to overreact. In direct opposition to the claims of the EMH, two types of stock selection analysis are commonly utilized by investors who think the market averages can be out-performed. The first is known as *fundamental analysis* which attempts to determine the intrinsic value of a company[6]. Fundamental investors argue that an investor can make investment decisions based on whether a security is under- or over-priced compared to its true value. The second common type of stock selection is known as *technical analysis*.

---

[5] Lawrence J. Gitman and Michael D. Joehnik, "Fundamentals of Investing," *(Boston: Addison Wesley)* (2002): 178.
[6] Ibid.

Technical analysis looks at the historical performance of securities to try to understand when to purchase and sell them in order to out perform the market[7].

Behavioral finance is a field that also directly opposes the EMH by looking at how the psychology of investors may affect their investment decisions[8]. As noted previously, the EMH is founded upon the assumption that investors are acting rationally. Behavioral finance suggests that the investors do not always act in a rational manner. Irrational decisions and cognitive errors by investors can thus lead to pricing bubbles and abnormal movements in stock prices that are not tied to the stock's actual quality. The Overreaction Hypothesis (ORH) is one of the fundamental theories within behavioral finance that attempts to explain such unusual movements in stock prices. The ORH is based on the idea that the stock market has movements in price followed by predictable reversals in price[9]. The ORH thus challenges the EMH by providing evidence of when above average returns can be obtained.

The aim of this study is illuminate whether the granting of patents has an impact on the price of securities and to examine whether or not this has implications for the EMH. This study analyzes a random selection from 5443 patents that were granted during a five year period (1999-2004) to companies classified into the Standard Industrial Classification (SIC) group number 28, entitled Chemicals and Allied Products. It should thus provide a general sense of the stock market's reaction to the granting of patents to chemical companies. In order to determine the effect of the granting of a patent, this study attempts to control for what the price of each security would be if a patent was not

---

[7] Ibid

[8] Robert J. Shiller, "From Efficient Markets Theory to Behavioral Finance," *Journal of Economic Perspectives* 17, no. 1 (2003): 83.

[9] Benou Georgina and Nivine Richie, "The Reversal of Large Stock Price Declines: The Case of Large Firms," *Journal of Economics and Finance* (2003): 19.

granted. Thus this study seeks to determine the "abnormal return" of an individual security that arises because of the company receiving a patent. A given security's abnormal return is considered to be the difference between the return that is actually realized at a given time and the expected return of the firm's stock at the same time. The abnormal returns in this study are calculated using four different statistical models: the mean adjusted returns model, the market model, the market adjusted returns model and the capital asset pricing model.

The first model, the mean adjusted returns model is a simple model that estimates the abnormal return of a stock as the difference between the return of the stock on the day of the event and the average of the stock's daily return during the estimation period. The second model, the market adjusted returns model, is identical to the mean adjusted returns model except that it estimates the abnormal return of a stock as the difference between the return of the stock on the day of the event and the average of the market's, rather than the stock's, daily return during the estimation period. The third model, the market model, essentially calculates the abnormal return for a security for each date as the difference between the return of the security to the return of the overall market, while controlling for the company's systematic risk. The market model incorporates the systematic risk of the stock by utilizing beta, the measure of a stock's volatility compared to the market's volatility during the estimation window. The last model, the capital asset pricing model (CAPM) attempts to determine the impact of events by considering the related risk-free rate of return, the return of the overall stock market, and the systematic risk associated with the stock. The model incorporates the time value of money through

the theoretical risk-free rate. Together the model states the expected return of a security should be equivalent to the risk-free rate plus a risk premium.

An event study is used to assess the impact of receiving a patent. The logic of using the event study methodology arises from the fundamental claim of the EMH that all available information about a firm, including new information, is instantaneously reflected in the price of each stock. An event study uses historical financial market data to evaluate the influence of an event, in this case receiving patents, on the market value of the company. Event studies examine the changes in the price of stocks during an event window, where the day of the event is referred to as day 0, the day before as day –1, the day after as day +1, and so forth. The event window in this study was set to 14 days: eight pre-event days, the event day, and five post-event days. Then the overall effect of the event is determined by summing the abnormal returns over a set length of event days into a cumulative abnormal return, which in this study is calculated twice (from day 0 to day 3 and from day 0 to day 5).

The foremost limitation of using an event study to explain movements in capital markets is the difficulty associated with differentiating between the impact a signal of future potential changes has from the actual changes in cash flow that may result.[10] Moreover, it can be argued that information regarding the granting of a patent is "leaked" into the market before the grant date, limiting the effects an event study can record. Furthermore, stock prices are naturally noisy. This noise implies that events such as the granting of a patent have to give the marketplace enough new information to cause a reaction that is significant enough to be apparent through this noise. This problem may

[10] Ibid

be particularly strong when looking at the patents of companies which carry varying levels of value. Another limitation of event studies is that events, at times, occur near each other. In this study for example, it is apparent that some highly inventive companies regularly receive patents which creates difficulties in developing an abnormal return resulting from the granting of a particular patent. However, such limitations do not discredit this highly used method of studying the effect of events on the capital markets and should not been seen as so great that they disable this study's results from providing a general sense of the stock market's reaction to the granting of patents.

CHAPTER II

REVIEW OF THEORY AND RELATED LITERATURE

Studying the ability to achieve consistent above average returns in the stock market is a topic of interest to many. The efficiency of the market is a topic that has thus created much debate and an abundance of literature. This study is focused on assessing the general reaction of a firm' stock price to the granting of a patent and the implications such reactions may have for the Efficient Market Hypothesis (EMH). Since this paper largely founded upon the efficiencies of the market, this chapter first examines in depth the theory and relevant literature of the EMH. The chapter thus delves into the area of Behavioral Finance and the Overreaction Hypothesis (ORH) and their relation to the EMH. Then this chapter introduces studies which have looked at the impact that innovation has had on the market value of firms. Additionally, previous event studies that have looked at the impact that various announcements have on the market value of firms are introduced. Ultimately this literature review ties these topics together which creates the foundation that is necessary to evaluate the general reaction of the stock market to patents and what such reactions mean in regards to how efficiently the stock market reacts to patent announcements.

The Efficient Market Hypothesis and its Support

Traditional valuation theory in the stock market asserts that the value of a firm in the market is the sum of both the expected future cash flows derived from assets a company *already* has and the expected net present value of cash flows from investment opportunities that are *expected* to exist and be carried out by the firm[1]. The extent to which markets function efficiently and adjust to reflect changes in the expectations of future cash flows is a topic that has received considerable debate. In fact, the study of the pricing efficiencies within the stock market has developed into one of the most commonly studied topics relating to corporate finance[2]. It is furthermore argued that the study is "one of the most important, controversial and well-studied propositions in all the social sciences.[3]"

In a survey of articles (Cootner 1964) the original idea of having random markets was expressed by looking at successive stock price changes. The study concluded that the manner in which markets acted previously have no predictive power for the way in which they will act in the future[4]. The Efficient Market Hypothesis (EMH) was initially introduced by Eugene Fama in 1965[5]. The EMH claims that all available information is fully incorporated and reflected in the price of each security, and that consistently gaining abnormally high returns in the stock market is unachievable. One method of testing whether stock prices adjust in an efficient manner is to examine the reaction of stock prices to events, known as event or case studies.

---

[1] R. A. Brealey and S. C. Myers, "Principles of Corporate Finance,"3rd Ed (1988): 198.
[2] J. Randall Woolridge and Charles C. Snow, "Stock Market Reaction to Strategic Investment Decisions," *Strategic Management Journal* 11, no. 5 (1990): 362.
[3] M. C. Findlay and E. E. Williams, "A Fresh Look at the Efficient Market Hypothesis: How the Intellectual History of Finance Encouraged a Real 'Fraud-on-the-Market'," *Journal of Post Keynesian Economics* (2000): 189.
[4] Paul Cootner, "The Random Character of Stock Market Prices," (1964)
[5] Eugene Fama, "Random Walks in Stock Market Prices," *Financial Analysts Journal* (Sept 1965)

There are a myriad of studies that support the EMH. Eugene Fama argues that events studies, such as this thesis, "...give the most direct evidence on efficiency... [because they] come closet to allowing a break between market efficiency and equilibrium pricing issues."[6] Fama concludes that such evidence is mostly supportive of the EMH. He notes that events which may appear to point to market inefficiencies tend to disappear when adjusted for risk and "normal" returns[7]. By 1988 Brealey and Myers concluded that the fact that the market is efficient regarding publicly available knowledge is supported by the majority of empirical research[8]. However, by the turn of the twenty-first century the EMH was much less universally accepted amongst academics[9].

The EMH is undoubtedly one of the most well known market behavior theories and is now considered by some to be a highly simplified account of the stock markets[10]. Findlay and Williams (2001) review three decades of research on the EMH and conclude a lack of consensus. However, they argue that although vast improvements exist in the statistical analysis, databases, and theoretical models used to evaluate the EMH, the EMH can *not* be empirically refuted because the vagueness of the definitions within the study. The article suggests that efficiency should be a relative measurement rather than a binary assessment of whether it does or does not exist.

Much of the literature that attempts to disprove the EMH point to instances where investors consistently have abnormally high returns, as will be described in the following

---

[6] Eugene F. Fama, "Efficient Capital Markets: II," *The Journal of Finance* 46, no. 5 (Dec. 1991): 1575-1617.

[7] Eugene F. Fama, "Market Efficiency, Long-Term Returns, and Behavioral Finance," *Journal of Financial Economics* 49, no. 3 (09 1998): 283-306.

[8] Brealey and Myers, *Principles of Corporate Finance*, 198.

[9] Malkiel, Burton G. "The Efficient Market Hypothesis and its Critics." *Journal of Economic Perspectives* 17, no. 1 (2003): 62.

[10] Gishan Dissanaike, "Do Stock Market Investors Overreact?" *Journal of Business Finance & Accounting* 24, no. 1 (1997): 27.

section. However, Farmer and Lo (1999) provide evidence in support of the EMH by illustrating how such instances, in themselves, do not discredit the EMH. The authors suggest that when investors consistently beat the market it does not automatically point to a market inefficiency. They argue rather that beating the market could come from unusual skill, extraordinary effort or a breakthrough in technologies.

Malkiel (2003) also argues that such instances do not necessarily prove that the markets are inefficient. In an article titled, *The Efficient Market Hypothesis and Its Critics*, Malkiel describes many of the patterns in the stock market that exist which are often used to argue against the EMH. He argues that the markets are far more efficient and function in a much less predictable manner than many of these critics suggest. Malkiel agrees that it is clear that there are people who participate in the market who do not act rationally which creates some short term predictable patterns and irregularities. Furthermore, he points out that markets could not be perfectly random or the incentive for people to follow the related information would no longer hold. He draws a distinction however, between economic significance and statistical significance. He concludes that even though the markets may not function in a completely random fashion, the statistical patterns that do arise do *not* enable investors to achieve consistently higher returns.

Many studies support Malkiel and the observation that there are not any consistent arbitrage opportunities which would allow investors to obtain excess risk adjusted returns. Odean (1999) finds evidence that because of the transaction costs associated with purchasing equities frequently, investors that attempt to exploit momentum did far worse than investors implementing a buy-and-hold strategy. Lesmond, Schill and Zhou (2004) likewise concluded that due to transaction costs investors cannot consistently

achieve above average returns using a "relative strength" strategy. Schwert (2002) describes how there is a lack of arbitrage opportunities because any time a predictable pattern is determined to be statistically significant investors quickly exploit them until they no longer exist. The findings from the studies which speak to the lack of opportunities to profit from patterns are captured well through the words of Richard Roll, an academic financial economist and portfolio manager:

> "I have yet to make a nickel on any of these supposed market inefficiencies....a true market inefficiency ought to be an exploitable opportunity. If there's nothing investors can exploit in a systematic way, time in and time out, then it's very hard to say that information is not being properly incorporated into stock prices."[11]

Challenging the EMH

While there is a large body of evidence that supports the EMH, another body of literature speaks to the market's inefficiencies and its tendency to overreact. Even the more recent work of Eugene Fama, the economist who introduced the Efficient Market Hypothesis, has noted along with Kenneth French that the theory of efficient markets has become "thornier" than it seemed to be twenty years before and that some of the previous studies on the subject "were kind of naïve."[12] Many studies have challenged the EMH. Lo and MacKinlay (1999) for instance rejected the idea that stock prices move randomly

---

[11] Richard Roll and Robert J. Shiller, "Comments: Symposium on Volatility in U.S. and Japanese Stock Markets," *Journal of Applied Corporate Finance* 5, no. 1 (1992): 25-29.

[12] Fama, Eugene, and Kenneth French. "Common Risk Factors in the Returns on Stocks and Bonds." *Journal of Finance* 33, no. 1 (1993): 3-56.

because they found non-zero serial correlations in short run prices. Similarly, a study by Lo, Mamaysky and Wang (2000) found that some technical analysis pricing strategies may have some predictive power. The authors thus provide evidence of stock prices moving in a non-random manner.

