The Addition and Deletion Effects of the Standard & Poor's 500 Index on both Stock and Option Markets

by

Libo Sui

A dissertation submitted to the Graduate Faculty in Economics in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

2004

This manuscript has been read and accepted for the Graduate Faculty in Economics in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

4/19/04 — Nusret Cakici

Date — Chair of Examining Committee

4/19/04

Date — Executive Officer

Professor Nusret Cakici

Professor Salih Neftci

Professor Michael Grossman

Supervisory Committee

THE CITY UNIVERSITY OF NEW YORK

Abstract

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Adviser: Professor Nusret Cakici

The S&P 500 index is one of the most widely tracked indices by investors who wish to remain diversified. Since October 1989, Standard & Poor allows approximately 5 days of trading between the announcement date and the change date. This study investigated both equity and option markets behaviors for firms added to or deleted from the S&P 500 index.

In the equity part of this study, I used the underlying stock markets data to analyze the post-1989 market behavior of index changes. I examined price and volume history for firms added to or deleted from the S&P 500 index from January 1990 through December 2002. I presented evidence against the down-ward sloping long-run demand curve hypothesis and offered a new explanation for the S&P 500 addition and deletion effect. I revealed the dynamic evolution of this effect from 1990 to 2002. I showed how human behaviors such as risk aversion and irrationality can influence market efficiency in the short-run. I also focused my research on the dynamic evolution of this effect from 1990 to 2002, which indicates markets are becoming more efficient.

This study also investigated option markets behavior. As is widely known, option markets provide a rich source of information for studying market sentiment. In this study, I presented the behavior of option markets of S&P 500 index changes for the first time. I found evidence supporting the liquidity hypothesis and information hypothesis from the option side. I derived the mean implied risk-neutral probability density function to show the option market reactions. I found that Standard & Poor prefers to delete stocks which have left-shift implied RNDs and add stocks which have right-shift implied RNDs. According to the implied RNDs, I found that the difference between addition and deletion groups exists even before the information is released. Markets have positive expectations for addition group stocks and negative expectations for deletion group stocks even before the addition and deletion information is known. I also found evidence of active arbitrage activities and heavy inside trading activities for the index changes. This is the first study focusing on the option markets of those addition and deletion effects.

Acknowledgements

To my advisor Nusret Cakici, who discussed with me so many times and inspired me always. To my advisor Salih Neftci, who awakened my interest and showed me the correct direction. To Professor Michael Grossman, who gave me so many helps. To Professor Thom Thurston, who always smiles at me. To my father Lei Sui, my mother Lingdi Jiang, my sister Lina Sui, who sacrificed so much.

My dissertation, which leads to the completion of the Ph.D program in economics, does not belong to myself. It belongs to the economics department of GC, CUNY and my family.

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Chapter 1

Introduction

Standard & Poor's 500 index is designed to reflect the U.S. equity markets and, through the markets, the U.S. economy. It consists of 500 stocks selected by market size, liquidity, and industry group representation. Based on the semi-strong form of the efficient markets hypothesis(EMH), which says that no publicly available information is useful in predicting stock returns, indexing has become a very successful strategy of investment. Now, the S & P 500 index is one of the most heavily tracked indices by worldwide investors.

1.1 Changes in S & P 500 Index

If companies in the index are involved in mergers, are acquired, become bankrupt or significantly restructured such that they no longer meet inclusion criteria or if companies substantially violate one or more of the addition criteria, then, the Standard & Poor's Index Committee will delete this stock from the index. In the case that an S&P 500 company merges with or is acquired by another firm, the stock is removed at a date that is close as possible to the tender offer expiration date or to the shareholder vote date. In the situation of corporate restructuring, whether the firm or any of its spin-offs stay in the index after the restructuring is decided on a case-by-case basis. Removal also occurs if a share-holder-approved-recapitalization dramatically changes the firm's debt ratio. When a company files Chapter 11 for bankruptcy, it will be removed immediately from the index.

If a stock is deleted, in most cases, the committee must select another stock to replace the deleted stock. Standard & Poor goes to its candidate replacement pool. The pool contains a set of firms that have been pre-approved by the Standard & Poor Index Committee to be included in the S & P 500. The pool is kept secret. The primary objective of the S & P 500 is to be the performance benchmark for U.S. equity markets. The selection criteria for the replacement pool include: 1) industry representation–the firm must be from an important U.S. industry segment; 2) firm size–the firm generally has the highest market value within its industry; 3) number of shareholders–the firm's shares must be widely held to avoid adverse effects of market inliquidity; 4) trading volume–the greater the trading activity of the firm's shares, the more efficient is their pricing and the more timely is the movement in the index; 5) financial soundness–the firm's financial and operating conditions are rigorously analyzed to ensure that added firms will have longevity. Based on these criteria, firms are identified and discussed at the periodic Standard & Poor Index Committee meetings. A firm is included in the candidate re-

Reason	02	01	00	99	98	97	96	95	94	93	92	91	90
Mergers & Acquisitions among companies in the S & P 500 Index	3	15	23	21	24	18	9	14	3	2	2	6	8
Acquisition by S & P MidCap 400 Index Company	0	0	2	2	2	0	0	0	1	0	0	0	0
Aquisition by company outside the Index	0	2	9	10	10	6	2	6	4	4	0	2	2
Restructurings	0	8	6	3	7	4	4	4	4	3	3	1	2
Bankruptcies	2	0	0	1	0	0	0	0	0	1	1	3	2
Lack of Representation	0	3	10	4	5	3	9	9	5	3	1	1	0
Moved to MidCap 400	0	1	0	1	0	0	0	0	0	0	0	0	0
Moved to SmallCap 600	0	1	8	0	0	0	0	0	0	0	0	0	0
Total Number	23	30	58	42	48	31	24	33	17	13	7	13	14

Table 1.1: S & P 500 COMPANY CHANGES(1990–2002)

placement pool if unanimously approved by the committee.

The addition and deletion activities have become more frequent in the recent economically prosperous years. In year 2000, there were 58 company changes, which means 10% of the index's stocks were changed, while in 1990 there were only 14 changes. Table 1.1 shows the statistics of S & P 500 company changes from 1990 to 2001.

Before October 1989, Standard & Poor announces the change after the markets close and executes the change when the markets open the next morning. Under this announcement policy, the first opportunity to buy the newly added stock was at the open on the day following the announcement. In October 1989, S & P changed its rule trying to give approximately 5 business days between the announcement day and the change day under possible situation to ease order imbalances. Under the new policy, Standard & Poor announces the name of the added and deleted firms, as well as the date on which the change will become effective after the market closes. Usually, Standard & Poor will announce the change five business days ahead. On occasion, Standard & Poor must use a shorter time due to a bankruptcy filing or acquisition. For example, on Oct. 12 JWP Inc. filed Chapter 11 for bankruptcy. Immediately following the close on that day, Standard & Poor announced that JWP Inc. would be dropped and Pioneer Hi-Bred Int'l would be added the next morning. Under very rare occasions, Standard & Poor may also choose to use an announcement interval longer than five days. In June 1994, Microsoft was announced to be added given a sixteen trading day interval due to its high market capitalization.

1.2 Index Fund

According to the stimulus mechanism of most index funds, if the managers can not minimize the tracking error, they will be punished. The fund managers will take some risk if they change their portfolios before the changes occur. At least fund managers would not be awarded because of their actions before the change day. Therefore, most index fund managers choose to change their portfolios on the change day instead of immediately after the announcement day. This behavior and the time window between addition and deletion give us an arbitrage possibility and a valuable chance to study the market behavior.

The fundamental theory of indexing comes from the capital asset pricing model(CAPM) of Sharpe(1964)/Lintner(1965) . The CAPM says that investors should hold portfolios that consist of all risky securities in the marketplace, with the proportion of wealth invested in each security equal to that security's market value relative to the total market value of all risky securities. Stock selection and market timing is unnecessary. Ever since then, the growth of the indexing fund has been dramatic. Moreover, Wall Street professionals estimate that privately held funds tracking the S&P 500 index have even greater value than public funds. They estimate about ten percent of the index is held by index funds both public and private.

As the growth of S&P 500 based investments increased since 1970's, several researches on the price and volume patterns of changed stocks have been done by both academia and Wall Street. The results of these studies all came to a similar conclusion: there is an Standard & Poor price effect. Due to the increasing scale of index funds based on S&P 500 and the historically high number of changes happened in recent years, this price effect becomes more and more important for Wall Street investors.

Chapter 2

Literature Review

A lot of research has already been done for the equity markets of this phenomena. There are altogether three areas related to this topic in equity markets: First, the empirical evidence and arbitrage opportunities; Second, the explanations for the price movements around the time of an index change; Third, What it means for market efficiency.

Our research is the first investigation talking about the option markets effect of this phenomena.

2.1 Empirical Evidence and Arbitrage Opportunities

2.1.1 Empirical Evidence

For the empirical evidence, there is disagreement about aspects of the price effect relating to its magnitude, whether it is increasing, decreasing or stable through time, its duration and reason. One thing is certain: there is always a positive price effect on companies added to the S&P 500 index and a negative price effect on companies deleted from the S&P 500 index. There is opportunity for profit.

For these researches before October 1989 on empirical evidences,the following common conclusions are observed:[1]

(1) There is a significant positive excess return on the day following the additions of a company to the 500.

(2) There is a significant negative excess return on the day following the deletion of a company from the 500.

(3) The positive price effect is sustained over the subsequent week and

[1]For additions, see Harris and Gurel(1986)(84 stocks); Shleifer(1986), who examined the 1976-83 period(102 stocks); and Dhillon and Johnson(1991), who examined the 1978-88 period (187 stocks). For deletions, see Goetzmann and Garry (1986) who examined the seven deletions on November 30, 1983 (caused by the breakup of AT&T), and Harris and Gurel(1986) who examined the 1978-83 period (13 stocks).

month and appears to be permanent. The range of the price effect is +3.0% to +8.0%.

(4) The negative price effect is also sustained over the subsequent week and month and appears to be permanent. The negative effect is about 1.5%.

(5) The primary reason behind the price effect is increased demand by index fund managers.

(6)Another reason for the price effect may involve qualitative factors such as a perceived increase in the quality of an addition or a tendency by foreign investors to focus only on the S & P 500 list.

For example, during the period of 1976 through 1983, Shleifer(1986) found an abnormal price increase of 2.79 percent on the day following the announcement. Using roughly the same period, Harris and Gurel(1986) report a 3.13 percent average increase.

Recently, there are several important papers based their researches on the phenomena after October 1989.

Beneish and Whaley (1997) is the first paper that studied the influence of the new Standard & Poor policy. They examined the effects of Standard and Poor's change in announcement policy regarding new listings to the S&P 500 index from January 1986 to June 1994. There are all together 177 additions in this period. They selected 103 suitable additions as their final sample, among which 33 occur under the new policy, while others occur under the old policy. In the period before the change in policy (from January 1986 through September 1989), they found that index funds pay a 3.7 percent premium for the shares of newly added stocks. Beneish and Whaley also found this premium is driven exclusively by the close-to-open return. It does not represent a profitable trading opportunity and consists with the market efficiency theory. They found a 23 percent higher premium than was reported in past works. They explain it is a result of the growth of the money indexed to the S&P 500 index. They also found the price increase during this period appears to be permanent. In the period after the change in policy (October 1989 through June 1994), they found the overnight return is only 3.1 percent, about 16 percent lower than the return under the old policy. By the effective day, the stock price has increased by another 4.1 percent, making the total premium paid for acquiring the new stock 7.2 percent, which indicates most index funds wait until the effective day to rebalance their portfolios. Although part of the increase reverses after the stock is included in the index, most of the overall price increase appears to be permanent in the sense that the abnormal return is nearly five percent two weeks after the effective day.

Lynch and Mendenhall (1997) examined the changes from March 1990 to April 1995. Altogether, there are 71 additions and deletions during this period. After kicking out the unsuitable firms, they finally setup a clean sample of 34 additions and 15 deletions. They found for both additions and deletions, the data revealed a distinct pattern of stock-price movements. For additions, they found a significantly positive announcement effect, they also found a positive abnormal return of about 3.8% over the period starting the day after the announcement and ending the day before the effective date of the change. Further more a significant negative abnormal return was found following the addition. They also found firms being deleted from the index exhibit a significant post-announcement drift and a significant price reversal, but in directions opposite to these for additions.

Philip A. Cusick (2001) analyzed price and volume data for firms added or deleted from the S&P 500 index from October 1989 through December 1999. In total he found 304 additions and 304 deletions within this period. After selection, his final sample was made up of 112 additions and 52 deletions. He found that for both additions and deletions the data revealed a distinct pattern of price and volume movements. For additions, the stocks exhibits significant increases form the announcement through the change day, and then a decline from the change day through the release-ending period when the price steadied approximately 8% above its pre-announcement price. The effect on deletion is more extreme, as the stock generally settles about 14% below its pre-announcement price. He also found a difference in that deletions do not exhibit a sustained price increase after the change day. For volumes, he found heavy spikes in market-adjusted volume on the day after the announcement and the day of the change. Evidence was found of increased steady state trading volumes after the change for both additions and deletions.

2.1.2 Arbitrage Opportunities

Beneish and Whaley (1996) studied overnight and intra-day returns. They argue that if the close-to-close return following the announcement is largely driven by the close-to-open price movement, the efficiency of price-setting in the marketplace is supported. If the close-to-close return is largely driven by the price movement from the open to the close on the day following the announcement, a case can be made for market inefficiency.

They found that the close-to-close return of pre-October 1989 group appears to be driven by the overnight return. Therefore, there is no arbitrage opportunities and the market is efficient. The data after October 1989, exhibited that the average abnormal return of the strategy of buying the stock and shorting the S&P 500 futures at the open on the day after the announcement day and closing the position at the close of the effective day is 4.011 percent. This indicates that an abnormal trading profit can be earned after the trading costs.

2.2 Explanations for the Price Movements

For the explanations of the price movements around the time of an index change, there are altogether four hypotheses:

(1) The price pressure hypothesis: Says that the price movements around the time of an index change are caused by heavy index funds trading that moves stock prices temporarily away from their equilibrium. The evidence

for this hypothesis should be a price reversal after the effective date of the index change.

(2) The downward-sloping long-run demand curves hypothesis: Says that as firms enter the S & P 500, index-fund buying removes a substantial fraction of the firm's shares from circulation. This demand by index funds reduces the stock's supply for nonindexing investors, causing the market clearing price to increase. For deletions, this effect should be in the opposite direction. If the long-term demand curves for stocks were horizontal, the reduction of the stock's supply would not influence the stock price. Therefore, the evidence for this hypothesis should be a permanent price effect after the change. Shleifer(1986) and Harris and Gurel(1986) were the first papers to recognize that a permanent price response associated with addition to or deletion from the index is consistent with stocks possessing downward-sloping demand curves.

(3) The information hypothesis: Argues that the price movement of change stocks could be due to the information content of Standard & Poor's addition and deletion. Standard & Poor must have some non-public information about firms and use this information to determine the composition of the index. Jain(1987) supports this hypothesis. He observed significant stock-price movements when firms are added to or deleted from S & P auxiliary indexes.

(4) The liquidity hypothesis: If being a member of the S&P 500 index leads to more attention by public and analysts. This may, in turn, lead to greater

institutional interest, greater trading volume, and lower bid-ask spreads. Harris and Gurel (1986) and Edmister (1995), studying pre-October 1989 data, do find evidence of a permanent increase in trading volume following S & P inclusion.

Prior studies of the effect of inclusion in the S & P 500 index include Shleifer(1986), Harris and Gurel(1986), Dhillon and Johnson(1991), Beneish and Whaley(1996), Lynch and Mendenhall(1997), and Wurgler and Zhuravskaya(2002). All but one of the prior studies report that the price increase is permanent, thus, supporting the hypothesis that demand curves for stocks slope downward in the long-run.

Studies based on other events come to mixed conclusions. For example, Scholes(1972), who examines stock price reactions to large-block trades, and Mikkelson and Partch(1985), who study price reactions to announcements of secondary equity offerings, conclude that their results are more consistent with an information effect than with a demand curve effect. Loderer, Cooney, and Van Drunen(1991), who studies Dutch auction share repurchases, conclude that their evidence is most consistent with a demand curve effect.

Recently, Denis etal. (2003) study the performance of 236 firms added to the S&P 500 index between 1987 and 1999 and report that "relative to various benchmark companies, newly-included companies experience significant increases in EPS forecasts and significant improvements in realized earnings". Their results indicate that Standard & Poor index inclusion is not an information free event. Chen, Noronha and Singal (2004) document an asymmetric price response. They explain this by changes in investor awareness which support the liquidity hypothesis.

2.3 Market Efficiency

Lynch and Mendenhall (1997) found that the significant abnormal returns following the announcement date are inconsistent with semi-strong form market efficiency.[2] They also found investors can use the publicly available information to construct trading rules that earned economically significant abnormal returns in index change. But studies examining the pre-October 1989 period did not show significant daily abnormal returns following the announcement. Therefore, the pre-October 1989 results do not violate semi-strong form efficiency, while the post-October 1989 results do. This discovery gives us a chance to test the market efficiency theory.

[2]see Fama 1970, 1991 about the theory and evidence of market efficiency.

Chapter 3

Equity Markets Study

3.1 Chapter Structure and Data

This chapter of my research will study the behavior of equity markets for these stocks added or deleted from S&P 500 index from 1990 to 2002. My research focuses on the post-October 1989 effect and the dynamic evolution of this effect from 1990 to 2002.

I noticed that most of the papers talking about the post-October effect only have a short period of time to study and only pay attention to the static side of this effect. My research has a longer time period and I try to reveal the dynamic evolution of this effect during past decade.

I collected data for this study from several sources. The index addition and deletion information including announcements and changing dates are collected from Standard & Poor's 500 Directory (1990-2003). For some announcement and changing dates which are not provided by Standard & Poor's 500 Directory, I checked Wall Street Journal. Volume , closing prices and open prices are from Bloomberg or Reuters (1990-2002). Stock specific information (for example, the reason of stock changes) is from Wall Street Journal.

The later part of this chapter is organized as follows: In section 3.2, I talk about equity markets data selection. In section 3.3, I talk about the methodology that I use. In section 3.4, I talk about equity markets results. Finally, I conclude equity markets in section 3.5.

3.2 Equity Markets Data Selection

There are all together 353 S & P 500 index changes (353 additions, 353 deletions) from 1990 to 2002. Because a significant number of index changes are caused by substantial fundamental changes of deleted companies (merger, acquisition, bankruptcy, restructure ...) and these fundamental changes will usually cause huge price movements near index change time, I removed a number of securities in order to study the clean index change effect of the equity markets. I classified the reason of deleting securities from my sample into five categories.

(1) I can not find data of one form or another for a security. 55 addition stocks and 51 deletion stocks are deleted from my sample because of the lack of data.

(2) There are some index changes for which no trading is required by index funds, such as name changes or replacements due to part of a company spinning off and the child or parent company remaining in the index. 54 additions and 2 deletions are removed because of this reason.

(3) Any big changes related with other companies, such as merger, acquisition, split activities and takeover. I searched Wall Street Journal articles close to the change time. Any company which was mentioned in connection with such activities around change time will be deleted from my sample. 2 additions and 188 deletions are kicked out because of this (This is the most popular reason for Standard & Poor's Index Committee delete one stock from S&P 500 index).

(4) Bankruptcy, restructuring or recapitalization. There are 8 additions and 48 deletions are removed because of this reason.

(5) There are not enough numbers of trading days between announcement day and change day. I require there is at least one day between announcement day and change day. If the change day just follows the announce day, these changes will be the same as pre-1989 changes. I deleted 42 additions and 2 deletions because of this.

Finally, my sample contains 192 additions and 62 deletions. Figure 3.1 and 3.2 show the frequency distributions of the number of trading days of these additions and deletions between the announcement day and the effec-

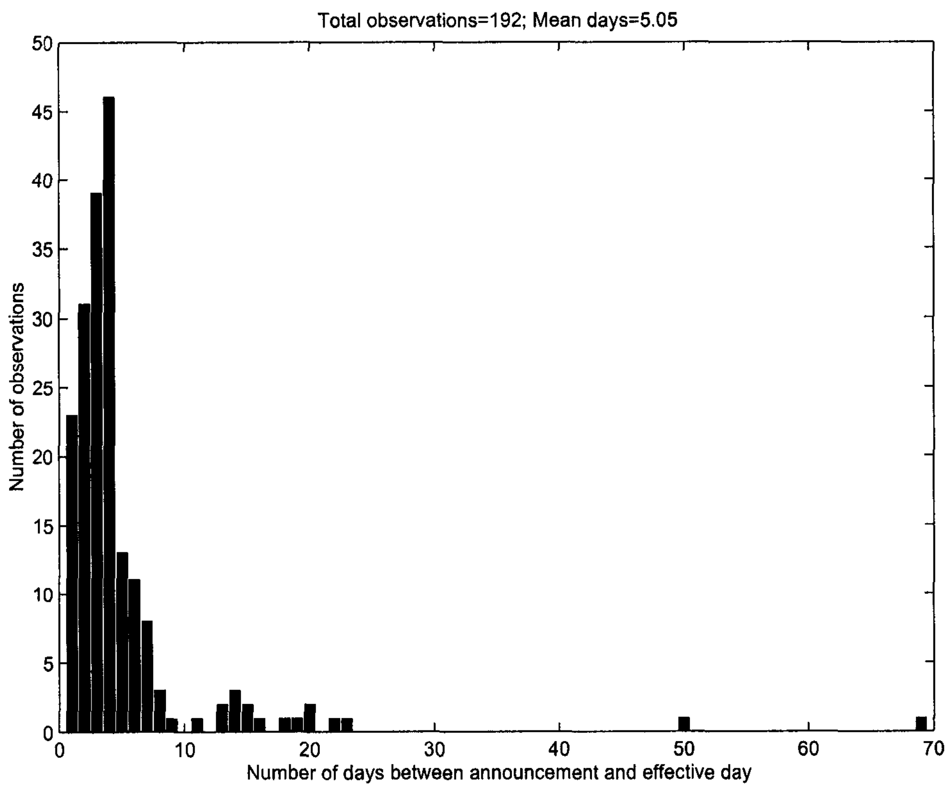

Figure 3.1: Frequency distribution of the number of trading days between the announcement day and the effective day for the sample of 234 additions during the period January 1990 through December 2002

tive day. The range of additions is from one to sixty nine trading days. The range of deletions is from one to thirteen trading days. The mean days of additions is 5.05 trading days. The mean days of deletions is 4.24 trading days. The outliers of additions at sixty nine and fifty trading days are the State Street Corp addition in 1997 and the Quintiles Transnational addition in 1999.

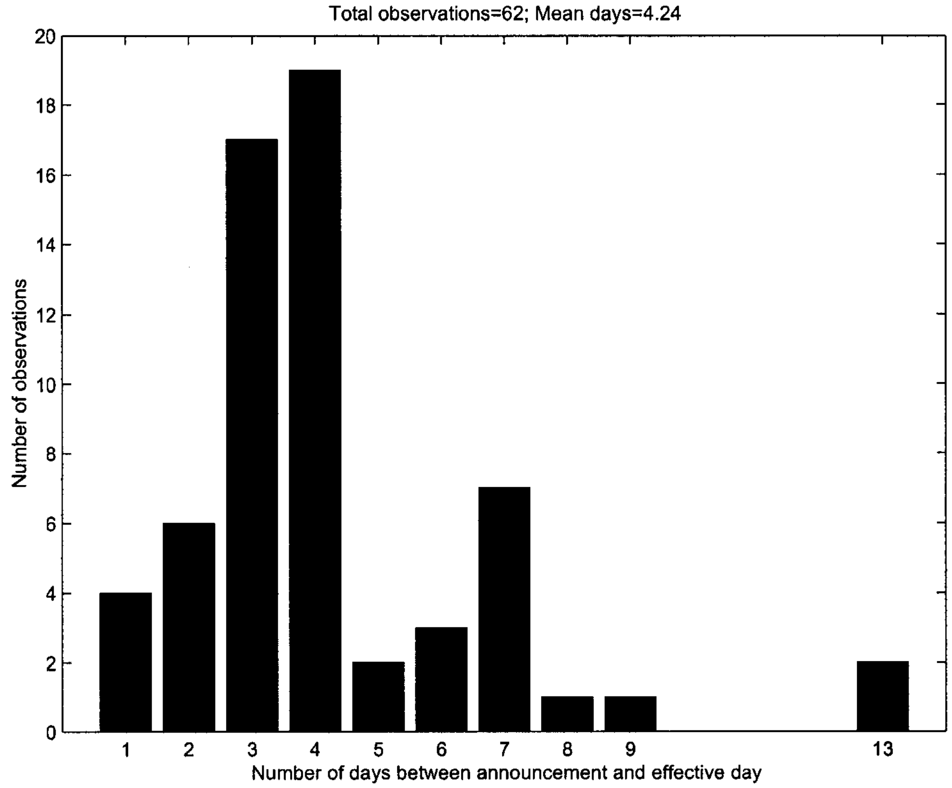

Figure 3.2: Frequency distribution of the number of trading days between the announcement day and the effective day for the sample of 64 deletions during the period January 1990 through December 2002

3.3 Methodology

I use an event-study methodology with two event dates for each sample: The announcement date of the addition/deletion, I call AD and the effective date of the addition/deletion , I call CD. Standard & Poor always announces changes after market closing of a particular day, therefore the first day of possible prices movements is AD+1 day. Standard & Poor will implement these changes using the closing price of the change day (CD). CD is the day on which most index funds will re-balance their portfolios.

3.3.1 Abnormal Return Calculation

Before starting my research, I need to introduce several basic definitions and measurements of abnormal return.

Definition of Raw Return: I define the raw return for a stock or S & P 500 index as the close price of that stock or index on day τ minus the close price on day τ-1 and then divided by the close price of that stock or index on AD.

$$RR_{i\tau} = \frac{CP_{i\tau} - CP_{i,\tau-1}}{CP_{iAD}} \tag{3.1}$$

Definition of Abnormal Return: The abnormal return for stock i on day τ ($AR_{i\tau}$) is defined as the stock's raw return on day τ ($RR_{i\tau}$) minus S & P 500's raw return on day τ (SPR_{τ}).

$$AR_{i\tau} = RR_{i\tau} - SPR_{\tau} \tag{3.2}$$

Definition of Mean Abnormal Return: Actually, I am interested in the measure of the abnormal price movement on an event day α which is called mean abnormal return for event day α (MAR_{α}). It is defined as the mathematic average of abnormal returns of every stocks I study on that event day.

$$MAR_{\alpha} = \frac{\sum_{i=1}^{n} AR_{i\alpha}}{N} \tag{3.3}$$

Definition of Cumulative Abnormal Return: I am also interested in calculating the cumulative abnormal return between day τ_1 and τ_2 ($CAR_{i,\tau_1-\tau_2}$). For example, I am particularly interested in the total cumulative abnormal return between announce day and the change day. It is defined as the stock's raw return between day τ_1 and τ_2 ($RR_{i,\tau_1-\tau_2}$) minus S & P 500's raw return between day τ_1 and τ_2 ($SPR_{\tau_1-\tau_2}$).

$$CAR_{i,\tau_1-\tau_2} = RR_{i,\tau_1-\tau_2} - SPR_{\tau_1-\tau_2} \tag{3.4}$$

Definition of Mean Cumulative Abnormal Return: It is defined as the mathematic average of cumulative abnormal returns of every stocks between event day τ_1 and τ_2 .

$$MCAR_{\tau_1-\tau_2} = \frac{\sum_{i=1}^{n} CAR_{i,\tau_1-\tau_2}}{N} \tag{3.5}$$

Because the average day between AD+1 (not include AD+1) and CD (not include CD) is different for additions and deletions, I divided this period to four event periods for additions (period A, B, C, D) and three event periods for deletions (period A, B, C) to indicate the mean days between AD+1 and CD is four for additions and three for deletions. The mean abnormal returns for those periods are calculated by MCAR between AD+1 (not include AD+1) and CD (not include CD) divided by four for additions and three for deletions.

3.3.2 Abnormal Close-Open Difference

In my study, I need to examine one unique day's abnormal close-open difference. It is the abnormal difference between the close price of announcement day and the open price of the day after that announcement day.

Definition of abnormal close-open difference: My abnormal close-open difference for stock i on day τ ($ACO_{i\tau}$) is defined as the stock's open price on day τ ($OP_{i\tau}$)minus the stock's close price on day τ-1 ($CP_{i(\tau-1)}$) divided by the stock's close price on day τ-1 ($CP_{i(\tau-1)}$) and then minus the same ratio for the market overall.

$$ACOi\tau = \frac{OP_{i\tau} - CP_{i(\tau-1)}}{CP_{i(\tau-1)}} - \frac{OP_{m\tau} - CP_{m(\tau-1)}}{CP_{m(\tau-1)}} \tag{3.6}$$

3.3.3 Arbitrage Opportunity Calculation

To find and identify the magnitude of arbitrage opportunity is one of the most important purpose of my research.

Definition of Arbitrage Space: The arbitrage opportunity available for stock i (AS_i) is defined as the difference between the stock's CD+1 closing price ($CD1C_i$) and AD+1 open price ($AD1O_i$) divided by the stock's AD+1 open price and then minus the market return between CD+1 close ($CD1C_m$) and AD+1 open ($AD1O_m$).

$$AS_i = \frac{CD1C_i - AD1O_i}{AD1O_i} - \frac{CD1C_m - AD1O_m}{AD1O_m} \tag{3.7}$$

This is the pure arbitrage caused by index changes. Some researchers define the arbitrage space just as the difference between CD+1 closing price and AD+1 open price divided by the AD+1 open price. If the market changes dramatically during the same period, their definition will cause bias in research.

In this definition, for example, for additions, I assume traders can take the arbitrage opportunity by buying stocks at the open of AD+1 and then selling them at CD close. Actually, for professional traders, their arbitrage space should be bigger than this estimation, I found that open prices of the AD+1 day are statistically higher than the close price in AD+1 day and traders can find a better price in AD+1 day than just taking the open price.

3.3.4 Abnormal Volume Calculation

Definition of Abnormal Volume: The abnormal volume for stock i on day τ ($AV_{i\tau}$) is defined as the stock's raw volume on day τ ($RV_{i\tau}$) minus ten day average volume before AD+1 day ($TDAV_i$) divided by the ten day average volume before AD+1 day and then minus the same ratio for the market overall.

$$AVi\tau = \frac{RV_{i\tau} - TDAV_{i\tau}}{TDAV_{i\tau}} - \frac{RV_{m\tau} - TDAV_{m\tau}}{TDAV_{m\tau}} \tag{3.8}$$

Definition of Mean Abnormal Volume: I am interested in the measure of the abnormal volume on an event day α which is called mean abnormal volume for event day α (MAV_α). It is defined as the mathematic average of abnormal volume of every stocks I study on that event day.

$$MAV_\alpha = \frac{\sum_{i=1}^{n} AV_{i\alpha}}{N} \tag{3.9}$$

Definition of Cumulative Abnormal Volume: I am also interested in calculating the cumulative abnormal volume between day τ_1 and τ_2 ($CAV_{i,\tau_1-\tau_2}$). It is defined as the stock's raw volume between day τ_1 and τ_2 ($RV_{i,\tau_1-\tau_2}$) minus $TDAV_i$ multiply the number of days (ND) between day τ_1 and τ_2.

$$CAV_{i,\tau_1-\tau_2} = RV_{i,\tau_1-\tau_2} - ND * TDAV_i \tag{3.10}$$

Definition of Mean Cumulative Abnormal Volume: It is defined as the mathematic average of cumulative abnormal volumes of every stock between event day τ_1 and τ_2.

$$MCAV_{\tau_1-\tau_2} = \frac{\sum_{i=1}^{n} CAV_{i,\tau_1-\tau_2}}{N} \tag{3.11}$$

The same as what I have done in abnormal return, I divide the period between AD+1 (not include AD+1) and CD (not include CD) into four event periods (A, B, C, D) for additions and three event periods for deletions to indicate the mean days between AD+1 and CD. The mean abnormal volumes for those periods are calculated by MCAV between AD+1 (not include AD+1) and CD (not include CD) divided by four for additions and three for deletions.

Above are the fundamental definitions and measurements I will use in my research. Basically, I use S & P 500 index as my benchmark for these definition. This will guarantee that the numbers I get are caused by the pure index change effect and not by the markets movements.

3.3.5 Significant Test

All significance tests in this chapter are performed using a cross-sectional variance estimator which is introduced by Asquith (1983) and used by Lynch and Mendenhall (1997). I present this significance tests on abnormal return, abnormal close-open difference, arbitrage space and abnormal volume.

For example, for abnormal return, they assume that the $AR_{i\tau}$s are cross-sectionally independently and identically distributed normal, then the mean abnormal return for event day α (MAR_α) will be a student t distribution with N-1 degrees of freedom. The cross-sectional variance for this distribution is:

$$S^2[MAR_\alpha] = \frac{1}{N}\sum_{i=1}^{n}\frac{[AR_{i\alpha} - MAR_\alpha]^2}{N-1} \tag{3.12}$$

The null hypothesis is:

$$H_0 : MAR_\alpha = 0 \tag{3.13}$$

The alternative hypothesis for additions are $MAR_\alpha > 0$ for event days before CD and $MAR_\alpha < 0$ for event days after CD; the alternative hypothesis for deletions are $MAR_\alpha < 0$ for event days before CD and $MAR_\alpha > 0$ for event days after CD.

For abnormal volume, I do similar tests.

3.4 Equity Markets Results

3.4.1 Price Results

Tables 1 and 2 present numerical data of mean abnormal return for addition and deletion from AD-10 to CD+20. The MARs between AD+1 and CD are displayed as if each daily MAR over this interval was the interval's MCAR divided by four for additions and three for deletions. Both the announce day price movements and change day price movements are significant.