As mentioned previously many studies challenge the EMH by pointing to instances of the markets acting irrationally. Some of these instances of irrationality, it is argued, are seemingly irrefutable. Some people simply point to vast numbers of investors that have been successful in beating the market. More specifically, some economists point to predictable patterns that have developed due to valuation parameters. For instance, Campbell and Shiller (1988) concluded that by using the initial dividend yield of the market index, as much as 40 percent of the variance of future returns for the market can be predicted. Malkiel (2003), although arguing that such results may still be aligned with the EMH, confirms similar results. Similarly, in Campbell and Shiller (1998) found strong evidence that once again as much as 40 percent of the variance in future returns was explained by low initial P/E ratios.

Instances of predictability have also arisen in relation to patterns that seem to exist seasonally and weekly. The well known January Effect, in which stock returns are higher in the beginning of January, is an example that is commonly pointed to describe an instance of the market's irrationality. The January effect is a very well known anomaly and is supported by various studies such as one by Davidson and Dutia (1989). Moreover, studies have found evidence of higher returns at the end of each month (Lakonishok and Smidt 1988), around holidays (Ariel 1990), and on Mondays (French 1980). Also, studies have found evidence that the stocks of smaller companies show a

long term pattern to out perform stocks of larger companies (Fama and French 1993). Specific events that have occurred are also commonly used to challenge the EMH. Two prime examples that are often cited are the crash of October 1987 and the internet bubble of the late 1990s. It is argued that the anomalies, events, and predictable patterns described above provide clear evidence that the markets are not always acting efficiently.

Behavioral Finance and the Challenges it Poses to the EMH

In the last decade a new extension of cognitive psychology, known as behavioral finance, has developed. Behavioral finance attempts to explain why investors may not always act rationally, a key assumption of the EMH. Investors, being human, are affected by their emotional states which result in cognitive errors and pricing inefficiencies not related to the quality of the actual stocks[13]. For instance, Weber (1999) provides evidence that the psychology of investors make it so that it is difficult for them to sell stocks for a loss. Behavioral models in finance thus integrate insights from psychology with economic theory in order to assess whether people in the markets act rationally. In 1996 Alan Greenspan used the phrase "irrational exuberance" in illustrating the emotion that drives investors and makes them act non-rationally at times[14]. The existence of the psychology within the markets and the importance of behavioral finance are further highlighted by a speech Greenspan gave in 2001 during a weakening U.S. economy in which he said:

"The unpredictable rending of confidence is one reason that recessions are so difficult to forecast. They may not just be changes in degree from a period of

[13] Geln Boyle and Brett Walter, "Reflected Glory and Failure: International Sporting Success and the Stock Market," *Applied Financial Economics* (2003): 225.
[14] Alan Greenspan, "Irrational Exuberance Speech," (1996)

economic expansion, but a different process engendered by fear. Our economic models never have been particularly successful in capturing a process driven in large part by nonrational behavior.[15]"

The psychology of investors, among many things, can lead to a phenomenon known as herd behavior. Herd behavior occurs when large numbers of individuals in a group act together at the same time without planned direction. Studies in behavioral finance often cite herd behavior as the driving force behind periods of large amounts of people purchasing stocks which creates 'bubbles' and selling stocks which creates 'crashes'. Markus Brunnermeier (2001), for instance, argues that such episodes of people either rushing in or out of the stock markets are clear examples of the market acting from emotion and in an irrational manner.

The psychology of individuals in the market has been studied in numerous ways. For instance, Peterson (2002) takes a multidisciplinary approach tying studies from finance, psychology and neuroscience together. The study looks at how investors respond to anticipated events and at the cognitive judgment and decision-making aspects associated with anticipated events. Interestingly, they illustrate how positive events do not necessarily lead to a securities appreciating in value. The authors suggest that following an anticipated event the investors state decreases from positive to neutral. They note that when the investor was in a positive state they were okay with having higher levels of risk but when their state reaches neutral they may become more risk adverse which puts downward pressure on the prices of securities.

---

[15] Alan Greenspan, "Monetary Policy Report to the Congress," *Before the Committee on Banking, Housing, and Urban Affairs* (Feb. 13, 2001)

In another article, Fromlet (2001) provides an overview of the psychology affecting investors. The article uses examples to introduce some of the most fundamental aspects of behavioral finance including: the psychology of sending messages, differences in interpretation, investor expectations, anchoring, the disposition effect, overconfidence and following the herd. Fromlet stresses the fact that psychology truly matters in the financial markets and that the study of behavioral finance can help investors understand the market better.

The psychology of investors can also lead to overreactions to news events. The EMH states that all investors act rationally and that all public information is fully and efficiently incorporated into the price of securities. Thus, when an overreaction occurs it provides evidence against the EMH. One of the fundamental theories within behavioral finance is known as the Overreaction Hypothesis (ORH). The following section examines the support for the ORH which challenges the EMH, by providing evidence of when investors can earn abnormally high returns.

The Overreaction Hypothesis and its Support

A common argument against market efficiency in the short run is that there often exist some positive serial correlations (see Lo and MacKinlay mentioned previously). However, many studies have provided proof that there exist negative serial correlations over long periods of time, known as return reversals. Return reversals (also known as price or mean reversals) are when equilibrium prices are restored in the market. For instance, Poterba and Summers (1988) as well as Fama and French (1988) determined that there exist substantial amounts of mean reversion over long periods of time. Many

studies point to the overreaction in the stock market to explain this longer term predictable pattern.

The Overreaction Hypothesis is based on the claim that the stock market experiences systematic extreme movements in price in one direction, followed by a compensating extreme reversal in the other direction[16]. This theory directly challenges the EMH by asserting that markets can be predicted and fail to efficiently reflect publicly available knowledge. The ideas within the ORH have been studied for a long time. One of the first people who laid out the ideas of an overreaction occurring in markets was John Maynard Keynes. Keynes stated in his *General Theory of Employment, Interest and Money* that, "...day-to-day fluctuations in the profits of existing investment, which are obviously of an ephemeral and non-significant character, tend to have an altogether excessive, and even absurd, influence on the market.[17]" Moreover, Williams described in his Theory of Investment Value at approximately the same time as Keynes that "...prices have been based too much on current earning power and too little on long-term dividend paying power.[18]" Similarly, Arrow (1982) concluded that "...excessive reaction to current information seems to characterize all the securities and futures markets.[19]"

Arrow spoke to two different phenomena that illustrated overreaction in the markets: excess volatility of the prices of securities and something known as the price earnings ratio anomaly. Various authors have studied the two specific examples that Arrow asserts. Shiller (1981) examined the excess volatility issue to a great extent.

---

[16] Benou Georgina and Nivine Richie, "The Reversal of Large Stock Price Declines: The Case of Large Firms," *Journal of Economics and Finance* (2003): 19.

[17] John M. Keynes, "The General Theory of Employment, Interest and Money," (1964 (reprint of 1936 edition)): 153-154.

[18] J. B. Williams, "The Theory of Investment Value," (1956 (reprint of the 1938 edition)): 19.

[19] K. J. Arrow, "Risk Perception in Psychology and Economics," *Economic Inquiry* 20 (1982): 1-9.

Shiller concludes that, especially for the last century, the aggregate changes in prices have not been justified by fluctuations in dividends. He suggests rather that investors act irrationally by paying too much attention to short-run developments and that there is strong evidence that such investors overreact. The price earnings (P/E) anomaly, as mentioned previously, describes the occurrence of stocks with lower P/E ratios earning higher returns adjusted for risk than stocks with higher P/E ratios[20]. Basu (1983) provides further support for the anomaly and for overreaction in the markets by concluding that after controlling for firm size there is a significant P/E effect. In his study, Basu suggests that companies with very low P/E ratios are thought to be undervalued and will predictably rise in price, and vise versa. A common response to the idea that predictable overreaction in the markets occur is that question of how such an anomaly is not exploited by arbitrage. In concentrating on this issue, Russell and Thaler (1987) conclude that in an economy that has "quasi-rational agents," the existence of some rational agents will not ensure that such arbitrage is exploited fully[21].

The Overreaction Hypothesis (ORH) was widely popularized by deBondt and Thaler in 1985. Their study compared portfolios of companies made up of prior "winners" and companies that were considered prior "losers." The results from this study had many important implications that were all consistent with the ORH. The study compared portfolios comprised of companies that had performed below average, in the fifty years before, to portfolios with companies that had performed above average. The results provided strong statistical evidence that 36 months after portfolio construction, the below average portfolios had outperformed the above average portfolios by

---

[20] Ibid.

[21] Thomas Russell and Richard Thaler, "The Relevance of Quasi Rationality in Competitive Markets: Reply," *American Economic Review* 77, no. 3 (06 1987): 499.

approximately 25 percent[22]. Moreover, the authors pointed to the fact that the overreaction that occurs is much larger for losers than for winners. More specifically, the study concluded that on average, thirty-six months after constructing the portfolios, the loser portfolios outperformed the market by 19.6 percent and the winner portfolios underperformed by 5.0 percent. The authors based their evidence on the idea that individuals do not always make rational decisions. Moreover they note that people are overly influenced by current information and assign too little importance to prior data. Thus the study provides evidence of when information based on the prior returns of companies is useful in predicting future returns.

DeBondt and Thaler's study provided support for mean reversions which are commonly identified by assessing the profitability of contrarian investment strategies that sell securities that have performed well in the past and vice versa. Many studies find evidence that supports deBondt and Thaler's results. Weber (1999) for instance, provides evidence that there is a tendency for stocks that experienced large increases in price in the preceding five year period to become under-performers in the subsequent five year period. Lehmann (1990) concludes, in opposition to one of the fundamental challenges presented against the ORH, that the arbitrage opportunities that arise because of these return reversals exist even after corrections for bid-ask spreads and transaction costs. Dissanaike (1997) claims that the ORH is a valid theory and provides evidence of return reversals in large U.K. based companies. In Dissanaike's study he speaks to the alternative views and challenges that often arise regarding the ORH. He concludes that his study was successful in disqualifying the challenges, largely because it was restricted

---

[22] Werner F. M. DeBondt and Richard Thaler, "Does the Stock Market Overreact?" *The Journal of Finance* 40, no. 3 (1985): 793.

to large companies, thus providing strong support for the ORH. He moreover points to the fact that studying companies listed in the U.K provides an independent test for the hypothesis and eliminates arguments that previous studies have suffered from "data-snooping."[23]

Mark Hirschey, in a 2003 article titled *Extreme Return Reversal in the Stock Market* provides strong evidence of return reversals in the S&P 500 and the Nasdaq. He argues that greed and fear create overreactions which cause large swings in short term stock prices. He also states that long term returns in the stock market are not random. Instead he suggests that the returns that are common in the stock market provide strong support for the ORH. Hirschey speaks to investor's cognitive biases associated with systematically overweighting recent bad or good news which creates predictable mis-pricing and thus challenges the EMH[24].

Additional support for return reversals and the ORH is drawn from Benou and Richie (2003). Their study looked at large firms listed in the US with prices that had decreased by 20 percent or more in a month. The study concluded that 6 and 12 months after the decline, the stocks respectively achieved approximately 4 and 12 percent more than what was expected. However, discrepancies were found in the amount of price reversal depending on the industry. Technology stocks and manufacturing stocks experienced the largest return reversals, providing support for the ORH, but in contrast the stocks for service industry companies continued to fall for three years.

---

[23] Gishan Dissanaike, "Do Stock Market Investors Overreact?" *Journal of Business Finance & Accounting* 24, no. 1 (1997): 27.

[24] Mark Hirschey, "Extreme Return Reversal in the Stock Market," *Journal of Portfolio Management* (2003): 78.

Various studies provide further support for the ORH. Veronesi (1999) examines the impact of uncertainty and individual investor's risk tolerance during different economic conditions. The study suggests that, during periods of increased uncertainty, investor's anticipate that future performance of companies will react more to news. He concludes that since investors are willing to hedge against uncertainty, the markets overreact to bad news during good economic times and under-react to good news in bad economic times. Daniel, Hirshleifer, and Subrahmanyam (1998) propose a theory that two psychological biases cause the market's under- and overreactions. The first bias they suggest comes from the overconfidence of investors about the accuracy of private information. The second bias is known as biased self-attribution, in which the investor's outcomes create asymmetric changes in their confidence. The authors suggest that the theories, taken together, show that investors do not place enough importance on data and news and place too much importance on their own ideas. The study concludes that investors under-react to public information and overreact to their own private signals. Moreover the authors point out that in some instances, if public information does come to validate an investor's personal ideas, further overreaction is created. However, over time more information is made public and this overreaction decreases, leading to a price reversal.

Challenging the Overreaction Hypothesis

It is apparent that the Overreaction Hypothesis and its implications towards the Efficient Market Hypothesis is a topic of continual debate. There are primarily three arguments that are used to challenge the ORH. First, some studies have found evidence that the

overreaction effect is simply a size effect. This argument implies that the overreaction effect only occurs in relation to smaller and less popular stocks.

Zarowin (1990) for instance argues from such a stance and concludes that market efficiency holds for more well known and larger stocks. After controlling for size differences amongst winner stocks and loser stocks, Zarowin suggests that there is not much evidence of any difference in the stocks returns. He finds evidence that the reason that losers later outperform winners is because the poor performing companies are typically smaller than the well performing ones. Moreover, Baytas and Cakici (1999) assess the opportunities to use arbitrage to capitalize on past performance, price and size in portfolios of seven countries. The study shows that out of the seven industrialized countries, long-term overreaction exists in all but the United States. Due to the fact that in their study losers were more likely to be low in price and low in market value and vice versa, the authors suggest that the long-term price reversals they saw were due to the price and size effect.