Figure 3.3 and 3.4 present the market adjust price levels from AD-10 to CD+20 using the announce day closing price as benchmark (1 unit). I noticed that the price began to increase or decrease slightly from AD-10 to AD for both figures. This can be explained by the leakage of information or inside trading. After the information of addition or deletion is announced, this movement becomes dramatic. The degrees of price movements for additions and deletions are asymmetric from AD to CD. For addition, I find 8.56% abnormal return for this period. For deletion, the abnormal return is -13.19%. After that, the abnormal return of addition reversed 2.37% to 6.19% and the deletion reversed 6.99% to 6.20% on CD+20. The deletion reverses near three times of the addition. Finally, the abnormal return becomes 6.19% for addition and -6.20% for deletion. The addition and deletion effect becomes symmetric on CD+20 and remains relatively stable near CD+20. This demonstrates that the long-run effect of addition and deletion are similar and symmetric. The asymmetry from AD to CD indicates that people are risk averse and irrational in financial markets in the short-run. Human behaviors such as risk aversion can cause inefficient market in the short-run. As time goes on, the market becomes more and more efficient. From this, I believe human behaviors influence the market prices in the short-run and cause a period of inefficient market, but in the long-run, most of these irrational behaviors will reverse to rational levels.

All but one of the prior studies report that the price increase is permanent, supporting the hypothesis that demand curves for stocks slope downward in the long-run. In my research, I divided the total abnormal return between announce day and change day into two parts. The first part is the abnormal return between AD and CD-1, because most index funds change their portfolios on CD, my hypothesis is that most of the abnormal returns of this period are caused by new information released on AD[1]; the second part is the abnormal return on CD on which most index funds change there portfolios and no new information comes in (the change of index has already been released on AD). Although part of the total price movement from AD to CD appears to be permanent (the abnormal returns still remain at 6.19% for addition and -6.20% for deletion on CD+20), the change day abnormal returns and part of the abnormal returns between AD and CD-1 are reversed on the CD+20. This gives us enough evidence to reject the downward-sloping long-run demand curves hypothesis under the discovery that the index change is not an information free event.

[1]Diane, John, Alexei and Yun demonstrate that S & P index inclusion is not an information free event

The downward-sloping long-run demand curves hypothesis says that as firms enter the S & P 500, index-fund buying removes a substantial fraction of the firm's shares from circulation. This demand by index funds reduces the stock's supply for nonindexing investors, causing the market clearing price to increase. For deletions, this effect should be in the opposite direction. If the long-term demand curves for stocks were horizontal and no new information comes in at the same time, the reduction of the stock's supply would not influence the stock price. All the prior studies analyze this hypothesis based on the assumption that Standard & Poor index change is an information free event, however recently Diane, John, Alexei and Yun demonstrated that Standard & Poor index inclusion is not an information free event. More importantly, if stocks are perfect substitute in the long-run, the reduction of one stock's supply should not influence that stock's price. Therefore, we can not use the long-run down-ward sloping demand curve hypothesis to explain the Standard & Poor addition and deletion effect.

Under the assumption of information free, only the abnormal return from AD to CD totally reverses can provide enough evidence rejecting the downward-sloping long-run demand curves hypothesis. While under the assumption that S&P index change is not an information free event, only part of the abnormal return from AD to CD reverses may give enough evidence rejecting the downward-sloping long-run demand curves hypothesis. The permanent part abnormal return can be contributed to the new information released on AD.

For the post-1989 effect, the change day abnormal volume is two times of the cumulative abnormal volume from AD1 to AD5 for additions and three times from AD1 to AD4 for deletions. Therefore, most of the change happens on the change day. At most, without the assumption of information free, if 1.5 times of the change day abnormal return for additions reversed or 1.33 times of the change day abnormal return for deletions reversed, I have enough evidence to reject the downward-sloping long-run demand curve hypothesis. In my research, without the information free assumption, I have enough evidence to reject the downward sloping long-run demand curve hypothesis. The reversing of change day abnormal return and part of the abnormal return between AD and CD-1 reject the downward sloping long-run demand curves hypothesis directly. The change day abnormal return can be explained as the evidence of downward-sloping short-run demand curves not long-run. The abnormal return on CD and part of AD to CD-1 reverses several days later indicates the long-run demand curves of stocks are horizontal.

The mean cumulative abnormal return from AD to CD is 8.44% for addition and -11.10% for deletion. I found an arbitrage space of 3.2% for additions and -6.7% for deletions which use the strategy of buying/selling at the open of AD+1 and covering these positions at the close of CD.

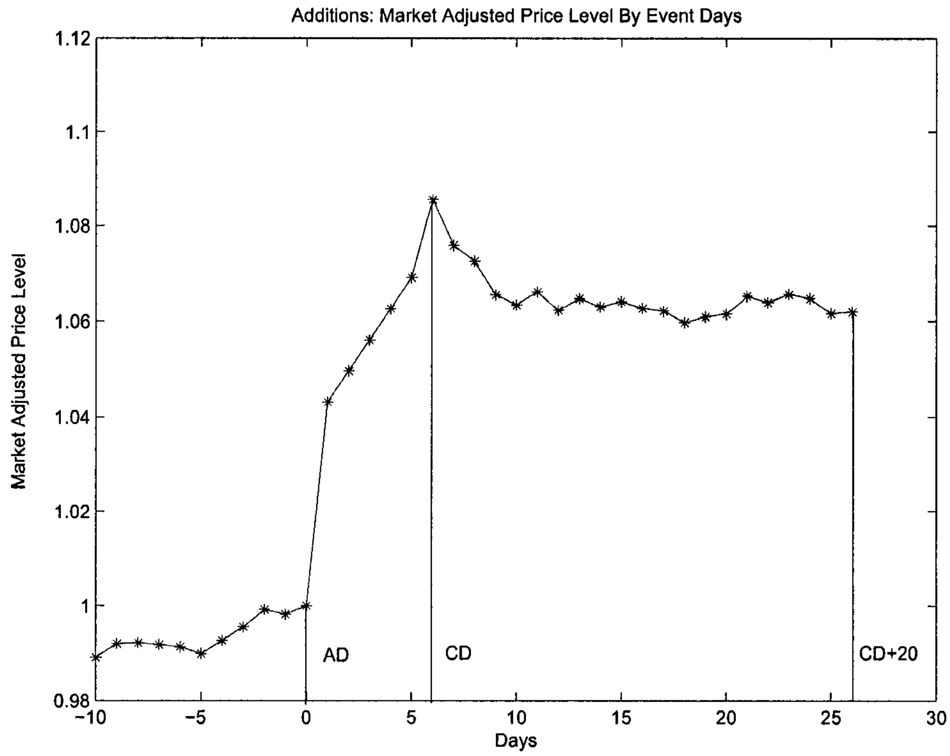

Figure 3.3: Market Adjust Price Level for Additions from AD-10 to CD+20 (I use the announce day close price as the benchmark (1 unit), the points on the figure are the mean abnormal price levels for each event day between AD-10 and CD+20)

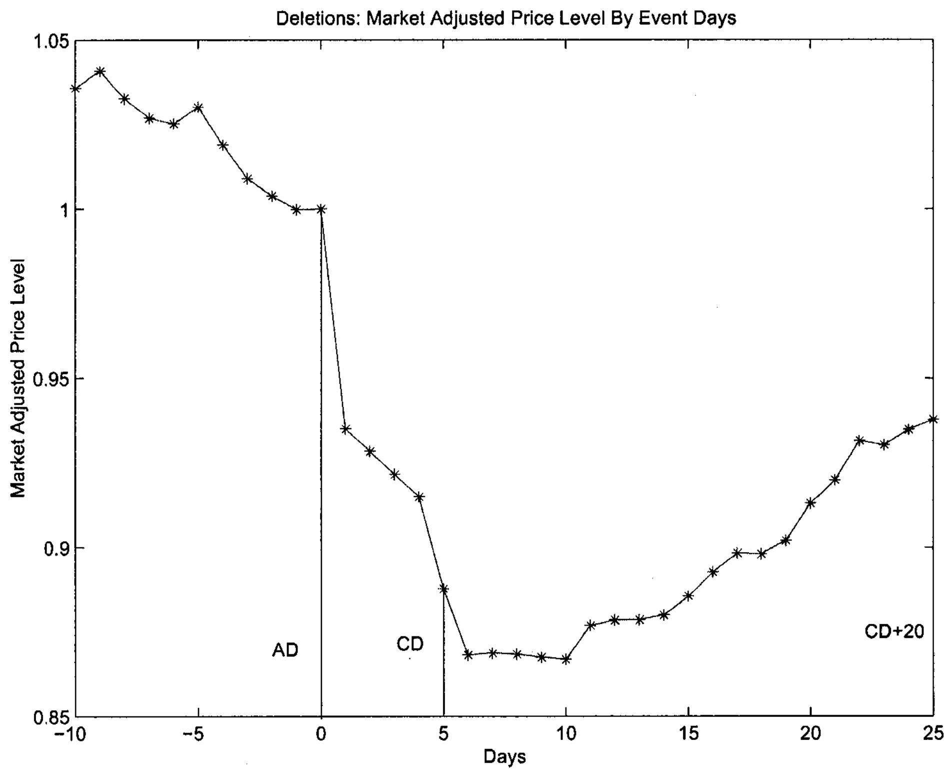

Figure 3.4: Market Adjust Price Level for Deletions from AD-10 to CD+20 (I use the announce day close price as the benchmark (1 unit), the points on the figure are the mean abnormal price levels for each event day between AD-10 and CD+20)

3.4.2 Volume Results

Table 3 and 4 present numerical data of mean abnormal volume for additions and deletions from AD-10 to CD+20. The MAVs between AD+1 and CD are displayed as if each daily MAV over this interval were the interval's MCAV divided by four for additions and three for deletions. Both the announce day abnormal volume and change day abnormal volume are significant.

Figure 3.5 and 3.6 present the market adjust volume level from AD-10 to CD+20 using the ten day average volume before announce day as the benchmark (1 unit). I noticed that the market adjust volume level on change day is 15.4 times the benchmark for additions and 21.1 times the benchmark for deletions. This indicates most index funds change most of their portfolios on change day.

3.4.3 Market Efficiency

One of the most important purpose of this paper is to show the dynamic evolution of the addition and deletion effect since the starting of Standard and Poor's new regulation.

My first attempt is to demonstrate the evolution of the market efficiency of changing the rule. In order to test the market efficient theory, I run linear regression for the arbitrage space against time. The outcomes are shown in figure 3.7 and 3.8. Both figures indicate that as time goes on, the ar-

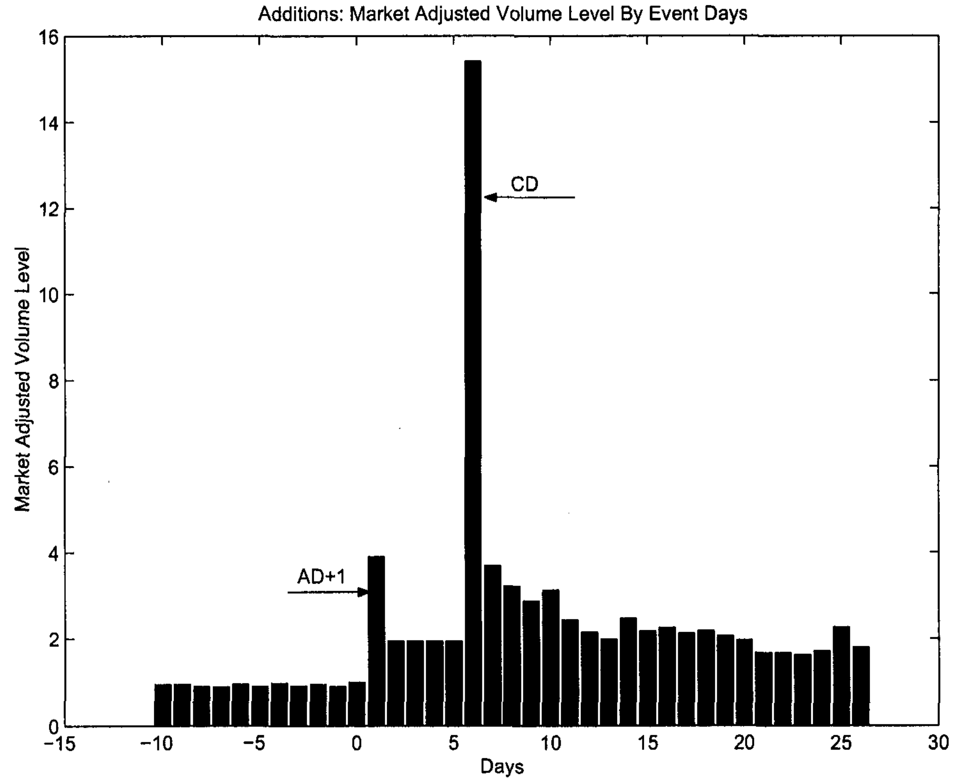

Figure 3.5: Market Adjust Volume Level for Additions from AD-10 to CD+20 (I use the ten day average volume before announce day as the benchmark (1 unit), the points on the figure are the mean abnormal volume levels for each event day between AD-10 and CD+20)

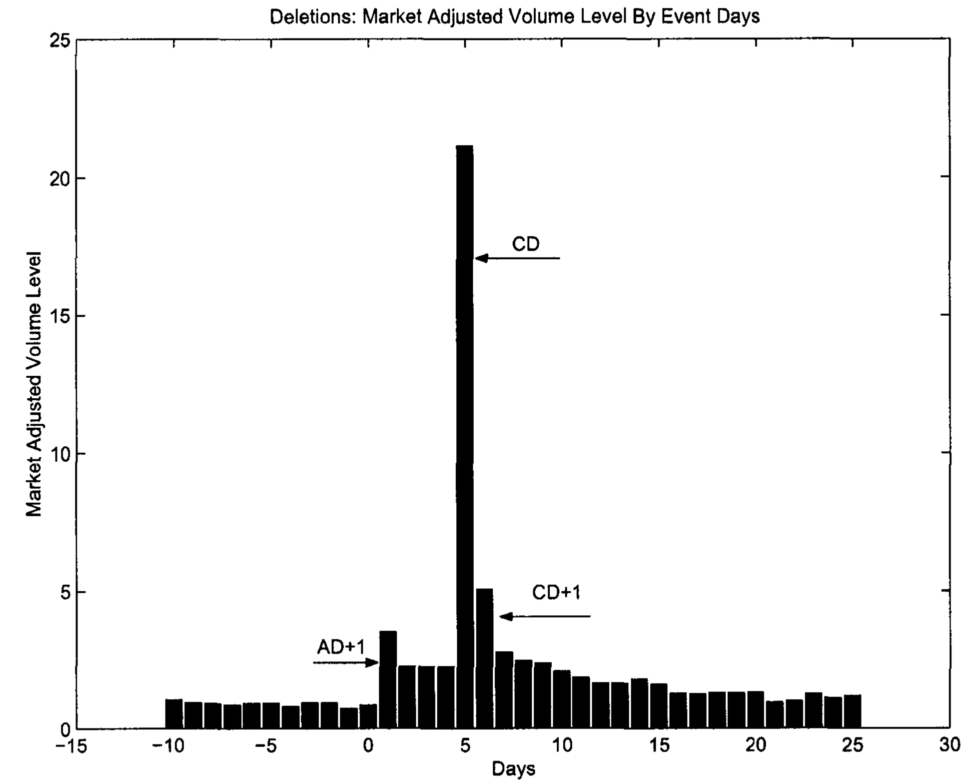

Figure 3.6: Market Adjust Volume Level for Deletions from AD-10 to CD+20 (I use the ten day average volume before announce day as the benchmark (1 unit), the points on the figure are the mean abnormal volume levels for each event day between AD-10 and CD+20)

bitrage spaces become smaller. Especially for the deletions in figure 8, the arbitrage space has declined dramatically since the beginning and has almost diminished recently. This is strong evidence that somebody is taking advantage of this arbitrage and making the market more efficient. This analysis also demonstrates the periodic inefficiency of markets. When there are some changes or new information comes into market places, markets will become inefficient in the short-run and it will take some time for the market to recalibrate from inefficiency to efficiency. Markets need time to adjust to the semi-strong form market efficiency when there are some structural changes or new information comes in. I call this period of adjustment the "inefficiency window". I believe the length of the inefficiency window is decided by how fast markets can understand and take advantage of the new information. The more difficult the market acclimates to the changes or new information, the longer it will take to return the market to the semi-strong form market efficiency. The short-run profits of traders come from the short-run inefficiency of markets.

Figure 3.9 and 3.10 show the relationship between AD+1 day abnormal volume and time for additions and deletions. Both figures show a positive coefficient which indicates more and more people are involved in profiting from this arbitrage.