The second argument that is commonly brought against the ORH is that time-varying risk can be seen as an explanation for the market inefficiencies. Chen and Sauer (1997), in a study that uses time series data to examine mean reversions in the stock market argue that although the market does experience overreaction at times, it does not occur consistently. The study provides evidence that there are periods in which investment strategies using the idea of overreaction would have achieved large positive profits, periods when they would have achieved large negative profits, and periods when they would have earned no abnormal profits. The article highlights how the overreaction

that occurs in the markets has varied greatly over time and thus no pattern can be generalized well. This makes using prior data to predict future performance difficult.

The third common argument used to challenge the ORH is that the overreaction in markets can be explained by problems with the method and results of the supporting studies. In a literature review of the ORH and mean reversion, William Forbes (1996) argues that different research methods need to be utilized to accurately assess the theories. Forbes, along with Conrad, Gultekin and Kaul (1997) and Conrad and Kaul (1993), speak to the importance of collecting data in a way that avoids bid-ask biases and the infrequent trading that might lead to skewed results.

As illustrated previously, a return reversal supports the ORH. However, Malkiel (2003) suggests that such reversals can be consistent with the EMH. He claims that interest rates also show a tendency to revert to a mean. Malkiel points to the inverse correlation that often exists between interest rates and the prices of bonds and equities. Rather than an inefficiency in the market, he argues, that such return reversals may thus be a product of this correlation to interest rates and the tendency of interest rates to return to a fundamental rate over time.

Furthermore, Malkiel argues that even if return reversals exist, investors may not be able to profit from them. As described previously, Fluck, Malkiel and Quandt (1997) tested a strategy of purchasing stocks that had in the preceding three to five years preformed very poorly. The study found very strong evidence of return reversals in which poor returning stocks performed well in the next period, and vice versa. Nonetheless the study showed that both the poor and strong performing stocks had similar returns in the following period. The authors thus conclude that excess returns

could not be achieved using such a strategy even though they found strong evidence of return reversals.

Similarly, Atkins and Dyl (1990) look at 835 losers and 836 winners and find evidence that a short run overreaction does exist in the stock market, particularly for stocks that have had large decreases in price. Nonetheless, as argued by Malkiel, the study concludes that investors cannot profit from such price reversals due to the magnitude of the bid-ask spread. The authors suggest that the markets are efficient if transaction costs are accounted for.

Previous Studies that Look at the Impact that Innovation has on the Market Value of Firms

There is limited empirical research that has looked at the relationship between components of intangible capital, such as patents, to the market value of firms.[25] A preliminary study by Pakes (1985) is considered to be the foundation of research regarding firm value and innovation. The study, which was conducted just after the US Patent and Trademark's Office (USPTO) made data available by computer, investigated the relationship between successful patent applications and movements in the stock prices of firms. Pakes did find evidence that, on average, patents granted to firms unexpectedly led to significant changes in the market value of the firm. However, Pakes noted that the amount the market value of the firm increases varies greatly across firms.

Determining the impact of R&D to the stock prices of firms is studied by Chan, Lakonishok, and Sougiannis (2001). The article points out the importance of intangible

---

[25] Lionel Nesta and Pier-Paolo Saviotti, "Intangible Assets and Market Value: Evidence from Biotechnology Firms," *SPRU Science and Technology Policy Research - Electronic Working Paper Series* 87 (2003): 2-19.

assets such as R&D to companies in modern economies. The authors note that the problem with such assets is that they are not always reported clearly, and if investors do not properly adjust the valuation of companies to account for the benefits from such assets, major mis-pricing will result. The study concludes that there is not a direct correlation between a company's future stock returns and incremental increases in spending on R&D. However, the study found evidence that companies with high values of R&D relative to their market capitalization are likely to achieve large excess returns.

Some literature that has assessed the impact of innovation to companies has focused on a measurement known as Tobin's q. Tobin's q compares the value of a company given by financial markets with the value of a company's assets, or the market value divided by the book value of assets. The advantage of using Tobin's q to measure the impact of innovations, it is argued, comes from the fact that it takes into account the future profit stream derived from such innovations[26]. Cao and Rao (2006) utilize quantile regression incorporating Tobin's q and note that the influence innovation has on the market value of firms varies. The study concludes that the market value of firms with high values of Tobin's q increases greatly when such firms innovate. Conversely, firms that have low values of Tobin's q are hardly affected by innovations. Nonetheless, the authors suggest, as the title *As Luck Would Have It: Innovation and Market Value* implies, that whether or not innovation is recognized by the market depends on a company's luck. In the author's words "...our results therefore emphasize the fundamentally uncertain nature of innovation and technological progress."[27]

---

[26] Alex Coad and Rekha Rao, "As Luck would have it: Innovation and Market Value in Complex Technology Sectors," *Centre d'Economie De La Sorbonne* (2006): 2-9.
[27] Ibid.

Previous studies have also looked at the value of patent citations as a measurement of the level of importance that a patent has to a company's stock market value (Hall, Jaffe, and Trajtenberg 2005). In their study, Hall, Jaffe, and Trajtenberg found, using patent citations from 1963-1999, that citations for patents significantly changed the market value of patents; each extra citation per patent increased the stock market valuation of the patent by three percent. The authors note that the results of their paper "clearly showed that patent citations contain significant information on the market value of firms, in addition to R&D and simple patent counts, thus enriching the toolkit available to economists trying to tackle empirically the [value of] intangible assets of....firms[28]" Nonetheless, their study is limited in assessing the Efficient Market Hypothesis as well as evaluating the average market value of a patent being granted to a firm because patent citations occur after the initial stock market reaction is assessed. Thus, a large amount of time is needed to determine the value of patents using citations. As the authors state, "citations-based analysis will never be usable for evaluation of current or very recent innovations[29]" as is used in this thesis.

Patent citations were also used by Bloom and Van Reenen (2002) to evaluate firm productivity and market value changes that arise because of patents. Their study is once again based on the concept that patents which are cited more often are more valuable. Their study did provide support that patents have value in the market place. They conclude that a doubling of the citation-weighted patent stock increases total factor productivity by three percent. However they speak to the problems associated with

---

[28] Bronwyn H. Hall, Adam Jaffe, and Manuel Trajtenberg, "Market Value and Patent Citations," *RAND Journal of Economics* 36, no. 1 (2005): 16.
[29] Ibid.

determining the effect a patent will have on the market value of a firm because productivity gains associated with patents take time to occur.

Some studies have been aligned even more closely with this thesis. Austin (1993) for instance, sought to determine the private market value of the application for, and granting of patents. Austin notes that "it is well known that patents vary widely in their economic values: a few patents are extremely valuable, and many are worth comparatively little." Various studies including: Griliches, Hall, and Pakes (1986), Scherer (1997), and Hall (1998) provide support for this idea. However, in estimating the private value of patents to specific companies and to their rivals Austin found that patents that were more readily identifiable with end products provide companies with a higher market value than the average patent. Austin's strongest finding was that patents which are announced in the press are highly valued in the eyes of the stock market. Moreover, he draws a distinction between *product* patents and *process* patents. He argues that while product patents are not necessarily more valuable than process patents, the latter "seem to cover intermediate processes that, in themselves, do not lead directly to marketable products." Conversely, product patents are often closer to end-products making them more "market-relevant" and thus more valued by the stock market.

Event Studies that Look at the Impact that Various Announcements have on the Market Value of Firms

Many of the studies that are aligned with the focus of this thesis look at the market's reaction to different announcements which are not necessarily related to patents. Many of such studies are known as event studies and use historical market data to assess

firm specific events. Event studies have been used in many studies looking at a wide range of events. According to MacKinlay (1997) the first of such studies was completed by James Dolley in 1933. Dolley took a sample of 95 stock splits that took place from 1921 to 1931 and analyzed their post-split performance, concluding that 57 increased and 26 decreased. The use of the events study was widely popularized by Fama, Fisher, Jensen, and Roll (1969) who analyzed the prices broken up by the month stocks following 940 stock splits for the 60 months following the splits.

There is evidence that the markets are able to gauge and place value on firm-level innovations well[30]. For example, a study by Jerrell, Lehn, and Marr (1985) that looked at 62 research and development (R&D) project announcements from 1973-83, found a significant positive relationship between a company making such announcements and their stock prices. This can imply that when companies make announcements regarding increases in R&D, the stock prices were adjusted to reflect the new public information and the changes in the expected cash flows of the company.

Another study looked the impact of announcements regarding changes in planned capital expenditure to stock prices. McConnell and Muscarella (1985) analyze 658 such announcements and concluded that announcements of increases in capital expenditure were correlated with increases in stock prices for industrial firms. Furthermore, McConnell and Nantell (1985) assess the relationship between the formation of joint ventures between two firms attempting to satisfy a strategic objective and the prices of their stocks. In this study stock prices for 210 companies were analyzed from the 180 days prior to the announcement to 180 days following it. The study determined that

---

[30] L. K. C. Chan, J. Lakonishok, and T. Sougiannis, "The Stock Market Valuation of Research and Development Expenditures," *Journal of Finance* 56, no. 6 (2001): 2431-2456.

during the day of an announced joint venture, the price of the stock of the associated company increased.

Hendricks and Singal (1996) assess the impact of a company that is recognized with a quality award for effectively starting quality improvement programs. To do so, Hendricks and Singal approximated the mean "abnormal" change in the prices of stock which had received quality awards. To determine the time when quality awards were announced the authors utilized a key-word search of the Trade and Industry Index (TRND) database and the Dow Jones News Service (DJNS). The daily abnormal returns were then assessed by using an estimation period of ten days before the announcement to 200 days after the announcement. The study found evidence that the stock market, particularly smaller firms, reacted to the announcement of quality awards positively.

The impact of stock prices and volumes to the recommendations that brokerage analysts make regarding individual equities was studied by Womanck (1996). The study examined a set of recommendations from the fourteen major brokerage firms that provide such recommendations in the U.S. The study found evidence that the returns were large for the three day period after recommendations were made and were aligned with the forecast of the analysts. More specifically, the study found that the during the three days after an announcement, there was a size-adjusted 3.0 percent increase for analyst's buy recommendations and a 4.7 percent decrease for sell recommendations. Moreover, the study claims to directly support the Efficient Market Hypothesis by pointing out that the returns that were realized seemed to be permanent rather than exhibiting a reversion to the mean.

The impact of stock splits and reverse splits to stock returns has also been investigated. Desai and Jain (1997) assessed the 1-3 year performance of equities following the announcement of 5,596 stock splits and 76 reverse splits made from 1976-91. The results from the study provide evidence that the stock market underreacts to firm specific announcements. In particular the study found that the market did not fully adjust to the announcement of stock splits in the month of the announcement. Rather the study concludes that after the initial announcement month, the mean one-year abnormal returns are 7.05 percent and increase to 11.87 percent after three years. For the sample of reverse splits the market did adjust in the announcement period and then exhibited a continual decrease; the announcement period had abnormal returns of – 4.59 percent, which after the 1- and 3- year period continued to decrease to – 10.76 percent and – 33.90 percent, respectively. Once again, the evidence points to an under-reaction to firm specific announcements.

The impact of Food and Drug Administration (FDA) announcements to the prices of securities was examined by Sarkar and DeJong (2006). The study assessed the impact that the stocks of companies experienced following announcements from the FDA during the four stages of their review process. Data for announcements made from 1990 through 2001 was taken from the FDA website as well as the Dow Jones News retrieval service (DJNS). The study provides evidence that investors do react positively to announcements that were positive and negatively to announcements suggesting that a rejection from the FDA was more likely. The highest abnormal return was found in the first stage in which the majority of uncertainty lies. The results from the study showed

that significant abnormal returns are realized within the first two days for the positive announcements and within the first day for the negative announcements.

Returning to the impact that innovation has on the performance of firms, Chaney and Devinney (1992) found evidence that when a company announces a product that is truly new, the company earned more than they otherwise would have. Chaney and Devinney's study incorporated traditional marketing behavior theory relating to a firm's decisions to innovate with techniques utilized in financial market analysis to gauge a firm's value. They note that in doing so they are unique in combining the most commonly accepted valuation metric of firms, their stock price, with strategic decisions that firms face. The study utilized the Wall Street Journal Index from 1975 to 1988 to determine when products were announced. The stock prices of companies that announced products were evaluated for three days after the product announcement

The study presented by Chaney and Devinney attempted to examine a wide array of hypotheses including: whether innovating firms receive a market premium in their valuation, whether firm size or firm industry is related to the amount of value derived from introducing an innovation, and whether the introduction of original products increases the market value than the announcement of an update to an existing product. The study found empirical evidence that, on average, the announcement of a new product increased the price of a company's stock by approximately 0.75 percent over a three day time period. They furthermore concluded that the impact of a product announcement depended on the industry, with that the greatest impact occurring within the most technologically-driven industries. Moreover, their study found clear evidence that the announcement of original innovations had a significantly higher impact than did updates

to existing products. However, the study did not find evidence that the size of the innovating firm affected the impact that the innovation had.