Figure 3.11 and 3.12 show the relationship between CD day abnormal return and time for additions and deletions. Both figures indicate the degree of abnormal return is getting smaller and smaller which also means more and

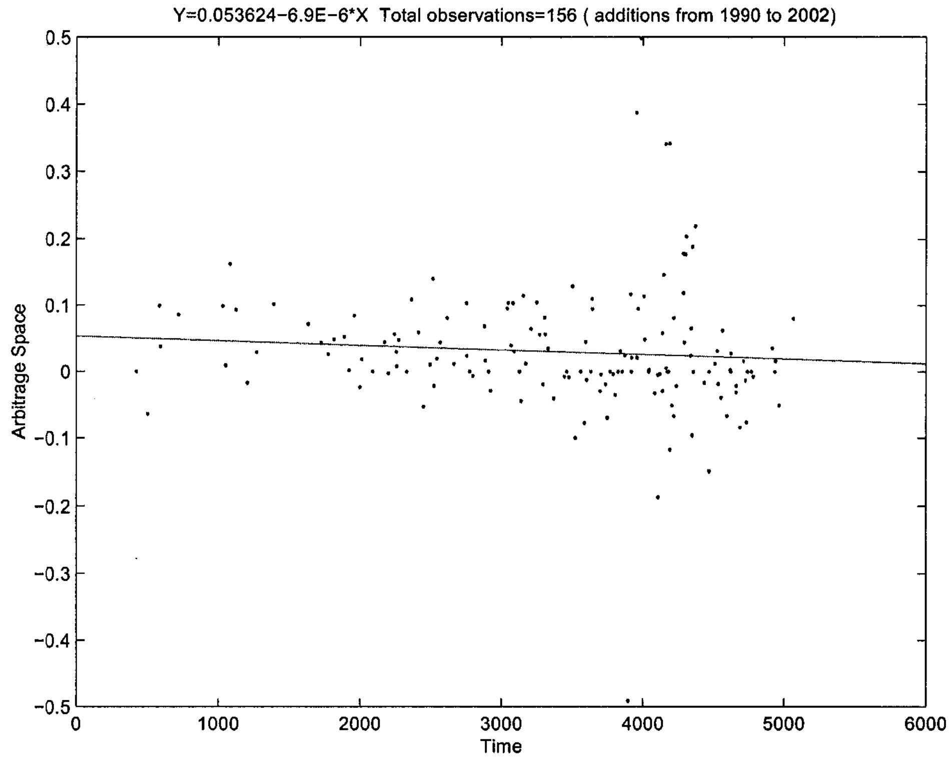

Figure 3.7: Arbitrage space of additions against time during the period January 1990 through December 2002(using average value if there are more than one observations in one day)

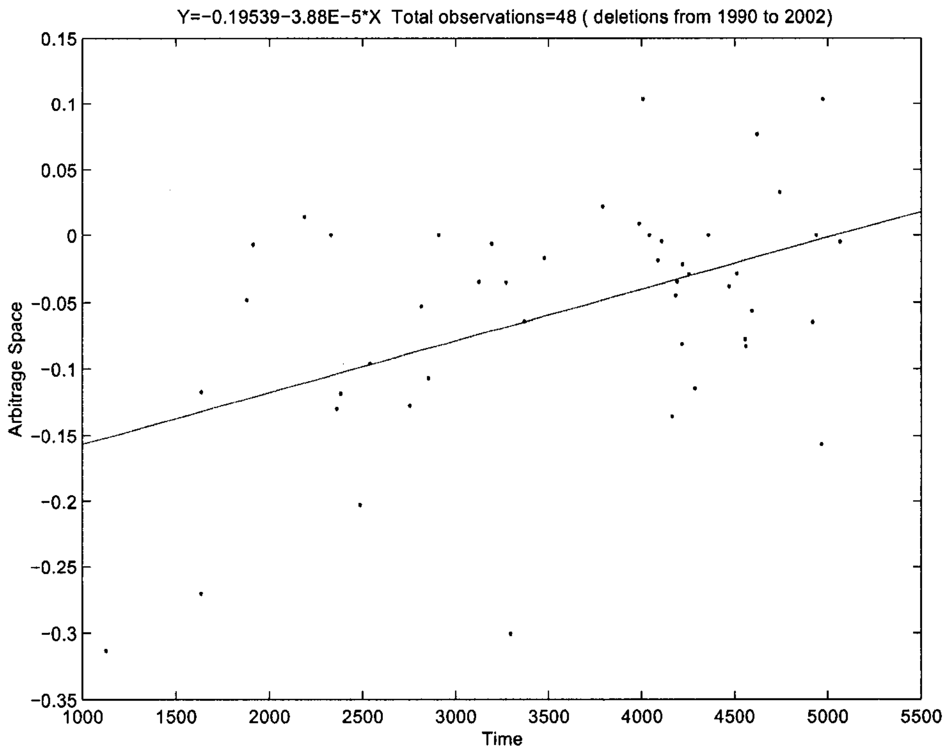

Figure 3.8: Arbitrage space of deletions against time during the period January 1990 through December 2002(using average value if there are more than one observations in one day)

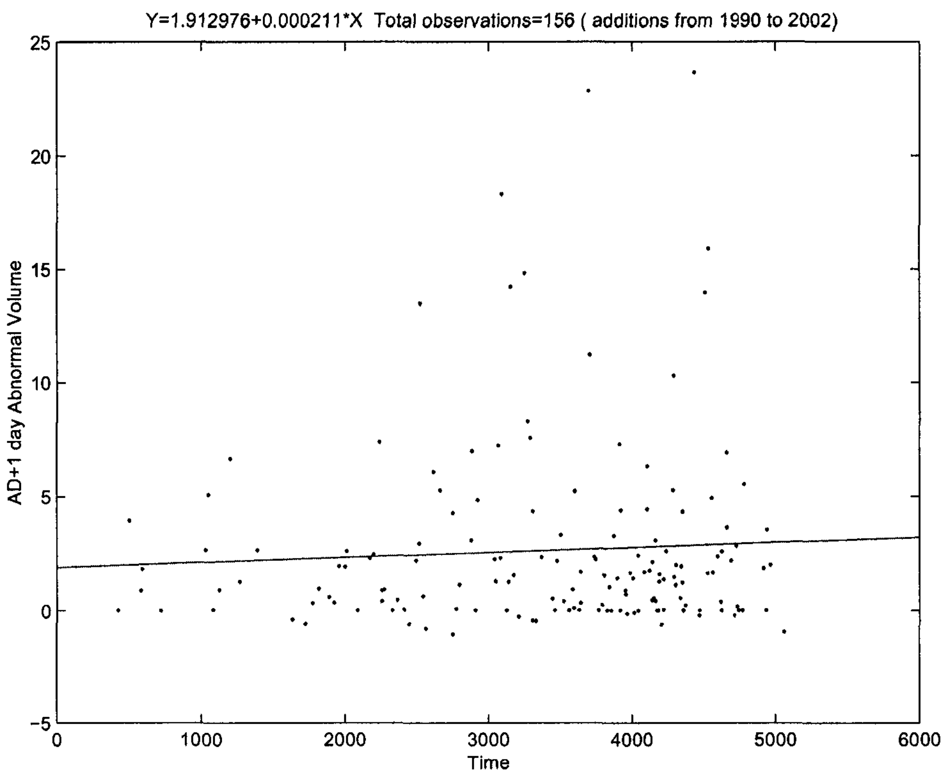

Figure 3.9: AD+1 day abnormal volume against time for additions(using average value if there are more than one observations in one day)

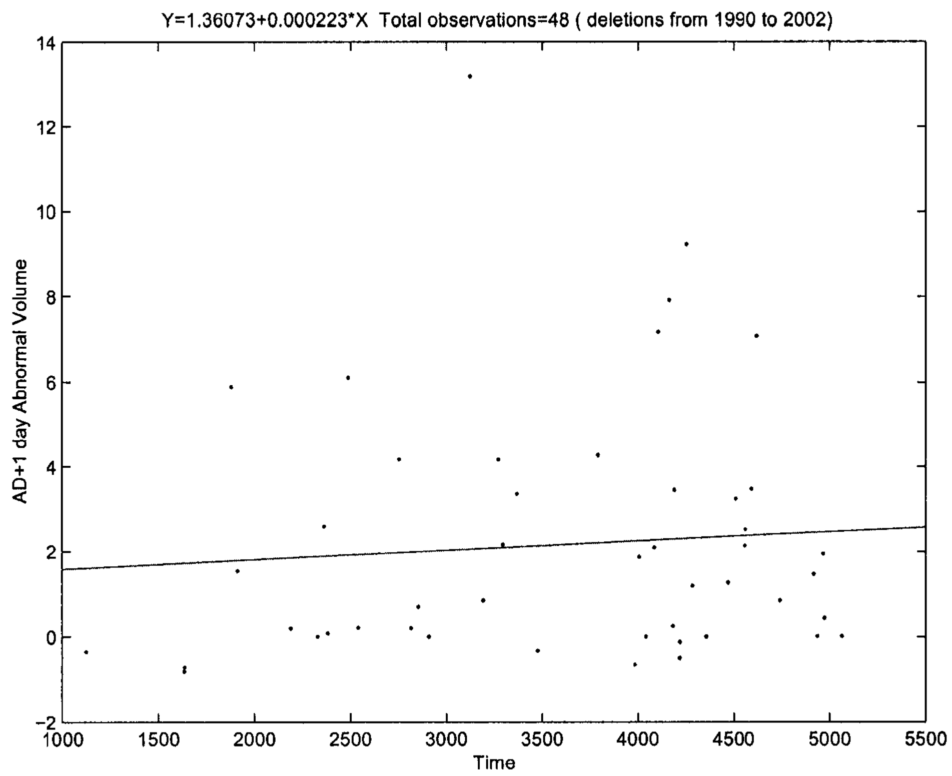

Figure 3.10: AD+1 day abnormal volume against time for deletions(using average value if there are more than one observations in one day)

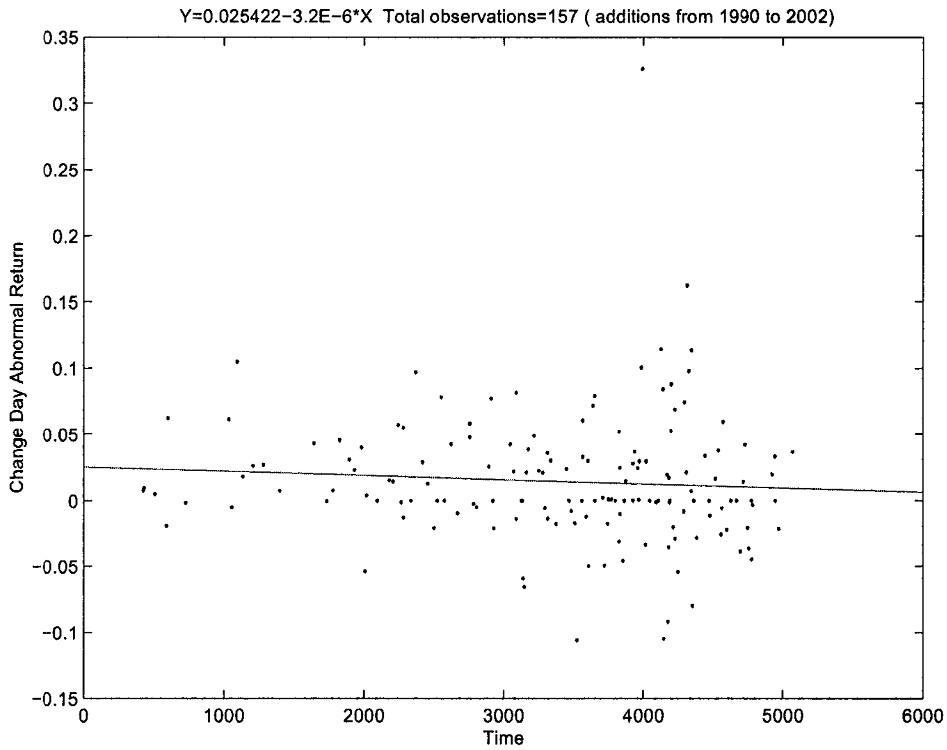

Figure 3.11: Change day abnormal return against time for additions(using average value if there are more than one observations in one day)

more people are taking advantage of this arbitrage by selling these stocks on CD.

3.4.4 Index Fund Premium

The second dynamic evolution that I want to present here is the dynamic change of index fund premiums from 1990 to 2002. I define index fund premium as the cumulative abnormal return from announce day to change day. Figure 3.13 and 3.14 show the evolvement of index fund premiums from 1990

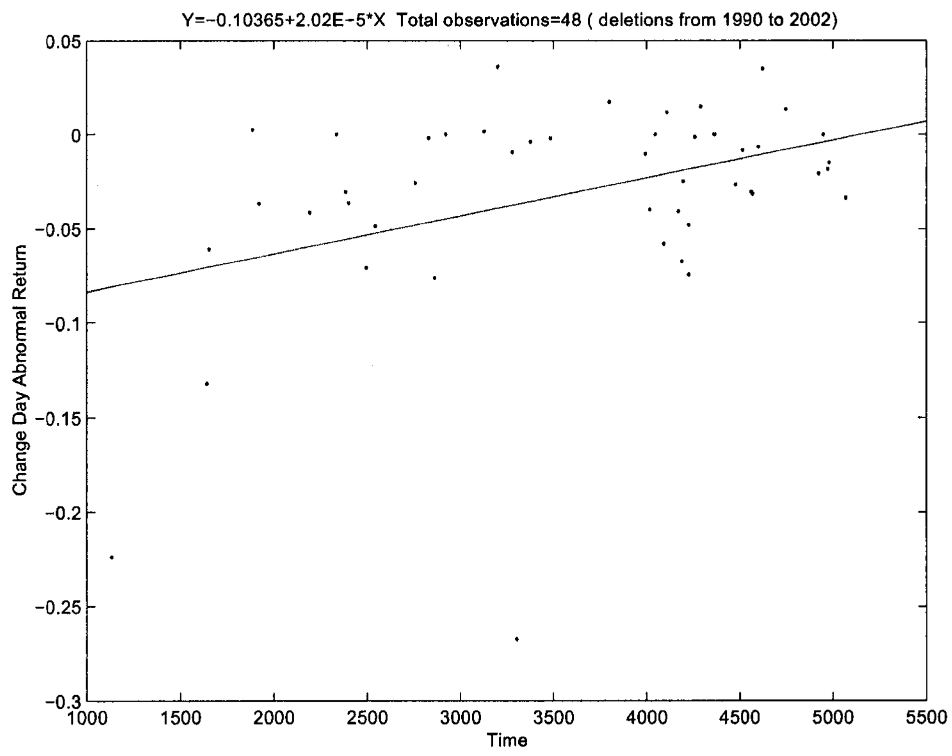

Figure 3.12: Change day abnormal return against time for deletions(using average value if there are more than one observations in one day)

to 2002.

Both additions and deletions show decline of this index fund premium. The decline for addition is slight while the decline for deletion is obvious. Both tell us, index funds still need to pay a premium in additions and deletions although the magnitude of this premium for deletions declined dramatically during the past decade. I worry about the long-run performance of the index funds because the total premium paid by index fund will accumulate to a significant number as time goes on. This is one of the increasing problems of index funds.

3.4.5 Return Volume relations

Figures 3.15, 3.16, 3.17 and 3.18 show the relationship between abnormal return and abnormal volume on AD+1 and CD. On AD+1 day, the coefficient of correlation between abnormal return and abnormal volume is 0.2227 for additions and -0.1664 for deletions. On change day, it becomes -0.10759 for additions and 0.09464 for deletions.

Previous studies have documented the positive contemporaneous correlation between a stock's trading volume and its return. Most of these researches found a positive correlation between contemporaneous trading volume and price changes.

My outcome on the announce day is consistent with these findings. Both

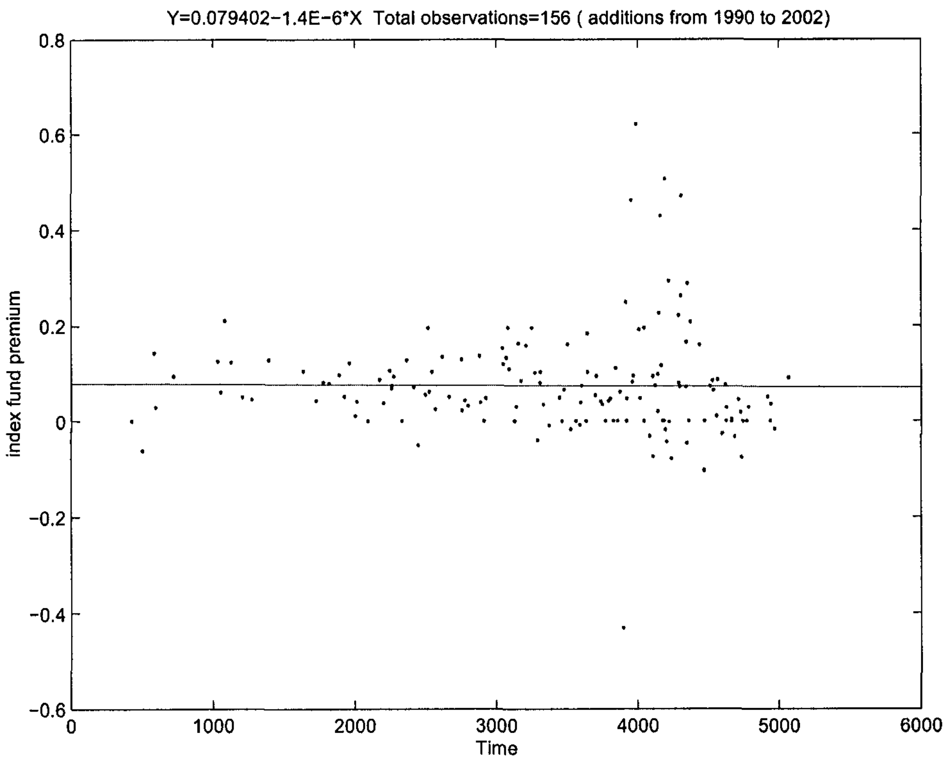

Figure 3.13: Index fund premium against time for additions from 1990 to 2002 (using average value if there are more than one observations in one day)

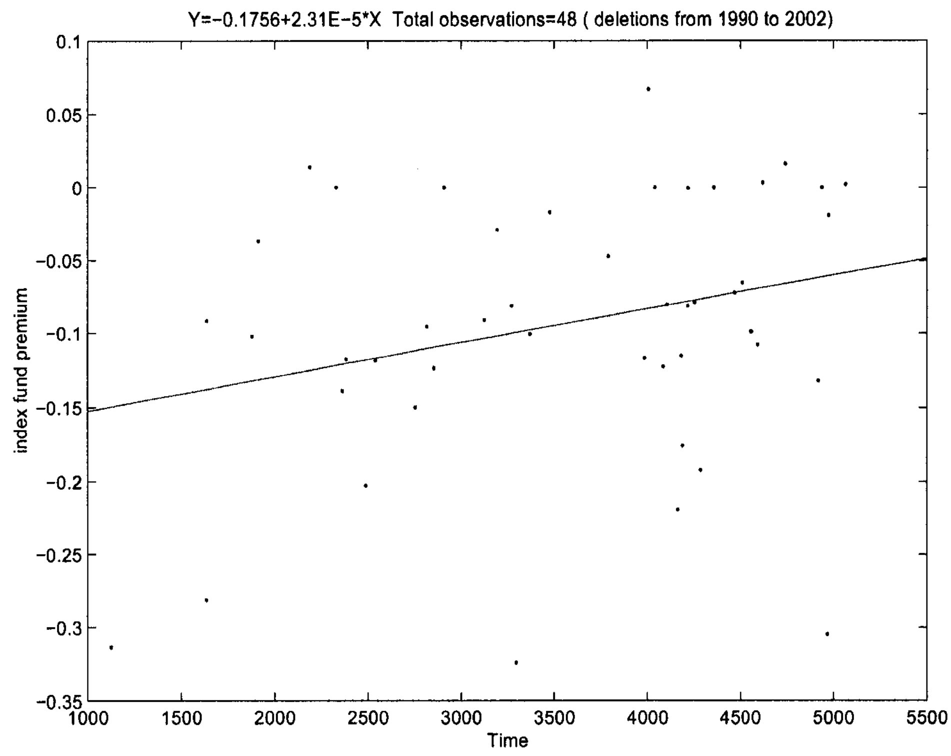

Figure 3.14: Index fund premium against time for deletions from 1990 to 2002 (using average value if there are more than one observations in one day)

figures 3.15 and 3.16 show a positive correlation between contemporaneous trading volume and absolute price changes. I also found that the directions of price changes are on the opposite side for additions and deletions. My outcome demonstrates volume does not predict direction, but only price volatility. It is the nature of information (good or bad) causing the abnormal volume which decides the directions of stock movements. For additions (good), the direction is positive; For deletion (bad), the direction is negative.

More interestingly, my outcome on change day (figure 3.17 and 3.18) is inconsistent with what has been found in previous studies. The correlation between contemporaneous trading volume and absolute price changes is negative on change day. I believe this difference is caused by the different information content of abnormal volume on announce day and change day. The announce day abnormal volume is caused by information while the change day abnormal volume does not indicate any additional information, it is only caused by the changing of index funds. From this, I can also conclude that information plays an important role in the relationship between abnormal volume and abnormal return. The volume is only a proxy of information flow in some cases.

3.5 Equity Markets Conclusion

This chapter studies the equity markets addition and deletion effects of the Standard & Poor's 500 index from 1990 to 2002. I found direct evidence re-

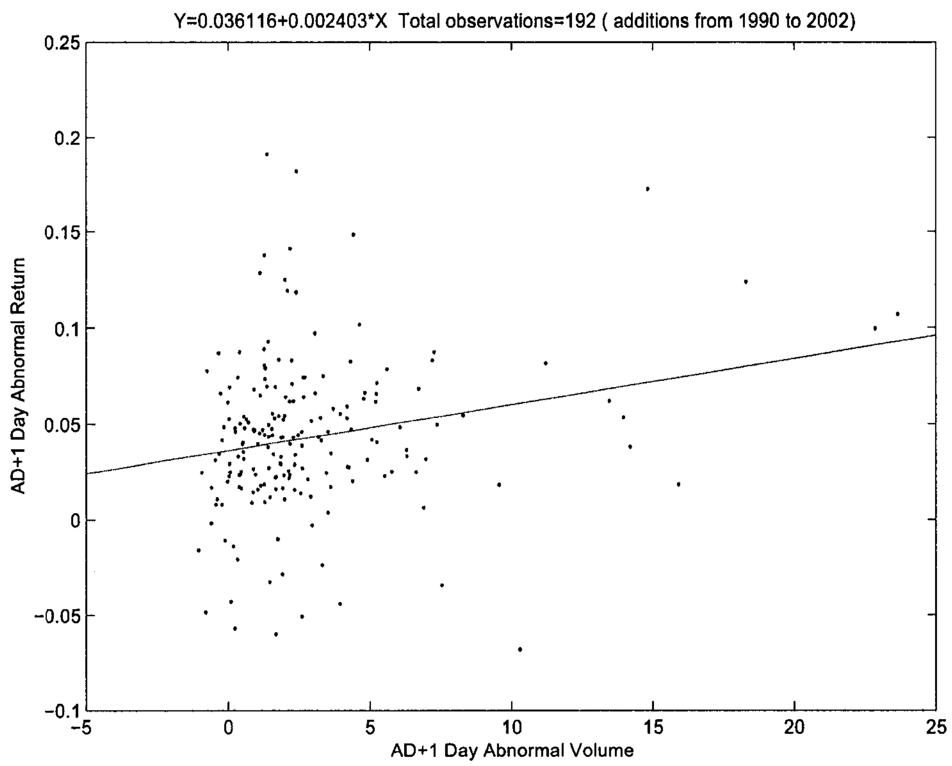

Figure 3.15: Relationship between abnormal return and abnormal volume on AD+1 day for additions

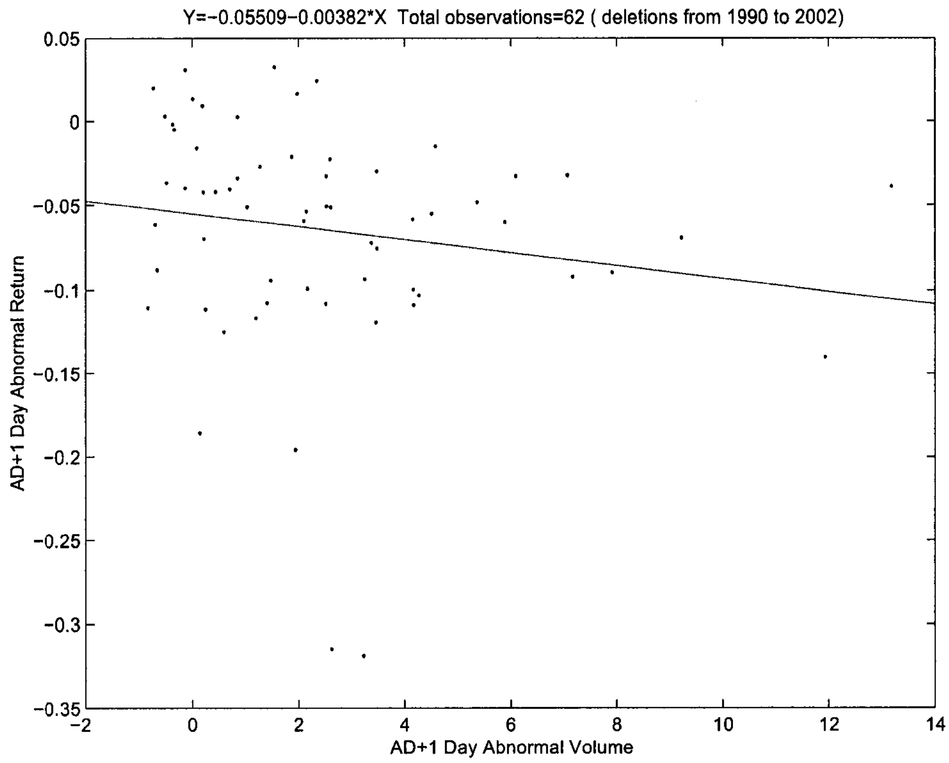

Figure 3.16: Relationship between abnormal return and abnormal volume on AD+1 day for deletions

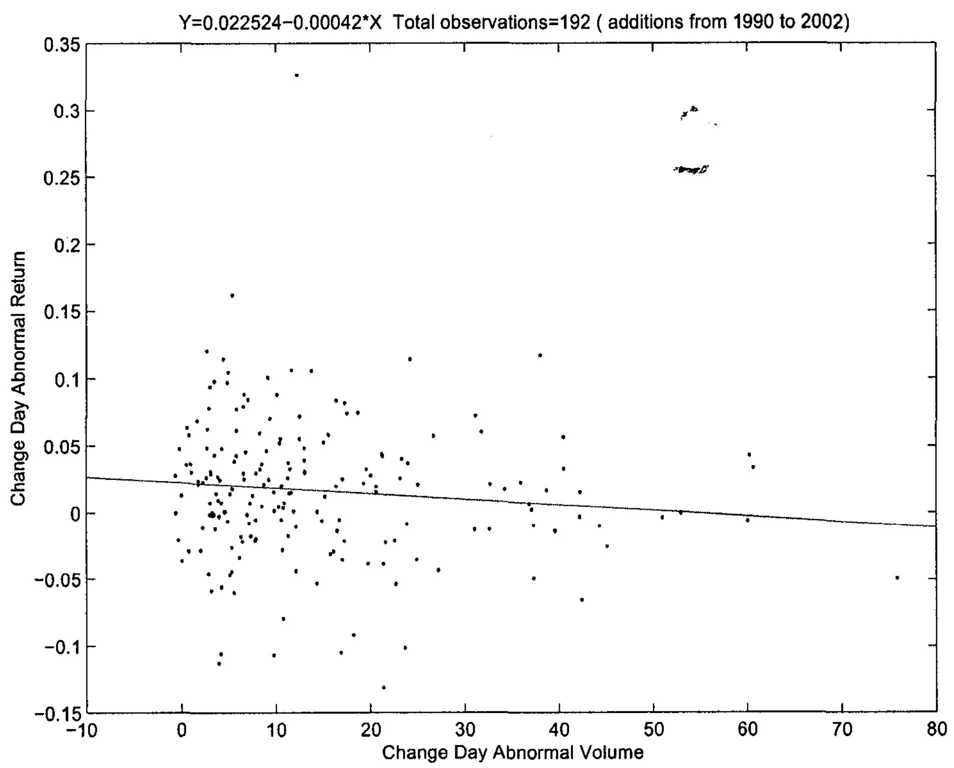

Figure 3.17: Relationship between abnormal return and abnormal volume on change day for additions

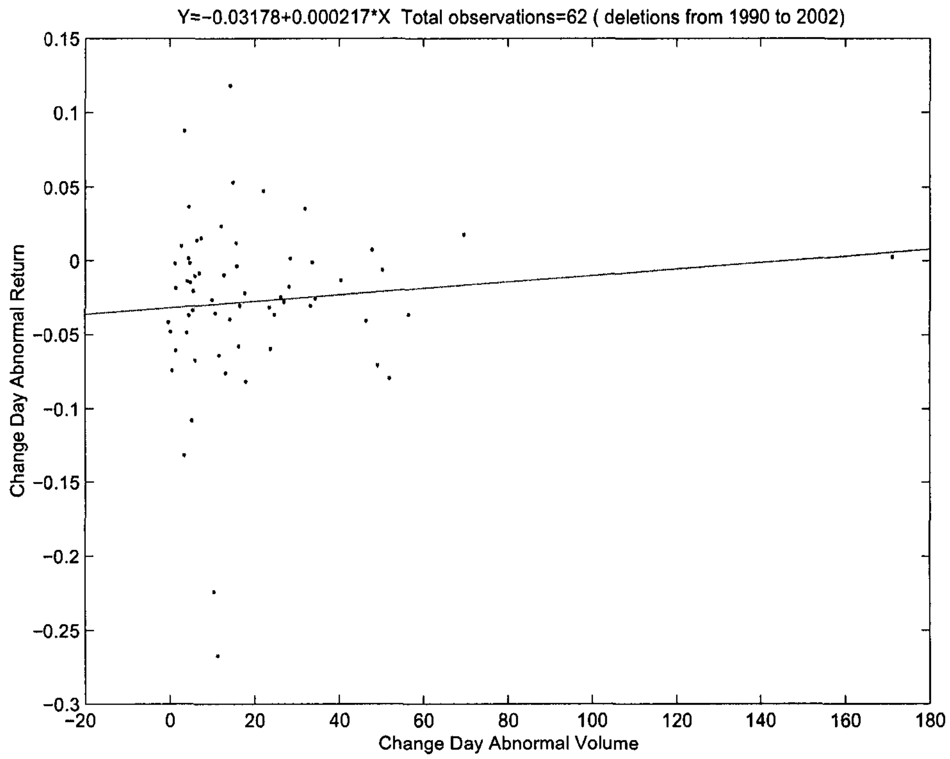

Figure 3.18: Relationship between abnormal return and abnormal volume on change day for deletions

jecting the downward-sloping long-run demand curves hypothesis which has been supported by most of the prior studies for decades. I demonstrated that the demand curves are only downward-sloping in the short-run and horizontal in the long-run. I also focused my research on the dynamic evolution of these effects from 1990 to 2002 which indicates markets are becoming increasingly efficient. Markets need time to adjust to semi-strong form market efficiency when there are some structural changes or new information comes in. I use this sample to demonstrate the relationship between volume, return and information. My outcome indicates volume does not predict direction, but only price volatility. It is the nature of information (good or bad) which causes the abnormal volume which decides the directions of stock movements. Information plays an important role in the relationship between abnormal volume and abnormal return. The volume is only a proxy of information flow in some cases. This paper also shows how human behaviors such as risk aversion can influence market efficiency in the short-run and how market evolves from inefficiency to efficiency in the long-run. The short-run profits of traders come from the short-run inefficiency of markets. I worry about the long-run performance of the index funds, because the total premium paid by index funds will accumulate to a significant amount as time goes on. This is one of the uprising problems of index funds.

There are a total of 353 S & P 500 index changes (353 additions, 353 deletions) from 1990 to 2002. My clean sample contains 192 additions and 62 deletions from 1990 to 2002. I found a mean cumulative abnormal return from AD to CD of 8.44% for additions and -11.10% for deletions. The abnormal returns still remain at 6.19% for additions and -6.20% for deletions 20 days after change day. I found an arbitrage space of 3.2% for additions and -6.7% for deletions which use the strategy of buying/selling at the open of AD+1 and covering those positions at the close of CD. I found indications of leakage of information and inside trading.

I found the degree of price movements for additions and deletions are asymmetric from announce day to change day. This asymmetry indicates people are risk averse and irrational in the short-run. Finally, the addition and deletion effect become symmetric on CD+20. This indicates that human behaviors influence the market prices in the short-run and cause a period of inefficient market while most of these irrational behaviors will reverse to efficient levels in the long-run.

My findings directly rejects the downward sloping long-run demand curves hypothesis. I divide the total abnormal return between announce day and change day into two parts. The first part was the abnormal return between AD and CD-1, most of it is caused by new information released on AD; the second part is the abnormal return on CD, most of it caused by short-run downward-sloping demand curves on CD. The later part are totally reversed several days later and part of the first part also reversed on CD+20 in my research. The change day abnormal return can be only explained as the evidence of downward-sloping short-run demand curves not long-run. The abnormal return on CD reversed several days later which indicates the long-run demand curve of stocks are horizontal.

By analyzing the evolution of this effect, I found as time goes on, the arbitrage spaces become smaller. Markets become more efficient. The analysis also demonstrated the periodic inefficiency of markets. When there are some changes or new information comes into market places, markets will become inefficient in the short-run and it will take some time to recalibrate the market from inefficiency to efficiency. Markets need time to adjust to semi-strong form market efficiency when there are some structural changes or new information comes in. I call these periods of adjustment inefficiency windows. I believe the length of an inefficiency window is decided by how fast markets can understand and take advantage of the new information. The more difficult the market acclimate to the changes or new information, the longer it will take to return the market to efficiency. The short-run profits of traders come from the short-run inefficiency of markets.

Both additions and deletions' index fund premium declined from 1990 to 2002. The decline for addition is slight while the decline for deletion is obvious. However, index funds still need to pay a premium in additions and deletions although the magnitude of this premium for deletions declined dramatically during the past decade. I worry about the long-run performance of the index funds because the total premium paid by index funds will accumulate to a significant amount over time.

My outcome of the volume return relationship on announce day is consistent with previous findings. Both additions and deletions show a positive correlation between contemporaneous trading volume and price changes on announce day. I also found the directions of price changes are on the opposite side for additions and deletions. My outcome demonstrates volume does not predict direction, only price volatility. It is the nature of information (good or bad) that causes the abnormal volume which decides the directions of stock movements. For additions (good), the direction is positive; for deletions (bad), the direction is negative.

I found the volume return relationship on announce day and change day are different. The correlation between contemporaneous trading volume and price changes is positive on announce day and negative on change day. I believe this difference is caused by the different information content of abnormal volume on announce day and change day. The announce day abnormal volume is caused by information while the change day abnormal volume does not indicate any additional information. I can conclude that information plays an important role in the relationship between abnormal volume and abnormal return. The volume is only a proxy of information flow in some cases.