Woolridge and Snow (1990) looked at the impact of a variety of announcements made by firms of corporate strategic investment decisions regarding the formation of joint ventures, research and development (R&D) projects, major capital expenditures, and the diversification into new products or markets. The objective of the study was to assess whether when investing, firms set out long-term objectives to allow for the continual competitiveness of their firm or if they rather set objectives to increase short-run profitability and thus attractiveness to security analysts. The results from the study show that long-run investment decisions are rewarded. The analysis of 767 investment decisions across 102 industries provided evidence that when such decisions were announced by firms, the stock market generally reacted quickly and in a positive way. More specifically, they concluded that the markets reacted more positively to investment announcements regarding R&D and joint ventures than it did to announcements relating to capital expenditures and diversification.

The Use of Patents as a Case Study to Assess the Efficient Market Hypothesis

The stated purpose of the patent system is to encourage technological improvements and innovation by allowing an inventor to have a temporary monopoly[31]. It is evident that innovation and thus patents are important to companies. As Nesta notes, there is "....growing evidence that intangible capital has become a very important determinant of a firm's market value. Since the 1950's the intangible capital of firms has

[31] Zvi Grilches, "Patent Statistics as Economic Indicators: A Survey," *Journal of Economic Literature* XXVIII (1990): 1661-1701.

surpassed their physical capital." Griliches, Pakes, Hall (1986) determined that patents are a good indicator of differences in inventive activity across different firms[32]. Nevertheless, there has been only limited research on the relationship that new products and intangible capital such as patents have to the market value of firms.

This study attempts to use patents as a case study to determine if above normal returns can be made when patents are granted. This chapter has highlighted the fundamental literature and theory pertaining to the EMH and the conflicting ORH, as well as highlighted prominent studies relating to the value of innovation and the impact of announcements to firms. The chapter has thus acted as a guide of the current relevant literature demonstrated the potential for this study to contribute to the field.

The basis of the study rests on the claim of the EMH that the stock market should efficiently react to the granting of patents. This study uses the fact that patents, like any asset, add value to companies and thus should be reflected in the valuation of a company's stock price. As Channey, Devinney and Winer note, "...new product innovations are necessary because of competitive pressures and are therefore per se valuable.[33]" If patents are granted and the stock price of the company that obtains the patent is efficiently adjusted, then the results would support the EMH. As Brealey and Myers note for instance, support for the EMH is provided by studies which illustrate when there is an announcement of increases in dividend payments, stock prices increase on the first day and exhibit a random pattern during the subsequent days[34]. Such a pattern, Brealey and Myers argue, illustrates that markets are reflecting the information in

---

[32] Zvi Grilches, Ariel Pakes, and Bronwyn Hall, "The Value of Patents as Indicators of Inventive Activity," *NBER Working Series Paper* , no. 2083 (1986): 2-21.
[33] Paul K. Chaney, Timothy M. Devinney, and Russell S. Winer, "The Impact of New Product Introductions on the Market Value of Firms," *The Journal of Business* 64, no. 4 (1991): 573-610.
[34] Brealey and Myers, *Principles of Corportate Finance*, 198.

the dividend announcement on the first day of the announcement which thus supports the EMH. However, if the granting of a patent causes a temporary jump in the price of the stock, and then exhibits a reversion to the mean, the results would support the ORH. Indeed, there is no consensus in current literature as to the value of an average patent to firms. Thus, the granting of a patent may not be significant enough in any direction to provide strong evidence for or against the EMH. This would rather add to the current literature regarding the value of an average patent to a company's market value.

CHAPTER III

DATA AND METHODOLOGY

In order to isolate the effect of the granting of a patent, this study attempts to control for what the price of each security would be if a patent grant had not been granted. Therefore this study aims to determine an abnormal return of an individual security that arises due to the company receiving a patent. A given security's abnormal return is the difference between the return that is actually realized during a specified time frame and the expected or normal return of that firm's stock over the same time frame. To evaluate the impact of receiving a patent an event study is utilized. An event study uses historical financial market data to assess the influence of an event, in this case receiving patents, to the market value of the company. The empirical testing procedures for this study are based on event studies models that have been used frequently in the field of financial economics.

The Use of an Event Study

As MacKinlay (1997) describes, in order to utilize an event study to determine the impact of the release of information on the value of a firm's equity "it is essential to posit the relation between the information release and the change in value of equity." In this study this link is assumed to be a clear one. It is assumed that the granting of a patent to

a company is beneficial to the company and should be associated with an increase in the value of the company's equity.

The logic of using the event study methodology is derived from the fundamental claim of the EMH that all available information about a firm, including new information, is instantaneously reflected in the price of each stock. Therefore the influence of a specific event can be evaluated with stock prices from a rather short period of time. As Chaney, Devinney and Winer (1991) point out, as with all evaluations of capital markets, the efficiency of the market is being tested in addition to the hypothesis being tested.

Event studies examine the change in a price of a stock near the time when an event takes place. They assess the impact of specific reoccurring events to the return of stocks by studying historical market data in an event window. In an event window the day of the event is referred to as day 0, the day before is referred to as day –1, the day after is referred to as day +1 and so forth. The overall effect of the event is determined by summing the abnormal returns over a set length of event days into a cumulative abnormal return. In doing so, event studies explicitly test an event's impact on the overall market forecast of the firm's value[1].

Event studies have been widely used in the fields of finance, economics and accounting as described in the Review of Literature and Theory Chapter. Prominent examples of event studies include research related to FDA announcements[2], new debt

---

[1] Paul K. Chaney, Timothy M. Devinney, and Russell S. Winer, "The Impact of New Product Introductions on the Market Value of Firms," *The Journal of Business* 64, no. 4 (1991): 573-610.

[2] Sarkar, Salil K., and Pieter J. de Jong. "Market Response to FDA Announcements." *Quarterly Review of Economics & Finance* 46, no. 4 (2006): 586-597.

issues, mergers and acquisitions, and earnings announcements[3], as well as research relating to trade deficit announcements[4].

The length of the parameters utilized in event studies vary, but each study sets a specific length for the observation interval, event window, and estimation window. The observation interval describes the length of time at which security prices are considered. In this study the observational interval is set to one day, and therefore adjusted daily stock prices are analyzed. The event window is the timeframe used to evaluate the effect of the event which in this case is set to 14-days: eight pre-event days, the event day, and five post-event days. The length of the event window used in this study is aligned with previous event studies and is appropriate to determine abnormal returns around the weekly occurrence of patent grants. Lastly, the estimation window is used to determine the normal return of a security or the overall market. This study uses an estimation window of 95 days (beginning t= -100 to t= -6) before the granting of a patent. The length of the estimation window is guided by previous event studies in attempt to provide an estimate of the normal return not influenced by the event. Notably, the estimation window does not include the event of interest in the window to avoid manipulating the stocks normal return.

---

[3] A. Craig MacKinlay, "Event Studies in Economics and Finance," *Journal of Economic Literature* 35, no. 1 (Mar. 1997): 13-39.

[4] McQueen, Grant Richard and Vance V. Roley. "Stock Prices, News, and Business Conditions." NBER Working Paper No. W3520 (December, 1990)

Data Selection and Collection

This study focused on patents that were granted during a five-year period (1999-2004) to companies classified as chemical companies by the United States Patent and Trademark Office. A large range of chemical companies are included in this classification such as: Johnson & Johnson (NYSE: JNJ), Abbott Laboratories (NYSE: ABT), Edwards Lifesciences Corp (NYSE: EW) and Arch Chemicals Inc (NYSE; ARJ). From the 5443 patents granted to this group, the final sample of data used for analysis consisted of a random selection of 90 patents. As previously mentioned, the length of observation interval was set to one day so adjusted closing prices were used which account for dividends and stock splits. The return of the S&P 500's Spider exchange traded fund (SPY) served as the proxy for the overall market return. The adjusted closing prices of the stocks and the SPY prices were gathered from Yahoo! Finance's historical price search. The risk-free rate of return is considered to be the US Three Month Treasury Bill rates, and was gathered from the US Department of the Treasury's website[5]. Again, this study uses an event window of 14-days: eight pre-event days, the event day, and five post-event days. Thus, adjusted closing prices for individual stocks, the overall market and the risk-free rate of return were collected for this time period. Furthermore, in order to determine the impact that a patent has over a securities expected return, data for a further period of time preceding the event was collected, as will be described in the following sections.

---

[5] United States Department of the Treasury. "Daily Treasury Yield Curve Rates." Available from http://www.ustreas.gov/offices/domestic-finance/debt-management/interest-rate/yield_historical.shtml.

In calculating the overall impact of patents to stock prices, the sample of patents was divided into three different size groups according to the company's current market capitalization values. Large capitalization stocks are defined as companies with capitalization over approximately $10 billion, mid capitalization stocks as companies with capitalization between approximately $2 billion and $10 billion, and small capitalization stocks as companies with capitalization below $2 billion. The size of the companies accounts for the idea that patents may be more or less valuable to different sized companies (also see discussion on the size effect presented by Baytas and Cakici (1999) and Zarowin (1990) in Chapter 2). As is illuminated by Austin (1993), arguments can be made that patents are more valuable to small or large firms. A small size firm may derive more value from a patent simply because the return from the patent would be worth more relative to the size of the company. Conversely, Austin argues that patents may be worth more to larger firms because "...a larger firm may have greater resources to bring to bear in developing the patented product, say, or may have access to a larger market.[6]" Thus by looking at the three size groups by market capitalization this study tests whether more or less market value is associated with patents granted to different sized firms.

---

[6] Austin, David H. "An Event-Study Approach to Measuring Innovative Output: The Case of Biotechnology." *The American Economic Review* 83, no. 2, Papers and Proceedings of the Hundred and Fifth Annual Meeting of the American Economic Association (May 1993): 253-258.

Measuring the Impact of an Event

The use of an event study allows an examination of the informational content of a patent grant. In other words, the objective is to determine if the granting of patents provide information to the marketplace. If the granting of patents does in fact have informational value to the market then there should exist a correlation between the news that a company has been granted a patent and the market value of the related company. The company that is granted a patent should thus achieve higher returns (i.e. an abnormal return) than the return it would have otherwise been expected to have (i.e. its normal return). Thus the first step to determining the impact of receiving a patent, measured by the security's abnormal return, is to determine what can be considered the security's normal return.

The normal return of a security is defined as the expected return for the security if the event had not taken place. There are many existing approaches to measure the normal return of individual stocks which largely can be divided into two classifications: statistical models and economic models. Statistical models are based on statistical assumptions and are independent of arguments founded in economic theory. Economic models use statistical assumptions but also depend on assumptions relating to how investors act[7].

Models for Measuring the Normal Return of a Security

The two statistical models that are generally used to model a stock's normal return are the constant mean return model and the market model.

---

[7] A. Craig MacKinlay, "Event Studies in Economics and Finance," *Journal of Economic Literature* 35, no. 1 (Mar. 1997): 13-39.

Statistical Models

A. The Mean Adjusted Returns Model:

The mean adjusted returns model, also known as the constant mean return model, is a simple model that estimates the abnormal return of a stock as the difference between the return of the stock on the day of the event and the average of the stock's daily return during the estimation period. The model is based on the assumption that the mean return of a stock remains the same during the specified time period. While the constant mean return model is the most simple model, Brown and Weinstein (1985) find it often develops results similar to more sophisticated models.

The form of the mean adjusted returns model used in this study can be stated as:

$$AR_{it} = R_{it} - \bar{R}_{it}$$

where AR_{it} is the abnormal return from stock i at day t, $\bar{R}_{it}$ is the mean of the stock i's daily return, and R_{it} is the return from stock i at day t, all within the estimation period.

B. The Market Adjusted Returns Model:

The second model, the market adjusted returns model, is identical to the mean adjusted returns model except that it estimates the abnormal return of a stock as the difference between the return of the stock on the day of the event and the average of the market's, rather than the stock's, daily return during the estimation period. The model is primarily concerned with determining if the returns of the individual security are statistically different from the returns of the market during the same time frame[8]. The results of the model are consistent with the CAPM (discussed below) if all stocks share

[8] Ma, Shiguang. "The Efficiency of China's Stock Market." *The Chinese Economy Series,* Ashgate Publishing, Ltd. (2004): 87.

the same level of systematic risk[9]. This model is utilized by MacKinlay (1997) and Ma (2004) among others.

The form of the market adjusted returns model used in this study can be stated as:

$AR_{it} = R_{it} - R_{mt}$

where AR_{it} is the abnormal return from stock i at day t, R_{it} is the return from stock i at day t, and R_{mt} is mean of the overall market's return within the estimation period. The return of the stock market is considered the return of the S&P 500's Spider exchange traded fund (SPY).

C. The Market Model:

The most common model used to determine a firms normal return is the market model (see Sarkar and de Jong 2006; MacKinlay 1997). The market model posits a consistent linear relationship between the return of the market as a whole to that of a specific security during the event window. According to MacKinlay (1997) the market model can be an improvement over the mean and market adjusted returns models: "By removing the portion of the return that is related to variation in the market's return, the variance of the abnormal return in reduced. This can lead to increased ability to detect event effects."

The market model essentially calculates the abnormal return for a security for each date as the difference between the return of the security to the return of the overall

---

[9] Ma, Shiguang. "The Efficiency of China's Stock Market." *The Chinese Economy Series,* Ashgate Publishing, Ltd. (2004): 87.

market. The market model incorporates the systematic risk of the stock by utilizing beta, the measure of a stock's volatility compared to the market's during the estimation window. It is calculated as a value that illustrates the amount a stock will change on average in relation to changes in the market as a whole. Specifically, the beta is 1.0 for stocks that move in tandem to the overall market. A beta of greater than 1.0 indicates that the stocks price will have a greater level of volatility than the market, and vice versa. For example, if a stock has a beta of 2.0 it implies that theoretically the stock experiences twice the amount of change the overall market does. The return of the stock market is once again considered the return of the S&P 500's Spider exchange traded fund (SPY). Alpha ($\acute{\alpha}_1$) is the average predicted abnormal return. It was calculated as the difference between the average return of the individual security during the estimation window to the average return of the market during the same time multiplied by the stock's beta. In order to determine β the following equation was used:

$$\beta_i = \frac{\sum_{T0}^{T1} (R_{it} - \mu_i)(R_{mt} - \mu_m)}{\sum_{T0}^{T1} (R_{mt} - \mu_m)^2}$$

And $\acute{\alpha}_1$ was calculated as:

$$\acute{\alpha}_1 = \mu_i - \beta(\mu_m), \quad \text{where} \quad \mu_i = \frac{1}{L}\sum R_{it}$$

$$\text{and} \qquad \mu_m = \frac{1}{L}\sum R_{mt}$$

R_{it} and R_{mt} are the return in the event period for security i and the market, respectively. The form of this model used in this thesis can be stated as:

$$AR_{it} = R_{it} - \acute{\alpha}_1 - \beta_t R_{mt}$$

where AR_{it} is the abnormal return from stock i at day t, R_{it} is the return from stock i at day t and R_{mt} is the return on the SPY on day t.

An Economic Model

D. The Capital Asset Pricing Model (CAPM):

The most common *economic* model that is used to model a stock's normal return is based on the Capital Asset Pricing Model (CAPM). The CAPM is based on the fact that expected return should be positively correlated with the related risk, and is used to develop a theoretically correct required rate of return for an asset. The model attempts to determine the impact of events by considering the related risk free rate of return, the return of the overall stock market, and the systematic risk associated with the stock. Excluding the systematic risk variable, each of these independent variables should be positively correlated with the expected return of the stock. As the risk free rate of return and the return of the overall stock market increase, the expected return of a given stock should also increase because investments as a whole become more attractive. However, as the risk associated with a given stock increases and the investment becomes less attractive, the expected return should decrease[10]. If investments that were more risky were not expected to achieve higher returns than there would be no incentive to invest in them.

Like the market model, the CAPM incorporates risk by utilizing beta, the measure of a stock's volatility compared to the market's during the estimation window. The model

[10] Gitman and Joehnik, "Fundamentals of Investing," 178.

incorporates the time value of money through the theoretical risk-free rate. Together the model states the expected return of a security should be equivalent to the risk-free rate plus a risk premium. The basic formula for the CAPM is:

$$r_a^e = r_f + \beta_a (r_m^e - r_f)$$

where r_a is the expected return of the security, r_f is the risk free return, β_a the beta of the security, and r_m^e equals the expected return for the market. In this study the abnormal return was calculated as the difference between the actual realized return and the expected return of the security as calculated in the above formula.

Determining the Overall Impact of Patents: Cumulative Abnormal Returns

This study uses cumulative abnormal returns (CARs) to determine the overall impact of the granting of a patent to a company's market value. Cumulative abnormal returns are the aggregation of abnormal returns across all securities over the course of the event window as described by the following equation:

$$CAR_n = \sum_{t=0}^{n} AR_t$$

where CAR_n represents the cumulative abnormal return as of day t. AR_t is the average abnormal return for event day t. This study examined two sets of CARs, from day 0 to day 3 as well as from day 0 to day 5. The CAR of a model is crucial in the analysis of whether an event has a significant impact on the value of a security. The null hypothesis being tested is CAR = 0. If the null hypothesis is found to hold (CAR = 0) with significant t-statistics, it would imply that the information given by the patent grant had

no impact on a security's market value. Conversely, if there are significant t-statistics for a result with CAR $\neq$ 0, it would imply that the security's market value reacts either positively or negatively to the granting of a patent.

CHAPTER IV

RESULTS AND CONCLUSIONS

The sample of 90 patent grants gathered from the initial pool of 5443 patents were analyzed using the four models described in the previous chapter. The four models are the market model, the mean adjusted returns model, the market adjusted returns model and the capital asset pricing model (CAPM). While the market model and the CAPM are more commonly utilized in event studies in finance and economics, the mean adjusted returns model and the market adjusted returns model were included to provide a more comprehensive look at the impact of patents being granted.

Results of the Study

Each of the models estimates a normal return before the patent event and an abnormal return during the event window. This enables the average abnormal returns of each day to be calculated. Again, each model was calculated for the entire sample of patents as well as for three different size groups (small-cap, mid-cap, and large-cap) according to the company's current market capitalization values.

Abnormal Returns

To determine whether the average abnormal returns were statistically significant from zero, meaning that there was a noticeable change in the pricing of the security on a given day, t-statistics were calculated for each day's average abnormal return. The

results for the entire sample population, small-cap, mid-cap, and large-cap companies are presented in tables and graphs on the following pages.

TABLE 4.1

Average Percentage Abnormal Returns and T-Statistics for the Entire Sample

Entire Sample								
Market Model			**Mean Adjusted**		**Market Adjusted**		**CAPM**	
Day	Avg. AR	T-Stat	Avg. AR	T-Stat	Avg. AR	T-Stat	Avg. AR	T-Stat
-8	-0.017%	-0.005	0.055%	0.021	0.251%	0.083	0.583%	0.382
-7	0.798%	0.071	0.423%	0.136	-0.326%	-0.101	0.433%	0.253
-6	0.129%	0.035	0.220%	0.063	0.468%	0.139	0.760%	0.483
-5	0.138%	0.051	0.065%	0.031	0.097%	0.039	0.448%	0.258
-4	0.537%	0.176	0.042%	0.008	0.792%	0.224	0.752%	0.464
-3	0.209%	0.061	-0.919%	-0.253	0.570%	0.203	0.637%	0.368
-2	-0.006%	-0.003	0.479%	0.167	-0.293%	-0.101	0.746%	0.393
-1	-0.105%	-0.024	0.168%	0.058	-0.088%	-0.031	0.477%	0.224
0	-0.333%	-0.083	-0.172%	-0.063	-0.136%	-0.065	0.501%	0.301
1	0.255%	0.088	0.280%	0.067	0.452%	0.160	0.639%	0.314
2	0.021%	0.008	-0.328%	-0.125	0.034%	0.013	0.425%	0.241
3	0.018%	0.006	-0.016%	-0.005	0.453%	0.102	0.617%	0.362
4	-0.109%	-0.029	0.096%	0.037	-0.504%	-0.144	0.631%	0.371
5	0.712%	0.104	0.359%	0.115	-0.111%	-0.038	-0.314%	-0.036

FIGURE 4.1

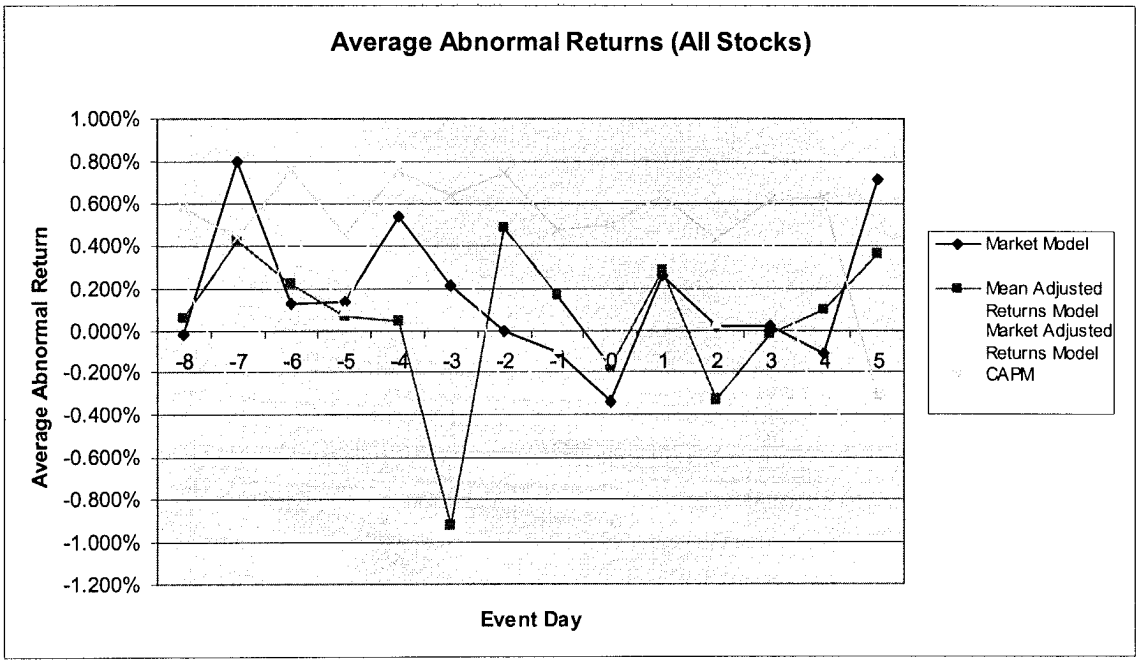


TABLE 4.2

Average Percentage Abnormal Returns and T-Statistics for the Small Cap Firms

Small Cap Sample*								
Market Model			**Mean Adjusted**		**Market Adjusted**		**CAPM**	
Day	Avg. AR	T-Stat	Avg. AR	T-Stat	Avg. AR	T-Stat	Avg. AR	T-Stat
-8	-0.679%	-0.209	-0.144%	-0.055	0.053%	0.061	0.557%	0.287
-7	-0.773%	-0.301	0.115%	0.039	-0.255%	-0.067	0.238%	0.115
-6	0.347%	0.121	0.430%	0.152	1.608%	0.351	0.746%	0.367
-5	-0.391%	-0.141	-0.295%	-0.139	0.108%	0.038	0.235%	0.099
-4	0.740%	0.265	-1.494%	-0.470	1.710%	0.349	0.449%	0.211
-3	-0.306%	-0.120	-1.076%	-0.281	0.441%	0.112	0.141%	0.060
-2	0.206%	0.070	0.321%	0.122	-0.662%	-0.204	0.309%	0.108
-1	0.536%	0.078	0.035%	0.015	-0.278%	-0.076	-0.077%	-0.025
0	-1.825%	-0.414	-0.391%	-0.146	-0.363%	-0.129	0.337%	0.163
1	-0.172%	-0.065	0.691%	0.170	0.738%	0.187	-0.011%	-0.004
2	0.098%	0.037	0.243%	0.092	0.324%	0.096	-0.080%	-0.032
3	-0.500%	-0.101	1.331%	0.392	1.484%	0.193	0.492%	0.234
4	-0.429%	-0.097	0.762%	0.218	-1.323%	-0.219	0.582%	0.258
5	0.019%	0.005	0.109%	0.038	-0.239%	-0.054	-2.628%	-0.163

* Small Cap refers to stocks with a current market capitalization of less than $2 billion.