Chapter 4

Option Markets Study

4.1 Chapter Structure and Data

This chapter will study the behavior of option markets for these stocks added or deleted from S & P 500 index from 1996 to 2002. My research focuses on the post-October 1989 effect. This is the first research which uses options data to study these addition and deletion effects. It is the recent available of the historical option data make this research possible.

Based on these equity markets results, my option markets research will be very helpful in explaining the puzzle of underlying stock price changes around the index changes. Option markets are a useful source of information for gauging market sentiment about future values of financial assets. Equity and future prices can only reveal one point of markets expectations, while option prices can indicate the whole shape of the markets expectations. More importantly, index funds only change their portfolios on equity markets. Option markets will be able to release markets attention and information changes without the influence of index funds.

This research contributes to the literature in several ways. First, it presents the behavior of option markets of S&P 500 index changes for the first time. Second, this research finds evidence supporting the liquidity hypothesis and information hypothesis from the option side. Third, I found that Standard & Poor prefers to delete stocks which have left-shift implied RNDs and add stocks which have right-shift implied RNDs. Fourth, I found evidence of active arbitrage activities and heavy inside trading activities for the index changes.

I collected data for this study from several sources. The index addition and deletion information including announcements and changing dates are collected from Standard & Poor's 500 Directory (1996-2002). For some announcement and changing dates which are not provided by Standard & Poor's 500 Directory, I checked Wall Street Journal. Equity information such as prices is from Bloomberg or Reuters (1996-2002). Stock specific information (for example, the reason of stock changes) is from Wall Street Journal. Option information such as option volumes, open interests and option prices is from OptionMetrics.

The later part of this chapter is organized as follows: In section 4.2, I talk about option markets data selection. In section 4.3, I present the basic option markets analysis. In section 4.4, I derive implied risk-neutral probability density functions. Finally, I conclude option markets results in section 4.5.

4.2 Option Markets Data Selection

There are all together 256 S & P 500 index changes (256 additions, 256 deletions) from 1996 to 2002. Because a significant number of index changes are caused by substantial fundamental changes of deleted companies (merger, acquisition, bankruptcy, restructure ...) and those fundamental changes will usually cause huge option market movements near index change time, I removed a number of securities in order to study the clean index change effect of the option markets. I classified the reason of deleting securities from my sample into five categories.

(1) I can not find data of one form or another for a security. 102 addition stocks and 51 deletion stocks are deleted from my sample because of the lack of data.

(2) There are some index changes for which no trading is required by index funds, such as name changes or replacements due to part of a company spinning off and the child or parent company remaining in the index. 31 additions are removed because of this reason.

(3) Any big changes related with other companies, such as merger, acquisition, split activities and takeover. I searched Wall Street Journal articles close to the change time. Any company which was mentioned in connection

with such activities around change time will be deleted from my sample. 1 additions and 130 deletions are kicked out because of this (This is the most popular reason for Standard & Poor's Index Committee delete one stock from S & P 500 index).

(4) Bankruptcy, restructuring or recapitalization. There are 30 deletions are removed because of this reason.

(5) There are not enough numbers of trading days between announcement day and change day. I require there is at least one day between announcement day and change day. If the change day just follows the announce day, those changes will be the same as pre-1989 changes. I deleted 32 additions and 9 deletions because of this.

Finally, my sample contains 90 additions and 36 deletions. Figure 4.1 and 4.2 show the frequency distributions of the number of trading days of those additions and deletions between the announcement day and the effective day. The range of additions is from one to sixty nine trading days. The range of deletions is from one to thirteen trading days. The mean days of additions is 5.05 trading days. The mean days of deletions is 4.24 trading days. The outliers of additions at sixty nine and fifty trading days are the State Street Corp addition in 1997 and the Quintiles Transnational addition in 1999.

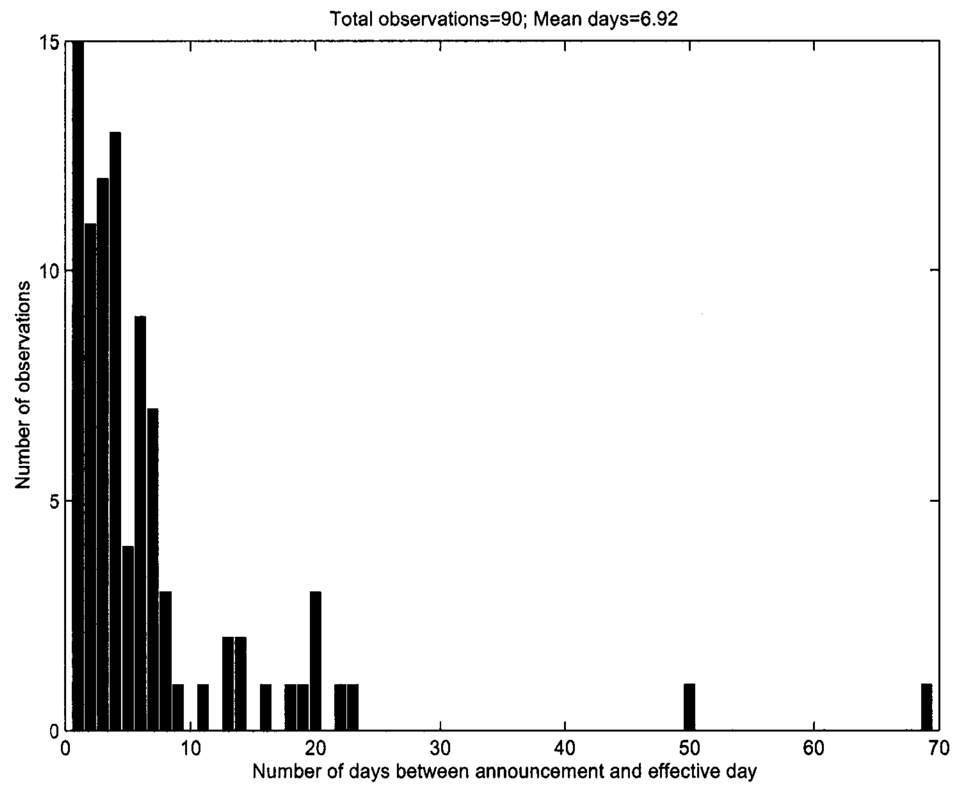

Figure 4.1: Frequency distribution of the number of trading days between the announcement day and the effective day for the sample of 90 additions during the period January 1996 through December 2002

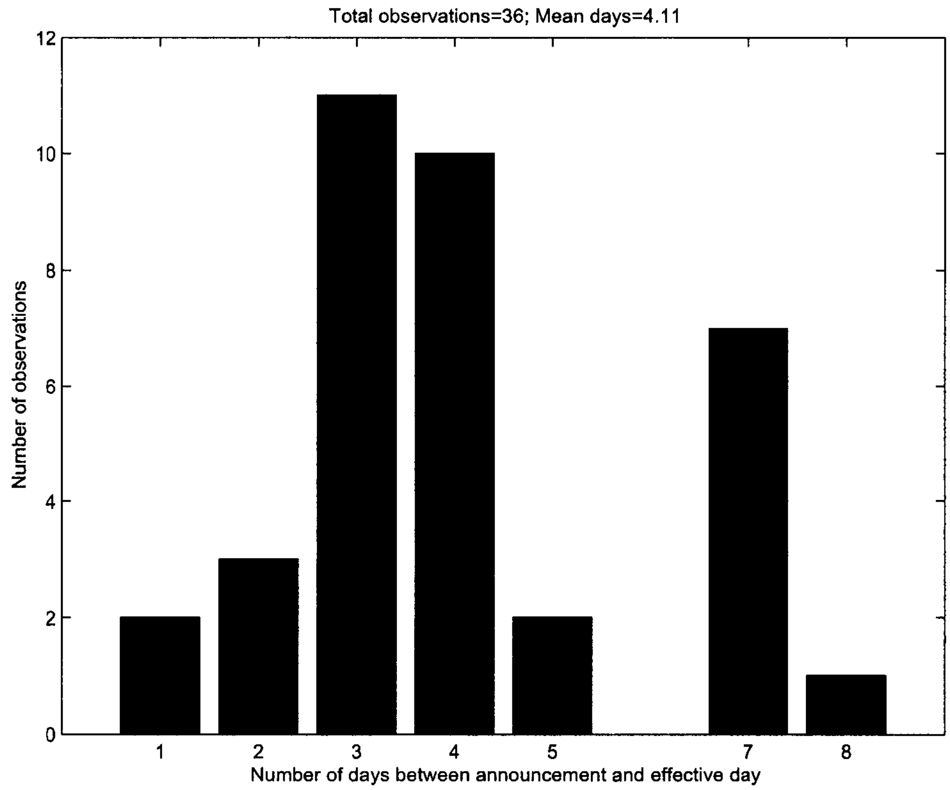

Figure 4.2: Frequency distribution of the number of trading days between the announcement day and the effective day for the sample of 36 deletions during the period January 1996 through December 2002

4.3 Basic Option Markets Analysis

In this section, I analyze option markets price, volume, open interest and sensitive information (Implied Volatility, Delta, Gamma, Vega, Theta).

The same as last chapter, I use an event-study methodology with two event dates for each sample in the following chapter: The announcement date of the addition/deletion, I call AD and the effective date of the addition/deletion , I call CD. Standard & Poor always announces changes after market closing of a particular day, therefore the first day of possible prices movements on option markets is AD+1 day. Standard & Poor will implement those changes using the closing price of the change day (CD). CD is the day on which most index funds will re-balance their portfolios.

4.3.1 Definitions and Measurements

Before starting my research, I need to introduce definitions and measurements of abnormal option volume and open interest for call and put options. I only present the definitions and measurements of abnormal option volume here. The definitions and measurements of abnormal option open interest are similar.

Definition of Abnormal Option Volume: The call (put) abnormal option volume for stock i on day τ ($AOV_{i\tau}$) is defined as the total volume of every contract for call (put) options with different expiration date and strike price of stock i on day τ ($TOV_{i\tau}$) minus stock i's call (put) ten day average option volume before AD+1 day ($TDAOV_i$) divided by the call (put) ten day average volume before AD+1 day.

$$AOVi\tau = \frac{TOV_{i\tau} - TDAOV_{i\tau}}{TDAOV_{i\tau}} \tag{4.1}$$

Definition of Mean Abnormal Option Volume: I am interested in the measure of the call or put abnormal volume on an event day α which is called mean abnormal option volume for event day α ($MAOV_\alpha$). It is defined as the mathematic average of the call or put abnormal option volume of every stocks I study on that event day.

$$MAOV_\alpha = \frac{\sum_{i=1}^{n} AOV_{i\alpha}}{N} \tag{4.2}$$

Definition of Cumulative Abnormal Option Volume: I am also interested in calculating the call (put) cumulative abnormal option volume between day τ_1 and τ_2 ($CAOV_{i,\tau_1-\tau_2}$). It is defined as the total call (put) option volume of every contract with different expiration date and strike price of stock i between day τ_1 and τ_2 ($TOV_{i,\tau_1-\tau_2}$) minus call (put) $TDAOV_i$ multiply the number of days (ND) between day τ_1 and τ_2.

$$CAOV_{i,\tau_1-\tau_2} = TOV_{i,\tau_1-\tau_2} - ND * TDAOV_i \tag{4.3}$$

Definition of Mean Cumulative Abnormal Option Volume: It is defined as the mathematic average of call (put) cumulative abnormal volumes of every stock between event day τ_1 and τ_2.

$$MCAOV_{\tau_1-\tau_2} = \frac{\sum_{i=1}^{n} CAOV_{i,\tau_1-\tau_2}}{N} \tag{4.4}$$

Because the average day between AD+1 (not include AD+1) and CD (not include CD) is different for additions and deletions, I divided this period to six event periods for additions (period A, B, C, D, E, F) and three event periods for deletions (period A, B, C) to indicate the mean days between AD+1 and CD is near six for additions and three for deletions. The mean abnormal volumes for those periods are calculated by MCAOV between AD+1 (not include AD+1) and CD (not include CD) divided by six for additions and three for deletions.

4.3.2 Significant Test

All significance tests except implied volatilities in this chapter are performed using a cross-sectional variance estimator which is introduced by Asquith (1983) and used by Lynch and Mendenhall (1997). I present this significance tests on abnormal option volume and open interest.

For example, for abnormal option volume, they assume that the $AOV_{i\tau}$s are cross-sectionally independently and identically distributed normal, then the mean abnormal option volume for event day α ($MAOV_{\alpha}$) will be a student t distribution with N-1 degrees of freedom. The cross-sectional variance for this distribution is:

$$S^2[MAOV_{\alpha}] = \frac{1}{N}\sum_{i=1}^{n}\frac{[AOV_{i\alpha} - MAOV_{\alpha}]^2}{N-1} \tag{4.5}$$

The null hypothesis is:

$$H_0 : MAOV_{\alpha} = 0 \tag{4.6}$$

The alternative hypothesis is:

$$H_1 : MAOV_\alpha > 0 \tag{4.7}$$

For abnormal option open interest, I do similar tests.

4.3.3 Basic Option Markets Results

Option Prices

On each day, there are many different option contracts trading for one stock with different expiration dates and different strike prices. To study option price changes, first, I select options that have more than 29 expiration days and less than 118 expiration days (one to four months) on AD. Based on experience, these usually are the most active options. Among them, I select the option contracts that have strike prices closest to 0.95,1 and 1.05 times the underlying stock price on AD closing. Then I study the price changes of these three contracts around the event dates. Every option price is adjusted from absolute price to relative price according to the same option contract price on AD. The benchmark price on AD is assumed to be 10. That is, every option price will divide the same option contract price on AD and multiply 10 before it is used in our study.

The results are presented in figure 4.3 and 4.4 and table 5 to 8. Because the information has been released, the prices change dramatically between AD and AD+1 . Put prices of the addition group and call prices of the deletion group start changing from AD-10 in the correct direction of this information (This information has not been known by the public yet). These changes become significant since AD-5. This may indicates heavy inside trading. (if only small inside trading exists, it would not cause significant changes). I did not find similar behaviors for call prices of the addition group and put prices of the deletion group. This may because arbitragers are more likely to use calls of the addition group and puts of the deletion group(I will show this later).

Like the underlying stock markets, there are abnormal returns from AD+1 to CD except for put options of the addition group. The abnormal return Between AD+1 and CD for call options of the addition group, call and put options of the deletion group are 2%, 17.74% and 35% respectively, according to correct positions.

Sensitive Information

OptionMetrics' standard option price file contains implied volatilities and other sensitive information on "standardized" (interpolated) options (at-the-money-forward options with expirations of 30, 60, 91,182,273, 365, 547, 730, 912, 1095 calendar days). For example, it calculates standardized option implied volatilities only if there exists enough option price data on that date to accurately interpolate the required values. I use these implied volatilities di-

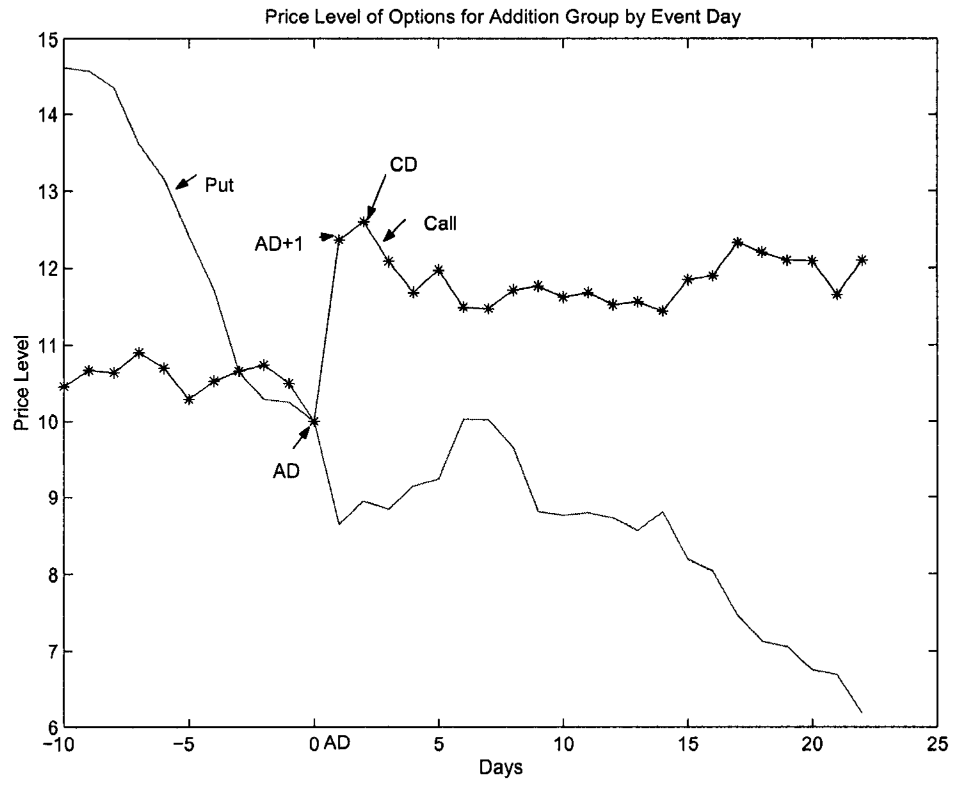

Figure 4.3: Mean price level of call and put options of addition group by event day with strike price closest to the underlying stock price on AD closing. 10 is the benchmark price on AD.

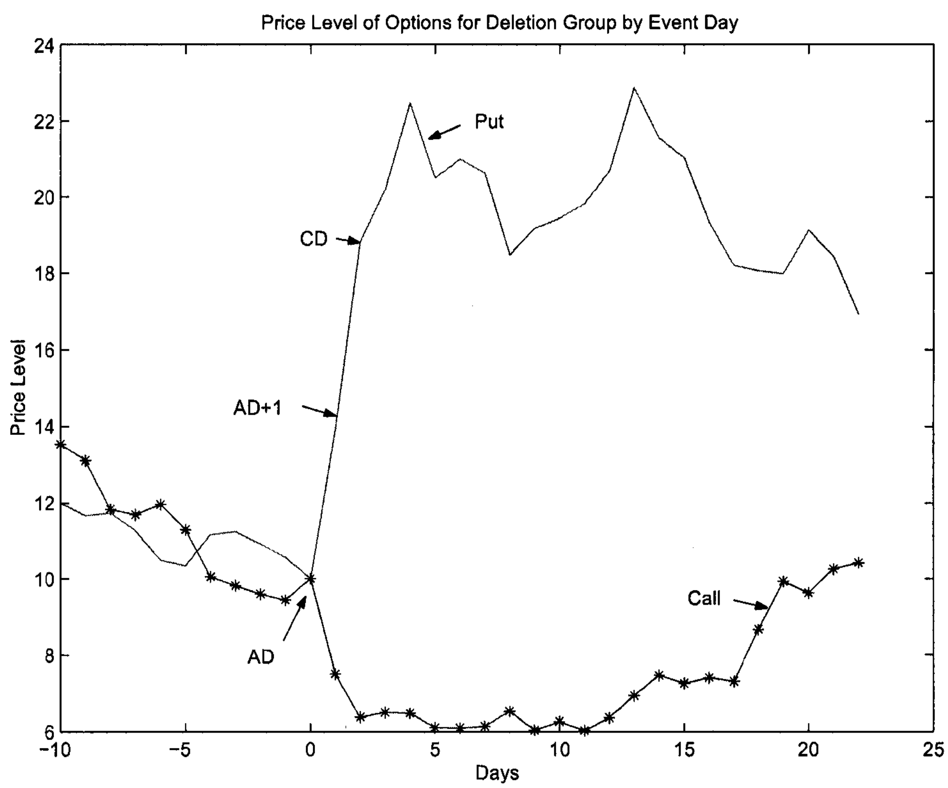

Figure 4.4: Mean price level of call and put options of deletion group by event day with strike price closest to the underlying stock price on AD closing, 10 is the benchmark price on AD

rectly in calculating out our mean implied volatilities. I present these mean implied volatilities on "standard" at-the-money options with expiration of 91 calender days in table 9 and 10. Table 9 and Table 10 also present other sensitive information like Delta, Gamma, Vega, Theta.

The significant test we used to compare two group of implied volatilities is the Goldfeld-Quandt F test. The Goldfeld-Quandt F test compares the variances of two groups and rejects if the variances differ. If there is no difference between these variances, the Goldfeld-Quandt F statistic is exactly 1, otherwise it will differ from 1. Although the Goldfeld-Quandt F statistics become much bigger than 1 after CD for deletion group, I did not find any of these implied volatilities significantly different from these implied volatilities on AD-10 at 5% and 1% significant level.

I use T-test for other sensitive information. The same as implied volatilities, I can not find any change significant.

Abnormal Option Volume and Open Interest

Table 11 to table 18 present numerical data of mean abnormal option volumes (MAOVs) and mean abnormal open interests (MAOIs) for additions and deletions from AD-10 to CD+20 . The MAOVs between AD+1 and CD are displayed as if each daily MAOV over this interval was the interval's MCAOV divided by six for additions and three for deletions. MAOIs between AD+1 and CD are calculated out by the same method.

Both the MAOVs and MAOIs on the day after announce day are significant and extremely big. For example, the MAOV for call option additions is 1779.32% on AD+1 and is significant at 1% significant level. The MAOVs and MAOIs are also extremely big between AD+1 and CD, but they begin to decrease after CD. The MAOVs and MAOIs are still positive and three of the four MAOIs are significant on CD+20.

Unlike the abnormal volume for equity markets, these abnormal volumes and open interests cannot be explained by the activities of index funds. However, they can be explained by investor awareness. For the addition group, all MAOVs and MAOIs increased after AD and most of them significantly increased. For the deletion group, most MAOVs and all MAOIs increased after AD, some of them significantly. Some MAOVs did decrease for the deletion group, but only two of them significantly. These findings are consistent with Chen, Noronha and Singal's assumption that investor awareness can increase following a stock's addition to the index, but awareness does not easily diminish when a stock is deleted from the index. In stead of awareness diminishing for deleted stocks, I find market awareness even increases for these stocks, because the dramatic price movements around these deletions attract investor awareness. This support the liquidity hypothesis and are consistent with Chen, Noronha and Singal's explanation of the asymmetric price response.

Most MAOVs and MAOIs on AD are relatively big compared to these measurements before AD and the MAOV and MAOI of put options for additions are significant. Because only the heavy inside trading can cause significant changes, the significant MAOV and MAOI can be seen as evidence of heavy inside trading on AD.

Because most index funds change most of their portfolios on change day, the research based on the equity market found huge abnormal volumes on change day. However, for the option markets, most abnormal values happened after AD and before CD. Compared to the total abnormal volume between AD and CD, the CD's abnormal volume was relatively small. Only call options' abnormal volume for addition on CD was relatively big. Obviously, these abnormal volumes cannot be explained by the activities of index funds. More interestingly, the open interest level increased dramatically from AD+1 to CD-1 and then decreased dramatically on CD. At the end of CD, the open interest level even come back to the level before announcement. Although the volume level remained bigger than the ten-day average volume before AD, the open interest level came back to normal level immediately on CD. Obviously, some people take positions on AD+1 and then cancel these positions on CD. In other words, some people are taking arbitrage between AD and CD.

The MAOV for AD1 additions is 1779.32% for call options and 3048.36% for put options; while for AD1 deletions, it becomes 5386.76% for call options and 3936.73% for put options. For additions on AD1, the put option MAOV is 1.71 times of that for call options; while for deletions, the call option MAOV is 1.37 times of that for put options. For addition group, put option's MAOV increase much more than call option's MAOV. For deletion group, call option's MAOV increase more than put option's MAOV. This is strange. One possible explanation is that, for additions, arbitragers will buy the underling stocks on the AD1 and also buy put options at the same time to hedge the position; While for deletions, they will short the underlying stocks and buy call options at the same time to hedge the position. The combination of equity markets and option markets may involve some arbitrage opportunities. This also explains why we can not find evidence of inside trading for call of the addition group and put of the deletion group.

4.4 Implied Risk-Neutral Probability Density Function

In order to present the whole option markets respondences to the S & P 500 additions and deletions, I estimated the mean implied risk-neutral probability density function (PDF) from option prices . These PDFs will release markets sentiment around index changes.

4.4.1 Background Introduction

Cox and Ross (1976) first demonstrated how to relate call option prices to risk-neutral densities. Cox and Ross (1976) showed, for the European options, the price of the call option with strike X can be written in terms of the risk-neutral PDF for the underlying price ($f(S_T)$) where $e^{-r.T}$ is the relevant discount factor:

$$c[X] = e^{-r.T}.\int_X^{\infty}(S_T - X).f(S_T)dS_T \tag{4.8}$$

Breeden and Litzenberger (1978) showed that if the underlying price at time T has a continuous probability distribution, then the state price at state S_T is determined by the second partial derivative of the European call option pricing function for the underlying asset(s) with respect to the exercise price, $\partial^2 c/\partial X^2$, evaluated at an exercise price of X=S_T. It follows that $\partial^2 c/\partial X^2$ is directly proportional to the risk-neutral probability density function of S_T. All of the techniques for estimating terminal PDF from options prices can be related to this result.

$$\frac{\partial^2 c[X]}{\partial X^2} = e^{-r.T}.f(S_T) \tag{4.9}$$

There are a number of different techniques currently used to estimate PDFs, most of which are based on the above theories. These techniques were classified by P H Kevin Chang and William R Melick in the background note of the workshop on estimating and interpreting probability density functions in 1999 into three areas:

(1)Recovering the underlying asset's stochastic process, and then derive PDF from the underlying asset's stochastic process.

(2)These techniques use equation (4.8) - setting up assumptions about the form or family of the PDF, and estimate the parameters of the PDF such that predicted option prices best fit the observed option prices.

(3) These techniques use equation (4.9) - using a variety means to generate the function c[X] and then differentiating the function twice to obtain the PDFs.

Making use of equation (4.9), Shimko (1993) was one of the first to recover the risk-neutral PDF. Shimko used the Black-Scholes formulae to translate a scatter-plot of option prices against strike prices into a scatter plot of implied volatilities against strike prices. He then fitted the volatility with the strike price by a quadratic equation, wrote the Black-Scholes equation in terms of only the strike price, and finally differentiated this equation twice to get the PDFs.

Malz (1997) also used equation (4.9), obtained a scatter plot of implied volatility against delta, then fitted a particular function form to this scatter-plot, wrote the option pricing equation in terms of the strike price, finally differentiated this equation twice to get the PDFs.

Based on equation (4.9), Jackwerth and Rubinstein (1996) propose a maximum smoothness criteria that essentially uses a butterfly spread variant of equation (4.9) to minimize the curvature in the resulting implied PDFs. Ait-Sahalia and Lo (1998) used a non-parametric kernel method to generate PDFs.

There are also a lot of techniques which are based on equation (4.8), making use of a nonlinear optimization method to find the exact form of the PDF that produces predicted option prices that are close to the observed option prices.

For example, Sherrick, Garcia and Tirupattur(1996), specified a Burr PDF and estimated the parameters of this density by minimizing the sum of squared option pricing errors.

Melick and Thomas (1997), using a model proposed by Ritchey (1990), specify that the PDF is to be a mixture of lognormal densities, providing bounds on American options on futures that are similar to equation (4.8) in that they are written in terms of the PDF. In their application to the crude oil market, they used a mixture of three lognormals, other analysts applying their technique have often used a mixture of two lognormals. Mizrach (1996) also specifies that the density is a mixture of lognormals.

In a related approach, Buchen and Kelley (1996) proposes a maximum entropy estimate of the distribution. Madan and Milne (1994) propose a finite Hermite polynomial expansion to estimate the PDF. Corrado and Su followed a very similar approach to recover implied measures of skewness and kurtosis.

4.4.2 Method

In my dissertation, I use the two-lognormal mixture approach which was first introduced by Melick and Thomas (1997) in estimating American style options and later applied by Bahra (1997) in estimating European style options. As was pointed out by Melick and Thomas (1997), it is more natural to begin with an assumption about the future distribution of the underlying asset, rather than the stochastic process by which it evolves, and to use option prices to directly recover the parameters of that distribution. It is because a given terminal distribution encompasses many stochastic process, while a given process is consistent with only one terminal distribution.

With European style options, the relationship between the distribution of futures prices and the option price is very clear. For calls (puts), the value of the option is simply the value of the portion of the distribution above (below) the strike discounted back to the present using an appropriate interest rate (See Cox and Ross 1976).

$$c[X] = e^{-r.T}.\int_X^\infty (S_T - X).f(S_T)dS_T \quad (4.10)$$

$$p[X] = e^{-r.T}.\int_X^\infty (X - S_T).f(S_T)dS_T \quad (4.11)$$

In theory any reasonable functional form for the density function, $f(S_T)$, can be used in equation (4.10) and (4.11). For example, Melick and Thomas (1997) used a mixture of three lognormal distributions and Bahra (1997) used a mixture of two lognormal distributions. However their results usually have two or three peaks (see figure 4) which is inconsistent with the reality we found in figure 4.5.

Figure 4.5 shows the frequency distribution of SPX daily returns from 1/1/1996 to 31/12/2002 compared with the Normal distribution. We found that the distribution of stock price returns is highly peaked and fat-tailed relative to the Normal distribution. Fat tails and the high central peak are characteristics of mixtures of Normal distributions with the same mean and different variances.

Further more, Malz (1995b) found that a Bernoulli distribution jump-diffusion process consist with the terminal implied RND function which is

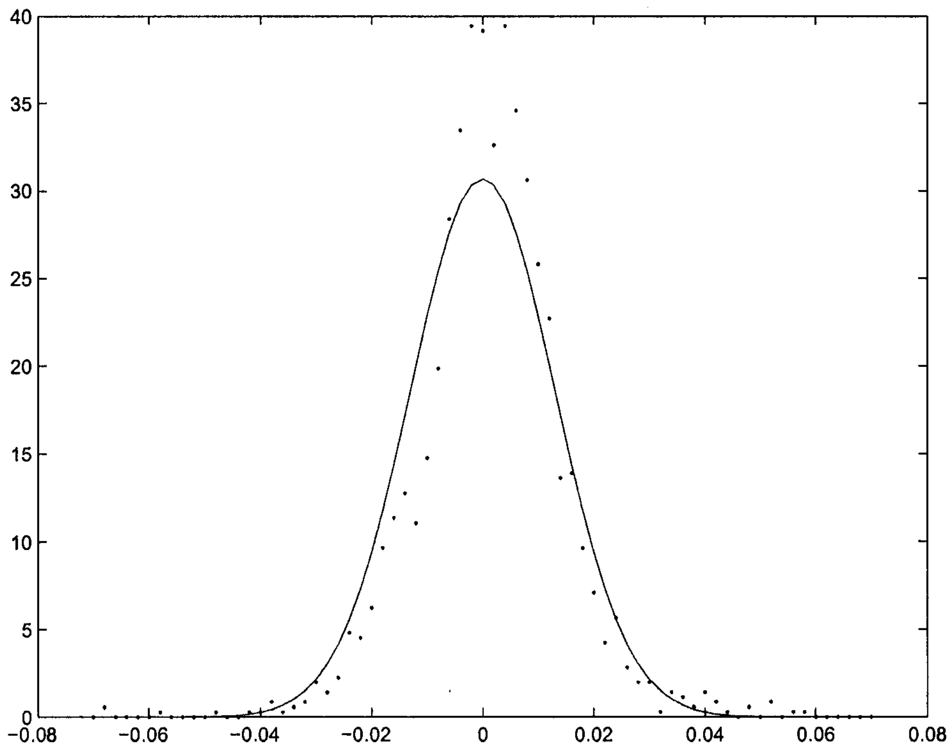

Figure 4.5: Frequency distribution of SPX daily returns from 1/1/1996 to 31/12/2002 compared with the Normal distribution

a mixture of two lognormal distributions. He assumes that exchange rates evolve according to a Bernoulli distribution jump-diffusion process and uses risk reversal prices to recover the parameters of this model. Finally, Malz derived a closed-form solution for the terminal implied RND function which is a mixture of two lognormal distributions. Also, given that the distribution of stock price returns is highly central peaked and fat-tailed relative to the Normal distribution , I use the two-lognormal mixture with the same mean approach in our study. The two-lognormal mixture distribution can incorporate a wide variety of possible functional forms while the same mean makes the implied RND one central peak only.

Equation 4.12 and 4.13 show the function form of our density function. Figure 4.6 shows the estimation results of the mixture of two (A) and three (B) lognormal distributions with different means and the mixture of two lognormal distributions with the same mean (C).

$$f(S_T) = \theta L(\alpha, \beta_1; S_T) + (1 - \theta) L(\alpha, \beta_2; S_T) \tag{4.12}$$

$L(\alpha_i, \beta_i; S_T)$ is the lognormal density function.

$$L(\alpha_i, \beta_i; S_T) = (\frac{1}{\sqrt{2\pi}\beta_i . S_T}).exp[-(\frac{ln(S_T) - \alpha_i}{\beta_i})^2/2] \tag{4.13}$$

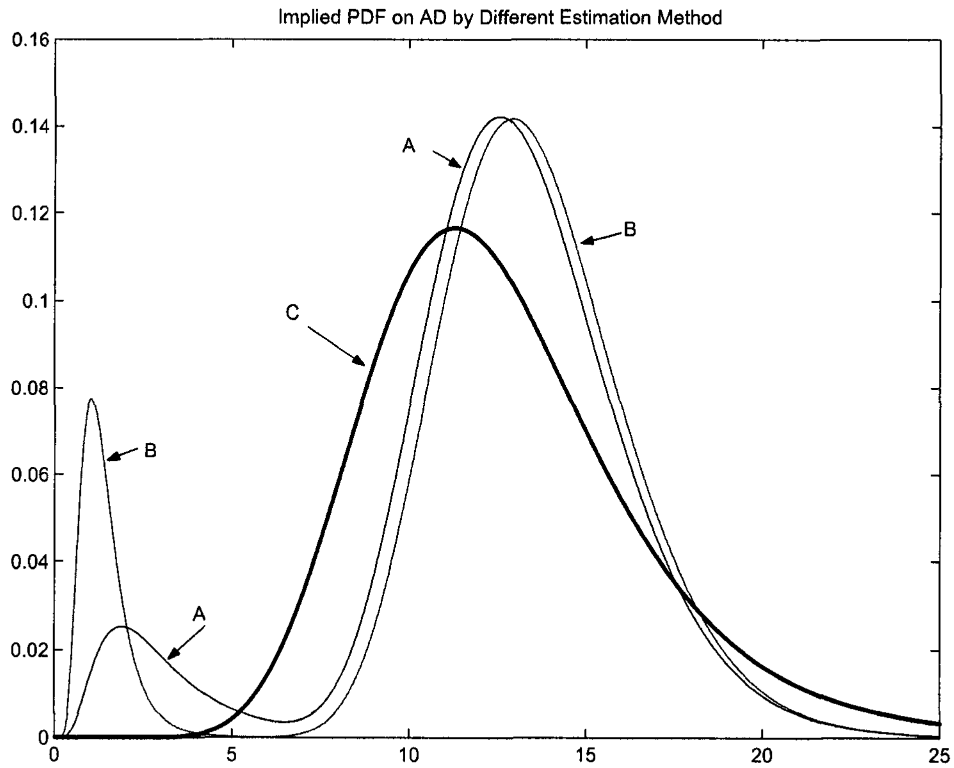

Figure 4.6: Estimation results of the mixture of two (A) and three (B) lognormal distributions with different means and the mixture of two lognormal distributions with the same mean (C)

However, most stock options are American style options, not European style options. For American style options, because of the early exercise premium, the relationship between $f(S_T)$ and option price is indirect. In general, the option prices will not only depend on the distribution for stock prices at the option's expiration, but also the entire stochastic process for stock prices. To deal with this difficulty, Melick and Thomas used derived bounds for the maximum and minimum value of an option. That is , for all stochastic processes that imply a given distribution for the stock prices at the option's expiration, there are bounds for the option's value that can be expressed in terms of that distribution alone. Melick and Thomas used both upper and lower bounds in their method. These bounds are:

$$C_t^u = E_t[max[0, f(S_T) - X]]; \quad (4.14)$$

$$C_t^l = max[E_t[f(S_T)] - X, e^{-r.t}.E_t[max[0, f(S_T) - X]]]; \quad (4.15)$$

$$P_t^u = E_t[max[0, X - f(S_T)]]; \quad (4.16)$$

$$P_t^l = max[X - E_t[f(S_T)], e^{-r.t}.E_t[max[0, X - f(S_T)]]]; \quad (4.17)$$

Where X denotes the option's strike price; $E_t[]$ denotes expectations taken with respect to the risk-neutral distribution t periods prior to expiration; r is the risk-free interest rate; and $e^{-r.t}$ is the discount factor to the option's expiration.