FIGURE 4.2

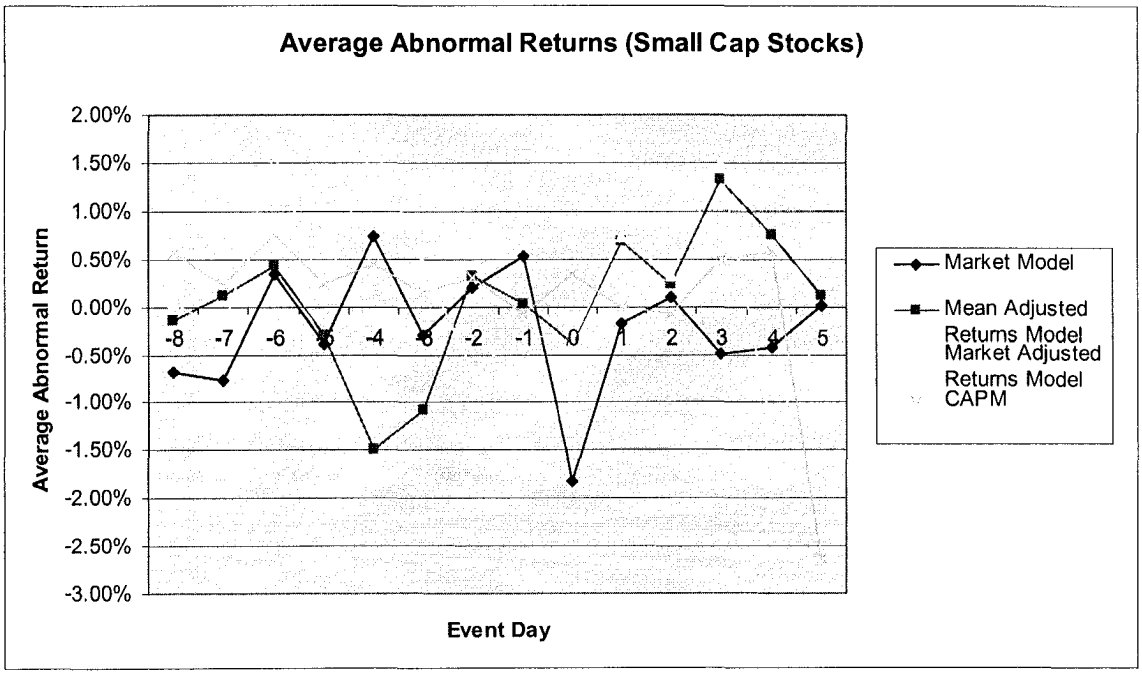


TABLE 4.3

Average Percentage Abnormal Returns and T-Statistics for the Mid Cap Firms

Mid Cap Sample**								
Market Model			**Mean Adjusted**		**Market Adjusted**		**CAPM**	
Day	Avg. AR	T-Stat	Avg. AR	T-Stat	Avg. AR	T-Stat	Avg. AR	T-Stat
-8	-0.928%	-0.257	1.113%	0.428	-0.068%	-0.022	0.427%	0.280
-7	-0.529%	-0.047	0.669%	0.215	-1.051%	-0.325	0.545%	0.319
-6	1.518%	0.412	2.627%	0.755	0.532%	0.158	0.493%	0.313
-5	1.369%	0.503	0.340%	0.164	0.872%	0.347	0.447%	0.257
-4	1.853%	0.609	-1.362%	-0.270	0.427%	0.121	0.983%	0.607
-3	-0.020%	-0.006	-0.288%	-0.079	0.307%	0.110	0.863%	0.498
-2	0.351%	0.163	1.937%	0.676	0.148%	0.051	0.609%	0.321
-1	-0.677%	-0.315	0.657%	0.229	-1.277%	-0.441	0.498%	0.262
0	-0.047%	-0.012	-0.020%	-0.007	-0.233%	-0.111	-0.144%	-0.086
1	0.317%	0.109	3.166%	0.757	-0.162%	-0.057	0.944%	0.465
2	-0.421%	-0.158	0.691%	0.264	0.584%	0.225	0.811%	0.460
3	-0.335%	-0.104	-1.248%	-0.343	-0.270%	-0.061	0.278%	0.163
4	-0.400%	-0.106	-0.349%	-0.134	-0.719%	-0.205	0.242%	0.142
5	3.479%	0.804	1.457%	0.467	1.174%	0.400	-0.813%	-0.094

** Mid Cap refers to stocks with a current market capitalization between $2 billion - $10 billion.

FIGURE 4.3

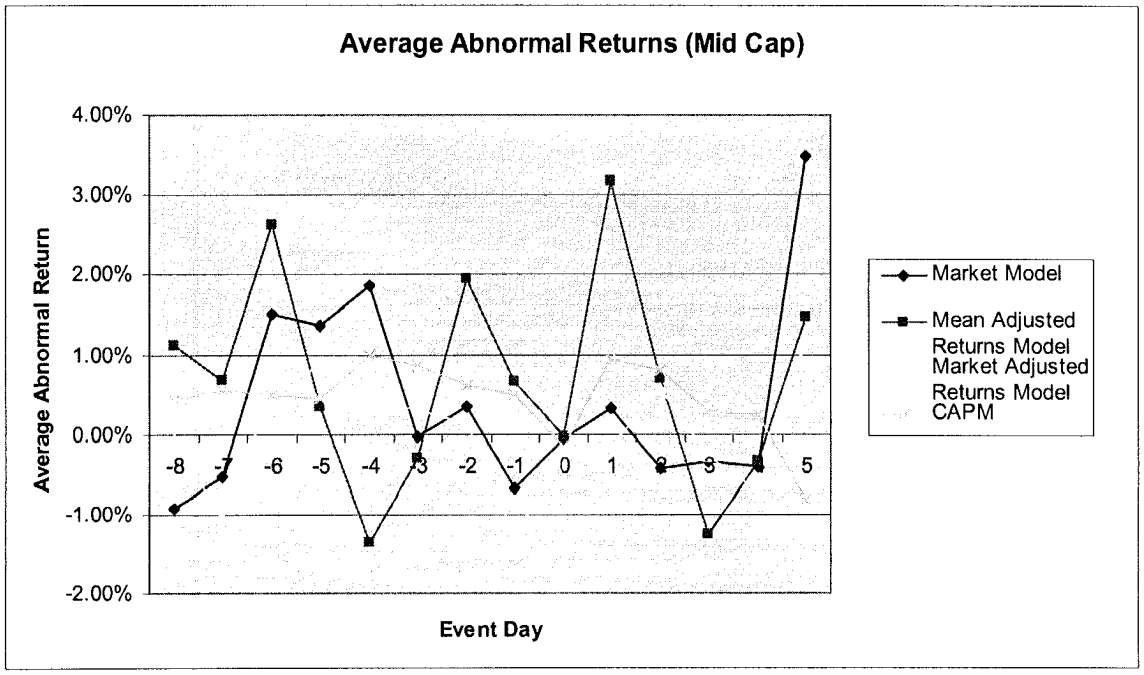


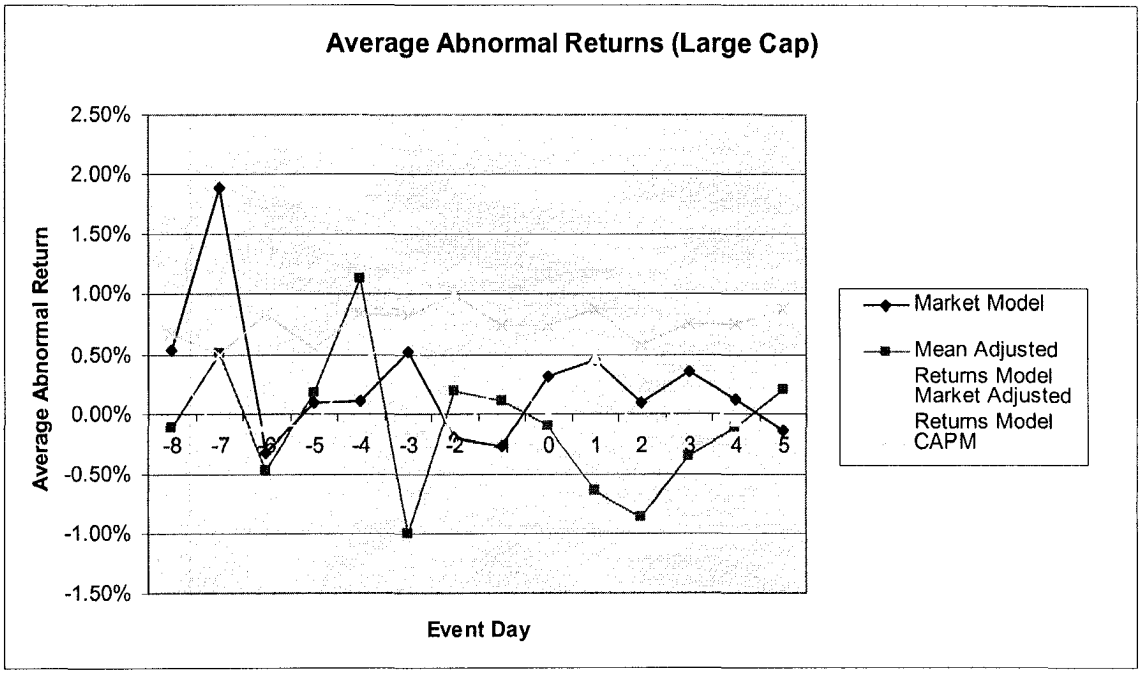
TABLE 4.4

Average Percentage Abnormal Returns and T-Statistics for the Large Cap Firms

Large Cap Sample***								
Market Model			**Mean Adjusted**		**Market Adjusted**		**CAPM**	
Day	Avg. AR	T-Stat	Avg. AR	T-Stat	Avg. AR	T-Stat	Avg. AR	T-Stat
-8	0.529%	0.150	-0.113%	-0.051	0.426%	0.186	0.670%	0.482
-7	1.885%	0.130	0.509%	0.162	-0.179%	-0.070	0.499%	0.313
-6	-0.323%	-0.098	-0.482%	-0.146	-0.096%	-0.038	0.834%	0.629
-5	0.085%	0.034	0.169%	0.083	-0.101%	-0.050	0.551%	0.372
-4	0.110%	0.036	1.132%	0.199	0.441%	0.153	0.841%	0.611
-3	0.515%	0.143	-1.001%	-0.299	0.698%	0.385	0.819%	0.559
-2	-0.197%	-0.113	0.191%	0.070	-0.227%	-0.076	0.991%	0.749
-1	-0.271%	-0.089	0.110%	0.037	0.301%	0.154	0.739%	0.447
0	0.313%	0.080	-0.104%	-0.039	-0.003%	-0.002	0.741%	0.524
1	0.445%	0.148	-0.640%	-0.178	0.468%	0.238	0.875%	0.619
2	0.095%	0.033	-0.858%	-0.330	-0.243%	-0.129	0.572%	0.405
3	0.355%	0.162	-0.357%	-0.099	0.138%	0.062	0.762%	0.508
4	0.118%	0.032	-0.112%	-0.052	-0.057%	-0.034	0.751%	0.505
5	-0.147%	-0.076	0.205%	0.066	-0.315%	-0.162	0.876%	0.593

*** Large Cap refers to stocks with a current market capitalization between $2 billion - $10 billion.

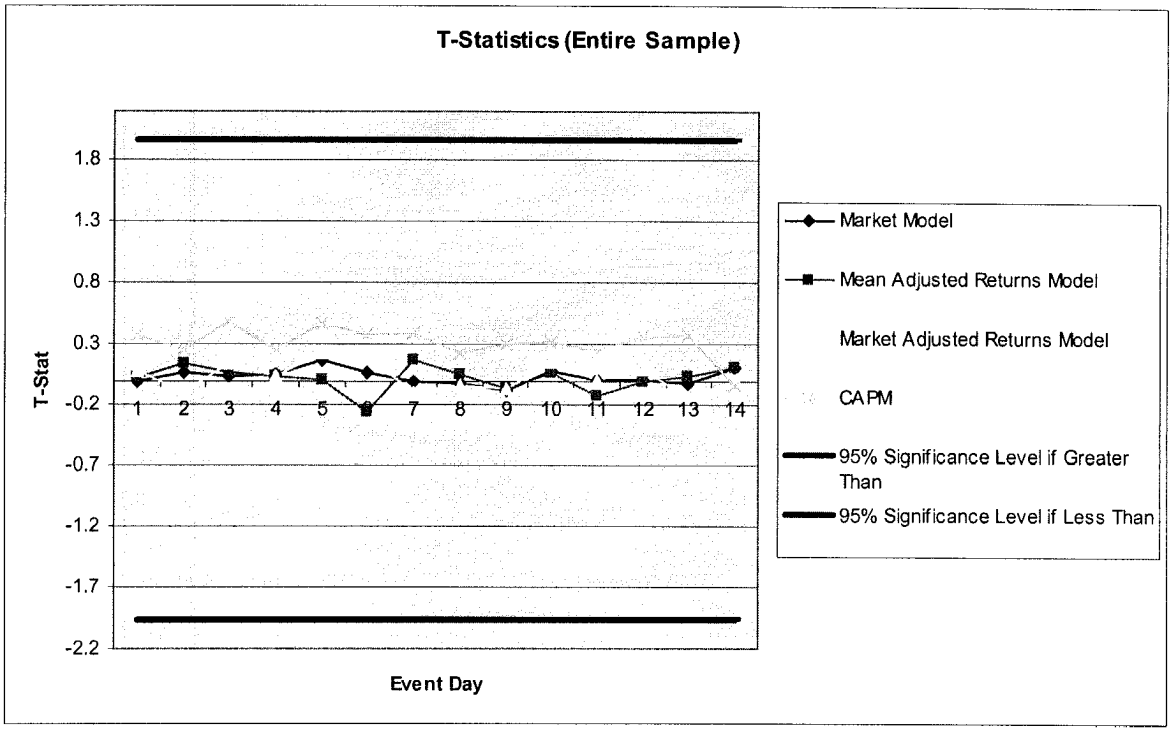
FIGURE 4.4



The previous graphs illustrate that patent grants do not have a clear influence on the market value of firms. It is evident that the size of the abnormal returns is small and varied across the event window and between the four models used in this study. More specifically, there is no clear pattern that arises in the returns of firms due to the granting of a patent chosen at random. In this study a two-tailed t-test was used to determine if results were significant. While there is varying strengths of significance and different values of t-statistics that are used to determine significance in studies, a common measure is the 95 percent confidence level. If a value's (in this case an abnormal return's) t-statistic is greater in absolute value than 1.96, it is said that there is a 95 percent confidence that that the value is statistically significantly different from zero. In this study a significant t-statistic would imply that the abnormal return that is obtained on a given day is statistically significant and thus that the granting of patents does have an impact on a firm's stock price. However, as presented in the previous tables, no t-statistics were found to be significant at any considerable level whatsoever. The t-statistics are similar when firms are divided into different size groups.

In following graph the t-statistics of the four models are shown across the event window along with two lines that depict the point at which these t-statistics would be considered significant at the 95 percent level. The below graph makes it clear that none of the abnormal returns found in this study should be considered significant. The results would look similar if they were constructed for the sample categorized into the three size groups (see Tables 4.2 – 4.4).

FIGURE 4.5



Cumulative Abnormal Returns

All of the abnormal return and t-statistic values presented above are for single event days within the event window. As previously mentioned, this study also uses cumulative abnormal returns (CARs) to determine the overall impact of the granting of a patent to a company's market value. Cumulative abnormal returns are a summation of the abnormal returns of individual days, across all securities, over the course of the event window. This study examined two sets of CARs, from day 0 to day 3 as well as from day 0 to day 5. The results for both the day 0 to day 3 and the day 0 to day 5 CARs are presented below.

TABLE 4.5

Cumulative Abnormal Returns and T-Stats of Each Model for the Entire Sample

Market Model

CUM. ABNORMAL RETURNS
(Day 0 – Day 3)

Average CAR (0 – 3) =	-0.035%
Sum of Var (0 – 3)=	0.0888
Std Dev.=	0.0008
CAR =	**-0.0384%**
T-Stat=	**-0.00035**

CUM. ABNORMAL RETURNS
(Day 0 – Day 5)

Average CAR (0 – 5) =	0.0058%
Sum of Var (0 – 5)=	0.1452
Std Dev.=	0.0011
CAR =	**0.5650%**
T-Stat =	**0.00575**

Mean Adjusted Returns Model

CUM. ABNORMAL RETURNS
(Day 0 – Day 3)

Average CAR (0 – 3) =	-0.307%
Sum of Var (0 – 3)=	0.1030
Std Dev.=	0.0009
CAR =	**-0.2370%**
T-Stat=	**-0.00307**

CUM. ABNORMAL RETURNS
(Day 0 – Day 5)

Average CAR (0 – 5) =	0.0018%
Sum of Var (0 – 5)=	0.0910
Std Dev.=	0.0008
CAR =	**0.2184%**
T-Stat =	**0.00177**

Market Adjusted Returns Model

CUM. ABNORMAL RETURNS
(Day 0 – Day 3)

Average CAR (0 – 3) =	0.824%
Sum of Var (0 – 3)=	0.0803
Std Dev. =	0.0008
CAR =	**0.8030%**
T-Stat=	**0.00824**

CUM. ABNORMAL RETURNS
(Day 0 – Day 5)

Average CAR (0 – 5) =	0.243%
Sum of Var (0 – 5)=	0.0930
Std Dev.=	0.0008
CAR =	**0.1880%**
T-Stat =	**0.00243**

CAPM

CUM. ABNORMAL RETURNS
(Day 0 – Day 3)

Average CAR (0 – 3) =	2.134%
Sum of Var (0 – 3)=	0.0102
Std Dev.=	0.0003
CAR =	**2.1820%**
T-Stat=	**0.02134**

CUM. ABNORMAL RETURNS
(Day 0 – Day 5)

Average CAR (0 – 5) =	2.496%
Sum of Var (0 – 5)=	0.1157
Std Dev.=	0.0009
CAR =	**2.4984%**
T-Stat =	**0.02496**

The primary results of the table on the previous page are the cumulative abnormal returns (CARs) for each model. If the results indicated that there were no statistically significant abnormal returns for an event day, but nonetheless showed significance over a short period of time following the event, than the granting of patents would be considered to impact stock prices. However, similar to the results of the abnormal returns, the CARs illustrate that there is no clear impact of patents on stock prices. As depicted in table 4.5, the CARs were found to be statistically insignificant. For example, a CAR of –0.0384% with a t-statistic of –0.00035 (see market model, day 0 to day 3) means that during the three days following the granting of a patent, the aggregation of the abnormal returns is equivalent to –0.0384%, a value not statistically significantly different from zero. The results found for the CAR are the most fundamental findings of this study. The null hypothesis being tested is CAR = 0. Since the null hypothesis was found to hold it suggests that the information that the granting of a patent provides to the market has no impact on a security's market value.

Implications

The results of this study provide evidence that contradicts studies such as Bloom and Van Reenen (2002) which noted that "...patents have an immediate impact upon market values." While this study uses similar methodology and the same models as studies like Bloom and Van Reenen's, the outcome of this study differs. The reason for the conflicting results is not clear. They may arise because this study looks at only the chemical industry which may be impacted by patent grants differently than the industries

examined in other literature. No matter the reason, the results of this study have a few key implications.

The purpose of this study was to address the general reaction of a firm's stock price to a patent grant and to look at the implications such reactions may have on the Efficient Market Hypothesis (EMH). The connection between this study and the EMH is grounded in the assumption that patents have value which thus should be depicted in the market value of a firm. The EMH asserts that markets have so many investors who are competing rationally and making timely decisions regarding relevant events that the prices of securities change in an almost instantaneous fashion. If the results of the study would have depicted a large increase following the granting of the patent without exhibiting a contraction afterwards, this would imply that information was being incorporated into the markets efficiently, and without overreaction. Such a result would have provided clear support of the EMH. Conversely, if the results of the study indicated that stock prices did increase but such increases were later reversed, it would provide support for the Overreaction Hypothesis as presented throughout this study.

However, failing to arrive at the results described above and thus failing to provide strong support for or against the EMH does not diminish the findings of this study. Each of the scenarios described above rests in the assumption that an average patent has enough value to a firm as to affect the firm's market value when granted. Even if the market does not significantly react to the granting of patents as was found in this study, the markets can be functioning in line with the EMH. Surely there are many events that take place everyday that could potentially impact the future value of a firm that are not incorporated into a firm's stock price. Returning to the idea established by

Austin (1993) in the previous chapter, it very well may be the case that some patents are extremely valuable to firms and others are worth almost nothing. The extent to which patents will be productive in the future is not certain. As Pastor and Veronesi (2005) note, "new technologies are characterized by high uncertainty about their average future productivity." Similarly, in a 2002 study by Bloom and Van Reenen which looked at the value of patents to companies, the authors speak to the problems associated with valuing patents because of the time it takes to affect productivity.

> "One potential explanation [for the time required to effect productivity] is that the new products and processes which are covered by the patents have to be embodied in new capital equipment and training. Firms may also need to undertake further research and development, as well as expensive marketing and advertising to promote their new products.[1]"

This uncertainty could make a randomly selected patent be worth very little, as was found in this study. Thus, rather than the markets not functioning efficiently, they could simply not be reacting because they do not see enough value in such patents. It also may be the case that it takes a longer period of time than was examined in this study to determine the value of patents to firms. Perhaps it is the case that the value of a patent is incorporated into the value of a firm at time further into the future than studied here. Unfortunately, as was introduced in the first chapter, a major drawback of event studies comes from the fact that events can be difficult to isolate unless they have a defined period of occurrence, such as the announcement of earnings. These and other limitations are discussed in the following section.

---

[1] Nicholas Bloom and John Van Reenen, "Patents, Real Options and Firm Performance," *The Economic Journal* 112, no. 478, Conference Papers (Mar. 2002): C97-C116.

Limitations and Direction of Future Research

There are a few key limitations of event studies such as this one. Perhaps the foremost limitation of using an event study to explain movements in capital markets comes from the difficulties associated with determining the value of an event to a company and the actual changes in cash flow that may result.[2] Moreover, as Chaney, Devinney, and Winer (1991) note, there are a few other key limitations to event studies. To begin, it is evident that stock prices do not follow a smooth trend line but rather are traded at prices that have "noise." This means that events such as the granting of a patent must provide enough information to the market to initiate a reaction that is large enough to be seen through this noise. Another limitation of event studies is that events, at times, occur near each other. In this study for instance, it is apparent that some highly inventive companies such as Johnson and Johnson (NYSE: JNJ) receive patents on a regular basis. It can thus be difficult to distinguish an abnormal return that arises from the granting of a particular patent from the company's normal return.

Also, Chaney, Devinney and Winer speak to problems associated with the lack of true dates for specific events. The extent to which this poses a problem to this study is not clear. Some argue that analyzing patents in event studies is highly effective because the granting of patents occur at defined times and until this time the result of the patent is largely unknown to the marketplace. For instance Austin (1993) notes that, "while patent grants may be partially anticipated by the market (which would dampen the effects an event study could record), anecdotal evidence suggests that their actual timing is a surprise. Therefore, this permits the use of a very short event window [when utilizing an event study]." Conversely, Marco (2005) argues that information often leaks into the

[2] Gitman and Joehnik, "Fundamentals of Investing," 178.

marketplace and that "the announcement effect of a patent application or patent grant cannot be readily interpreted as representing the full value of the patent because announcement effects only reflect changes in value with respect to news about the patent. It is more likely [he argues] that news about noteworthy patents may be known ahead of time."

There are also further limitations of this study in particular. While this study was guided by previous studies, future studies could look at both shortened and lengthened windows to see if results were significantly different. Furthermore, this study is limited to a sample of firms within the chemical industries. While the sample size should be sufficient to determine a general trend, future studies could look across different industries to once again see if results varied. Moreover, although beyond the scope of this study, previous studies have attempted to distinguish between patents that are granted. For instance, as mentioned previously Austin (1993) differentiated between patents that were more readily identifiable and found that patents which are announced in the press are highly valued in the eyes of the stock market. Future research could further test the value of patents by dividing them into other characteristics known to the market. However, if such categorizations were utilized for a study similar to this one it would be crucial to use characteristics that can be easily identified by the market at the time a patent is granted, such as press announcements, rather than a measure that is not known until the future, such as patent citations (see discussion in Chapter 2).

Summary and Concluding Remarks

This study has illustrated the connection between firm value and innovation. More specifically, this paper has addressed the general reaction a firm's stock price has when it receives a patent and has looked at the implications such reactions have on the EMH. This paper has moreover introduced the underlying theory and relevant literature to develop the foundation needed to assess these connections. The literature that examines the EMH is unmistakably extensive. Nonetheless, literature that looks at it in relation to patent grants is quite limited. Previous studies have looked at the influence that patents and innovations have on the profits of companies, the performance of innovative versus non-innovative companies, the market's reaction to product announcements as well as the private value of patents to specific companies and to their rivals for patents that are readily identifiable. This study has looked at a sample of 90 patents from 5443 patents that were granted during a five year period (1999-2004) to chemical companies. Through the use of four statistical models which attempt to control for what the price of each security would be if a patent was not granted, the results of this study are able to assess the general reaction of the stock market to the granting of patents to chemical companies.

The primary conclusion of this study is that the stock prices of chemical companies do not react to the granting of a randomly selected patent. This finding thus enriches the current literature relating to market value and innovation. In each of the models across each size group this study found no significant abnormal returns in the event window. The results of this study are likely aligned with the view that when a patent is granted its value is difficult to determine; while some patents undoubtedly have great economic value others are worth very little. The implications of this study for the EMH are unclear.

While it does not provide strong support for the efficiencies of the market, the results can still be aligned with the EMH because of the difficulties associated with determining the value of patents. Perhaps the results of this study demonstrate an instance of efficient markets because the markets are not reacting to an asset that may prove to be worth very little. As mentioned, this study has a few limitations. However, such limitations should not discredit this highly used method of studying the effect of events on the capital markets. Future research will be able to use the principles this study has developed to further the understanding of the connection between patents and market prices.

SOURCES CONSULTED

Empirical Studies

Ariel, Robert A. "High Stock Returns before Holidays: Existence and Evidence on Possible Causes." *Jounal of Finance* December, 45, no. 5 (1990): 1611-626.

Arrow, K. J. "Risk Perception in Psychology and Economics." *Economic Inquiry* 20 (1982): 1-9.

Atkins, B., and E. A. Dyl. "Price Reversals, Bid-Ask Spreads, and Market Efficiency." *Jornal of Financial and Quantitative Analysis* 25 (1990): 536-547.

Austin, David H. "An Event-Study Approach to Measuring Innovative Output: The Case of Biotechnology." *The American Economic Review* 83, no. 2, Papers and Proceedings of the Hundred and Fifth Annual Meeting of the American Economic Association (May 1993): 253-258.

Basu, Sanjoy. "The Relationship between Earnings' Yield, Market Value and the Returns for NYSE Common Stocks: Further Evidence." *Journal of Financial Economics* 12, no. 1 (1983): 129-56.

Baytas, A., and N. Cakici. "Do Markets Overreact: International Evidence." *Journal of Banking and Finance* 23 (1999): 1121-1144.

Benou, Georgina, and Nivine Richie. "The Reversal of Large Stock Price Declines: The Case of Large Firms." *Journal of Economics & Finance* 27, no. 1 (Spring 2003): 19.

Bloom, Nicholas, and John Van Reenen. "Patents, Real Options and Firm Performance." *The Economic Journal* 112, no. 478, Conference Papers (Mar. 2002): C97-C116.

Boyle, Geln, and Brett Walter. "Reflected Glory and Failure: International Sporting Success and the Stock Market." *Applied Financial Economics* (2003): 225.

Brown, Stephen, and Mark Weinstein. "Derived Factors in Event Studies." *Financial Economics* 14, no. 3 (1985): 491-95.

Campbell, John Y., and Robert J. Shiller. "Valuation Ratios and the Long-Run Stock Market Outlook." *Journal of Portfolio Management* 24, no. 2 (Winter 1998): 11-26.

"Stock Prices, Earnings, and Expected Dividends." *Journal of Finance* 43, no. 3 (07 1988): 661.

Chan, L. K. C., J. Lakonishok, and T. Sougiannis. "The Stock Market Valuation of Research and Development Expenditures." *Journal of Finance* 56, no. 6 (2001): 2431-2456.

Chaney, Paul K., and Timothy M. Devinney. "New Product Innovations and Stock Price Performance." *Journal of Business Finance & Accounting* 19, no. 5 (1992): 677.

Chaney, Paul K., Timothy M. Devinney, and Russell S. Winer. "The Impact of New Product Introductions on the Market Value of Firms." *The Journal of Business* 64, no. 4 (1991): 573-610.

Chen, Chen R., and David A. Sauer. "Is the Stock Market Overreaction Persistent Over Time?" *Journal of Business Finance and Financial Accounting* (1997): 27.

Coad, Alex, and Rekha Rao. "As Luck would have it: Innovation and Market Value in Complex Technology Sectors." *Centre d'Economie De La Sorbonne* (2006): 2-9.

Coleman, Nancy. "Wealth Flows to the Wealthiest as the Percentage of Americans Who Own Stock Falls." *Economic Policy Institute* (2006).

Conrad, Jennifer, Mustafa N. Gultekin, and Gautam Kaul. "
Profitability of Short Term Contrarian Strategies: Implications for Market Efficiency." *Journal of Business & Economic Statistics* 15, no. 3 (1997): 379.

Conrad, Jennifer, and Gautam Kaul. "Long-Term Market Overreaction Or Biases in Computed Returns." *The Journal of Finance* (1993): 39.

Cootner, Paul. "The Random Character of Stock Market Prices." (1964).

Cox, D., and D. R. Peterson. "Stock Returns Following Large One-Day Declines: Evidence on Short-Term Reversals and Longer-Term Performance." *Journal of Finance* 49 (1994): 225-267.

Daniel, Kent, David Hirshleifer, and Avanidhar Subrahmanyam. "Investor Psychology and Security Market Under- and Overreactions." *Journal of Finance* 53, no. 6 (12 1998): 1839.

Davidson III, Wallace N., and Dipa Dutia. "A Note on the Behavior of Security Returns: A Test of Stock Market Overreaction and Efficiency." *Journal of Financial Research* 12, no. 3 (Fall 1989): 245-252.

Davis, Julie L., and Suzanne S. Harrison. *Edison in the Boardroom: How Leading Companies Realize Value from their Intellectual Assets* (2001): 2.

DeBondt, Werner F. M., and Richard Thaler. "Does the Stock Market Overreact?" *The Journal of Finance* 40, no. 3 (1985): 793.

DeLaney, William J. "Stock Market Reaction to Product Announcements and its Implications Toward Market Efficiency." *Unpublished Paper, Colorado College* (2007): 30-38.

Desai, Hemang, and Prem C. Jain. "Long-Run Common Stock Returns Following Stock Splits and Reverse Splits." *Journal of Business* 70, no. 3 (07 1997): 409.

Dissanaike, Gishan. "Do Stock Market Investors Overreact?" *Journal of Business Finance & Accounting* 24, no. 1 (1997): 27.

Fama, Eugene. "Random Walks in Stock Market Prices." *Financial Analysts Journal* (Sept 1965).

Fama, Eugene F. "Market Efficiency, Long-Term Returns, and Behavioral Finance." *Journal of Financial Economics* 49, no. 3 (09 1998): 283-306.

"Efficient Capital Markets: II." *The Journal of Finance* 46, no. 5 (Dec. 1991): 1575-1617.

Fama, Eugene F., Lawrence Fisher, Michael C. Jensen, and Richard Roll. "The Adjustment of Stock Prices to New Information." *International Economic Review* 10, no. 1 (Feb. 1969): 1-21.

Fama, Eugene, and Kenneth French. "Common Risk Factors in the Returns on Stocks and Bonds." *Journal of Finance* 33, no. 1 (1993): 3-56.

Farmer, J. Doyne, and Andrew Lo. "Frontiers of Finance: Evolution and Efficient Markets." *Proceedings of the National Academy of Sciences* 96, no. http://www.econ.iastate.edu/tesfatsi/farmer99.pdf (1999): 1-7.

Findlay, M. C., and E. E. Williams. "A Fresh Look at the Efficient Market Hypothesis: How the Intellectual History of Finance Encouraged a Real 'Fraud-on-the-Market'." *Journal of Post Keynesian Economics* (2000): 189.

Fluck, Zsuzsanna, Burton Malkiel, and Richard Quandt. "The Predictability of Stock Returns: A Cross-Sectional Simulation." *Review of Economics and Statistics* 79, no. 2 (1997): 176-83.

Forbes, William. "Picking Winners? A Survey of the Mean Reversion and Overreaction of Stock Prices Literature." *Journal of Economic Surveys* 10 issue 2, no. 2 (1996): 123.

French, Kenneth. "Stock Returns and the Weekend Effect." *Journal of Financial Economics* March, no. 8 (: 55-69.

Fromlet, Hubert. "Behavioral Finance-Theory and Practical Application." *Business Economics* 36, no. 3 (07 2001): 63.

Georgina, Benou, and Nivine Richie. "The Reversal of Large Stock Price Declines: The Case of Large Firms." *Journal of Economics and Finance* (2003): 19.

Greenspan, Alan. "Monetary Policy Report to the Congress." *Before the Committee on Banking, Housing, and Urban Affairs* (Feb. 13, 2001).

Grilches, Zvi. "Patent Statistics as Economic Indicators: A Survey." *Journal of Economic Literature* XXVIII (1990): 1661-1701.

Grilches, Zvi, Ariel Pakes, and Bronwyn Hall. "The Value of Patents as Indicators of Inventive Activity." *NBER Working Series Paper*, no. 2083 (1986): 2-21.

Hall, Bronwyn H. "Innovation and Market Value." *NBER: Prepared for the NIESR conference on Productivity and Competitiveness*, (1998): 2-20.

Hall, Bronwyn H., Adam Jaffe, and Manuel Trajtenberg. "Market Value and Patent Citations." *RAND Journal of Economics* 36, no. 1 (Spring 2005): 16-38.

Hendricks, Kevin B., and Vinod R. Singhal. "Quality Awards and the Market Value of the Firm: An Empirical Investigation." *Institute for Operations Research and the Management Science* 42, no. 3 (1996).

Hirschey, Mark. "Extreme Return Reversal in the Stock Market." *Journal of Portfolio Management* (2003): 78.

Jarrell, G., K. Lehn, and W. Marr. "Institutional Ownership, Tender Offers and Long-Term Investments." *The Office of the Chief Economist, Securities and Exchange Commission* (1985).

Lakonishok, Josef, and S. Smidt. "Are Seasonal Anomalies Real? A Ninety-Year Perspective." *Review of Financial Studies* Winter, 1, no. 4 (: 403-25.

Lehmann, B. "Fads, Martingales, and Market Efficiency." *Quarterly Journal of Economics* 105 (1990): 1-28.

Lesmond, David A., Michael J. Schill, and Chunsheng Zhou. "The Illusory Nature of Momentum Profits." *Journal of Financial Economics* 71, no. 2 (02 2004): 349.

Lo, Andrew W., and A. Craig MacKinlay. "A Non-Random Walk Down Wall Street." (1999).

Lo, Andrew, Harry Mamaysky, and Jiang Wang. "Foundations of Technical Analysis: Computational Algorithms, Statistical Inference, and Empirical Implementation." *The Journal of Finance* LV, no. 4 (2000).

MacKinlay, A. Craig. "Event Studies in Economics and Finance." *Journal of Economic Literature* 35, no. 1 (Mar. 1997): 13-39.

Malkiel, Burton G. "The Efficient Market Hypothesis and its Critics." *Journal of Economic Perspectives* 17, no. 1 (2003): 62.

Mansfield, E., J. Rapoport, J. Schnee, S. Wagner, and M. Hamburger. "Research Innovation in the Modern Corporation." Norton (1971).

Mansfield, E. "Social and Private Rates of Return from Industrial Innovations." *Quarterly Journal of Economics* 91 (1977): 221-240.

Marco, Alan C. "The Value of Certainty in Intellectual Property Rights: Stock Market Reactions to Patent Litigation." *Vassar College Economics Working Paper*, no. 82 (2005): 1-21.

McConnell, J., and C. Muscarella. "Corporate Capital Expenditures Decisions and the Market Value of the Firm." *Journal of Financial Economics* (1985): 339-422.

McConnell, J., and T. Nantell. "Corporate Combinations and Common Stock Returns: The Case of Joint Ventures." *Journal of Finance* (1985): 519-536.

McQueen, Grant Richard and Vance V. Roley. "Stock Prices, News, and Business Conditions." NBER Working Paper No. W3520 (December, 1990): Available at SSRN: http://ssrn.com/abstract=471517

Nesta, Lionel, and Pier-Paolo Saviotti. "Intangible Assets and Market Value: Evidence from Biotechnology Firms." *SPRU Science and Technology Policy Research - Electronic Working Paper Series* 87 (2003): 2-19.

Odean, Terrance. "Do Investors Trade Too Much?" *American Economic Review* 89, no. 5 (12 1999): 1279-1298.

Pakes, Ariel. "On Patents, R & D, and the Stock Market Rate of Return." *Journal of Political Economy* 93, no. 2 (04 1985): 390.

Pastor, Lubos, and Pietro Veronesi. "Technological Revolutions and Stock Prices." *CEPR Discussion Paper* No. 5428 (2005): 3-26.

Peterson, Richard L. "Buy on the Rumor: Anticipatory Affect and Investor Behavior." *The Journal of Psychology and Financial Markets* (2002): 218.

Roll, Richard, and Robert J. Shiller. "Comments: Symposium on Volatility in U.S. and Japanese Stock Markets." *Journal of Applied Corporate Finance* 5, no. 1 (1992): 25-29.

Russell, Thomas, and Richard Thaler. "The Relevance of Quasi Rationality in Competitive Markets: Reply." *American Economic Review* 77, no. 3 (06 1987): 499.

Sarkar, Salil K., and Pieter J. de Jong. "Market Response to FDA Announcements." *Quarterly Review of Economics & Finance* 46, no. 4 (2006): 586-597.

Schwert, William G. "Anomalies and Market Efficiency." *Handbook of the Economics and Finance* (2002): Ch. 17.

Shiller, Robert J. "From Efficient Markets Theory to Behavioral Finance." *Journal of Economic Perspectives* 17, no. 1 (2003): 83.

Shiller, Robert J. "Do Stock Prices Move Too Much to be Justified by Subsequent Changes in Dividends?" *American Economic Review* 71, no. 3 (06 1981): 421.

Sneed, Katherine A. "Is the Price Right? Determinants of Patent Value in an Auction Environment." Unpublished Paper, Colorado College (2007): 1-14.

Suchy, Donna. "The Block's New Big Kid." *ABA Journal* 92, no. 4 (2006): 54.

Veronesi, Pietro. "Stock Market Overreaction to Bad News in Good Times: A Rational Expectations Equilibrium Model." *The Review of Financial Studies* (1999): 975.

Weber, Martin. "Behavioral Finance." *Research for Practitioners* 8 (1999): 12-14.

Womack, Kent L. "Do Brokerage Analysts' Recommendations have Investment Value?" *Journal of Finance* 51, no. 1 (03 1996): 137-167.

Woolridge, J. Randall, and Charles C. Snow. "Stock Market Reaction to Strategic Investment Decisions." *Strategic Management Journal* 11, no. 5 (Sep. 1990): 353-363.

Zarowin, P. "Size, Seasonality, and Stock Market Overreaction." *Journal of Financial and Quantitative Analysis* 25 (1990): 113-125.

Books

Brealey, R. A., and S. C. Myers. "Principles of Corporate Finance." 3rd Ed (1988): 198.

Brunnermeier, Markus K. "Asset Pricing Under Asymmetric Information: Bubbles, Crashes, Technical Analysis, and Herding." (2001).

Gitman, Lawrence J., and Michael D. Joehnik. "Fundamentals of Investing." Boston: Addison Wesley (2002): 178.

Keynes, John M. "The General Theory of Employment, Interest and Money." (1964 (reprint of 1936 edition)): 153-154.

Ma, Shiguang. "The Efficiency of China's Stock Market." *The Chinese Economy Series,* Ashgate Publishing, Ltd. (2004): 87.

Williams, J. B. "The Theory of Investment Value." (1956 (reprint of the 1938 edition)): 19.

Periodicals

Samuelson, Robert J. "The Market's Echo Chamber." *BusinessWeek* CLI, no. 5 (2008).

Websites

Greenspan, Alan. "Irrational Exuberance Speech." (1996). Federal Reserve Board http://www.federalreserve.gov/boardDocs/speeches/1996/19961205.htm

United States Department of the Treasury. "Daily Treasury Yield Curve Rates." Available from http://www.ustreas.gov/offices/domestic-finance/debt-management/interest-rate/yield_historical.shtml.