Combining equations (4.10)-(4.17) and weighting the bounds yields the following American call and put pricing equations in terms of six estimated parameters $(\hat{\theta}, \hat{\alpha}, \hat{\beta_1}, \hat{\beta_2}, \hat{w_1}, \hat{w_2})$, two observables $(X, e^{-r.t})$, and an error term. There are two weights $(\hat{w_1}, \hat{w_2})$ one for options in-the-money, one for options out-of-the money. This is because, numerous studies have documented that option pricing errors vary systematically with the degree to which an option is in- or out-of-the-money (see Whaley (1986) and Cakici, Chatterjee, and Wolf(1993)).

$$C_t[X] = \hat{w_{it}}.C_t^u[X;\hat{\theta}, \hat{\alpha}, \hat{\beta}_{1,2}] + (1 - \hat{w_{it}}).C_t^l[X;\hat{\theta}, \hat{\alpha}, \hat{\beta}_{1,2}] + \hat{\epsilon}_{ct}[X] \quad (4.18)$$

$$P_t[X] = \hat{w_{it}}.P_t^u[X;\hat{\theta}, \hat{\alpha}, \hat{\beta}_{1,2}] + (1 - \hat{w_{it}}).P_t^l[X;\hat{\theta}, \hat{\alpha}, \hat{\beta}_{1,2}] + \hat{\epsilon}_{pt}[X] \quad (4.19)$$

$$i = \begin{cases} 1 & \text{if call and } X < E_t[f(S_T;\hat{\theta}, \hat{\alpha}, \hat{\beta}_{1,2}] \\ 1 & \text{if put and } X > E_t[f(S_T;\hat{\theta}, \hat{\alpha}, \hat{\beta}_{1,2}] \\ 2 & \text{otherwise} \end{cases}$$

Given X, t, six estimated parameters $(\hat{\theta}, \hat{\alpha}, \hat{\beta_1}, \hat{\beta_2}, \hat{w_1}, \hat{w_2})$ and risk-free interest rate r, equations (4.18) and (4.19) can be used to pricing American call or put options. On the other hand, given all exercise option prices, X, t and r (which can be observed approximately in practice), by minimizing the sum of squared errors, the six unknown parameters $(\theta, \alpha, \beta_1, \beta_2, w_1, w_2)$ can be derived across all exercise option prices. Consequently, the implied risk-neutral probability density function with four unknown parameters $(\theta, \alpha, \beta_1, \beta_2)$ are estimated. The non-linear least squares problem is:

$$\textbf{Min} \sum_{i=1}^{n} [c_i[X] - \hat{c_i}]^2 + \sum_{i=1}^{n} [p_i[X] - \hat{p_i}]^2 + [\theta e^{\alpha + \frac{1}{2}\beta_1^2} + (1-\theta) e^{\alpha + \frac{1}{2}\beta_2^2} - e^{rt} S_t]^2 \quad (4.20)$$

subject to $\beta_1, \beta_2 > 0,\ 0 \leq \theta \leq 1,\ 0 \leq w_1, w_2 \leq 1.$

Because the mean of the implied RND function should equal the forward price of the underlying asset, I included its forward price as an additional observation in the minimization problem, which constructs the last bracket in equation(4.20). The first two exponential terms in the last bracket in equation (4.20) represent the mean of the two-lognormal RND function. The last term in the last bracket represent the forward price of the underlying asset which actually is calculated from present stock price (S_t) using risk-free interest rate r.

In order to derive the mean implied risk-neutral probability density functions from our sample stocks' implied risk-neutral probability density functions, I need to adjust the option prices and stock prices from absolute measures to relative measures. Both option prices and stock prices of every stock in our sample are divided by its close price on announce day (AD) and then multiply by ten, before they are used to calculate the implied RND. Finally, the four unknown parameters $(\theta, \alpha, \beta_1, \beta_2)$ of my mean implied RND of an event day are calculated as the mathematic average of all sample stock's relative estimated parameters on the same event day. The option prices that I use are the average of the highest bid and lowest offer at close.

On each day, there are many different option contracts trading for one stock with different expiration dates. I select options which have more than 29 expiration days and less than 118 expiration days (one to four months). Usually, there are two groups of options which meet this requirement. I use the group which has relatively longer time to expire in estimating the RND.

4.4.3 Estimation details

This section shows details of how to combining the call and put pricing equations (4.18) and (4.19) with the bounds equations (4.14) (4.15) (4.16) and (4.17) to estimate the implied RND. Before starting our estimations, I need to express equations (4.14) (4.15) (4.16) and (4.17) in terms of four estimated parameters $(\hat{\theta}, \hat{\alpha}, \hat{\beta}_1, \hat{\beta}_2)$ and strike price X. Within these four bounds equations, there are three fundamental components which need to be calculated first. They are $E_t[f(S_T)]], E_t[max[0, f(S_T) - X]]$ *and* $E_t[max[0, X - f(S_T)]]$.

$E_t[f(S_T)]]$ is the mean of the two-lognormal mixture distribution of S_T. By plugging in equation (4.12), I get

$$E_t[f(S_T)]] = E_t[\theta L(\alpha, \beta_1; S_T) + (1-\theta)L(\alpha, \beta_2; S_T)] \tag{4.21}$$

$$E_t[f(S_T)]] = \theta E_t[L(\alpha, \beta_1; S_T)] + (1-\theta)E_t[L(\alpha, \beta_2; S_T)] \tag{4.22}$$

From the properties of the lognormal distribution, I get

$$E_t[f(S_T)] = \theta.exp[\alpha + \frac{\beta_1^2}{2}] + (1-\theta).exp[\alpha + \frac{\beta_2^2}{2}] \tag{4.23}$$

$E_t[max[0, f(S_T) - X]]$ *and* $E_t[max[0, X - f(S_T)]]$ are the un-discounted European call and put values, when $f(S_T)$ is a two-lognormal mixture distribution. I only present the estimation of $E_t[max[0, f(S_T) - X]]$ here. It follows that

$$E_t[max[0, f(S_T) - X]] = \int_X^\infty (S_T - X) f(S_T) dS_T \tag{4.24}$$

$$\int_X^\infty (S_T - X) f(S_T) dS_T = \int_X^\infty (S_T - X)[\theta L(\alpha, \beta_1; S_T) + (1-\theta) L(\alpha, \beta_2; S_T)] dS_T \tag{4.25}$$

$$\int_X^\infty (S_T-X)f(S_T)dS_T = \theta \int_X^\infty (S_T-X)L(\alpha,\beta_1;S_T)dS_T+(1-\theta)\int_X^\infty (S_T-X)L(\alpha,\beta_2;S_T)dS_T \tag{4.26}$$

let

$$A = \int_X^\infty (S_T - X)L(\alpha,\beta_i;S_T)dS_t \tag{4.27}$$

A is the un-discounted European call values, while $f(S_T)$ is a one-lognormal distribution. From the out come of Black-Scholes-Merton formula, we know:

$$A = e^{\alpha+\frac{\beta_i^2}{2}}N(d_a) - XN(d_b) \tag{4.28}$$

where

$$d_a = \frac{-lnX + \alpha + \beta_i^2}{\beta_i}, \qquad d_b = d_a - \beta_i \tag{4.29}$$

Plugging equation (4.28) into equation (4.26) and using equation (4.24), I get

$$E_t[max[0, f(S_T)-X]] = \theta[e^{\alpha+\frac{\beta_1^2}{2}}N(d_1)-XN(d_2)]+(1-\theta)[e^{\alpha+\frac{\beta_2^2}{2}}N(d_3)-XN(d_4)] \tag{4.30}$$

where

$$d_1 = \frac{-lnX + \alpha + \beta_1^2}{\beta_1}, \qquad d_2 = d_1 - \beta_1 \tag{4.31}$$

$$d_3 = \frac{-lnX + \alpha + \beta_2^2}{\beta_2}, \qquad d_4 = d_3 - \beta_2 \tag{4.32}$$

Combining equation (4.30) and equation (4.23), we can write the four bounds equations (4.14)-(4.17) in terms of four estimated parameters $(\hat{\theta}, \hat{\alpha}, \hat{\beta_1}, \hat{\beta_2})$ and strike price X. Further more, we can write American option pricing equations (4.18) and (4.19) in terms of these parameters and strike price X.

Finally, we can use the new equations (4.18) and (4.19) to minimize the sum of squared errors which is present in equation (4.20), to get the least square estimation of the six unknown parameters $(\theta, \alpha, \beta_1, \beta_2, w_1, w_2)$. Then, the four unknown parameters $(\theta, \beta_1, \alpha_2, \beta_2)$ of the implied risk-neutral probability density function are estimated.

4.4.4 Estimation Results

Figure 4.7 to 4.12 present the estimation results. These RND functions are only derived from the closing prices. The horizontal axis shows price, 10 indicates the closing price of underling stock on AD.

Figure 4.7 presents the implied RND functions derived from option prices for additions on AD-1 AD and AD+1. The implied RND on AD-1 and AD are similar because the addition information has not been known by the markets. Compared to the implied RND on AD, the AD+1 implied RND shifts to the right because the addition information has been know by the public and markets expectation changed. Because these implied RNDs are only derived from the closing prices, I cannot study the behavior of implied RND between AD closing and AD+1 open. Figure 4.8 presents the implied RND functions for additions on AD, AD+1, and CD. Compared to the implied RND on AD, CD's implied RND shifts to the right. The CD implied RND is relatively flatter compared to AD+1's RND. It means that the markets see more variability in the future on CD than on AD+1.

Figure 4.9 shows the implied RND functions derived from option prices for deletions on AD, AD+1, and CD. Both the AD+1 RND and CD RND shift left compared to AD. Interestingly, the AD implied RND has a bigger densities on lower prices. This can be explained that some people in the markets know this deletion information while others still do not know it at the closing of AD (the information is released after the closing of AD). The people who know it will cause the bigger density for the lower prices. The mystery is, that we did not find similar behavior on additions. From the equity markets research, the price decreases caused by deletions is much bigger than the price increase caused by additions. Therefore, more arbitragers will involve in the deletions than the additions, or the arbitrage in addition is not big enough for these people to participate. This may be the explanation for the failure to find a big shift for addition on AD.

Figure 4.10 shows the 3-D implied RND functions for both additions and deletions from AD-1 to CD+20, the dates between AD+1 and CD are both assumed to be three. We can easily classify these implied RNDs into two groups. The group with the peak on the right of 10 is the additions' implied RNDs; the group with the peak on the left of 10 is the deletions' implied RNDs. Markets have positive expectations for the addition group stocks and negative expectations for the deletion group stocks.

Figure 4.11 shows the 2-D implied RND functions for both additions and deletions on AD+1 and CD to CD+20. Figure 4.12 shows those RND functions from AD-10 to AD. The RNDs on figure 4.11 is the RNDs derived after the information is released while the RNDs on figure 4.12 is derived before the information is released. However, both figures show significant difference between addition groups and deletion groups. The peak of the addition group is on the right of the price 10 while the peaks of deletion is on the left of 10. The addition group RNDs have bigger densities on higher prices and the deletion group RNDs have bigger densities on the lower prices. By comparing these two graphes, I found, after the information is released, the deletion group shift to the left and the addition group shift to the right. The difference between addition group and deletion group after the information is released is bigger than the difference before the information is released. The difference between addition and deletion group exists even before the information is released may indicate that the markets have already known which stock has a high probability to be deleted and which stock has a high probability to be added. Markets have positive expectations for addition group stocks and negative expectations for deletion group stocks even before the addition and deletion information is released. It also indicates Standard & Poor prefers to delete stocks which have left-shift implied RNDs and add stocks which have right-shift implied RNDs. This make it possible to use implied RNDs as a benchmark in guessing the Standard & Poor's decisions on additions and deletions.

That the difference between addition and deletion group exists even before the information is released, consist with Denis, McConnell, Ovtchinnikov and Yu's discovery that companies newly added to the index experience significant increases in eps forecasts and significant improvements in realized earnings. My research supports the information hypothesis.

4.5 Option Markets Conclusion

I presented the behavior of option markets of S&P 500 index changes in this chapter. From this option markets empirical research, I found that the option volume for both addition group and deletion group tend to increase in some degree after the change information is released, which consists with Chen, Noronha and Singal's explanation of the asymmetric price response and supports the liquidity hypothesis. I found differences between the addition group RNDs and deletion group RNDs exist even before the announcement. This finding supports the information hypothesis. I found people may construct arbitrage positions by operating on both equity markets and option markets. From both option prices and option volumes, I found evidence of inside trad-

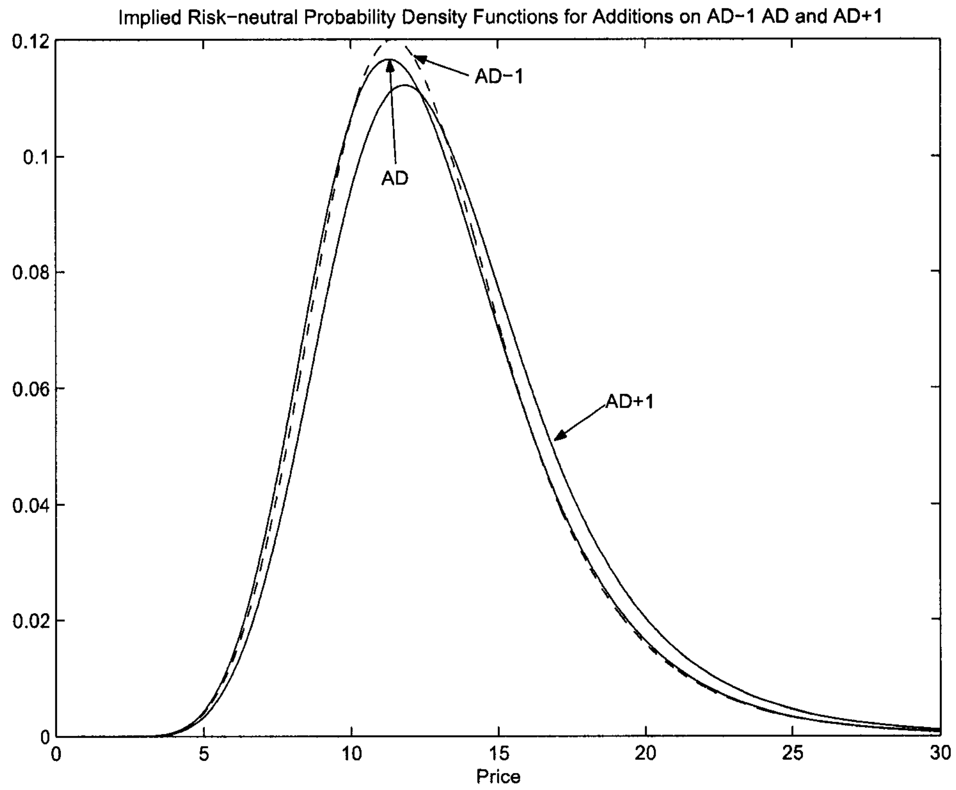

Figure 4.7: Implied Risk-neutral Probability Density Functions Derived from Option Prices for Additions on AD-1 AD and AD+1 (AD and AD-1 are quite near)

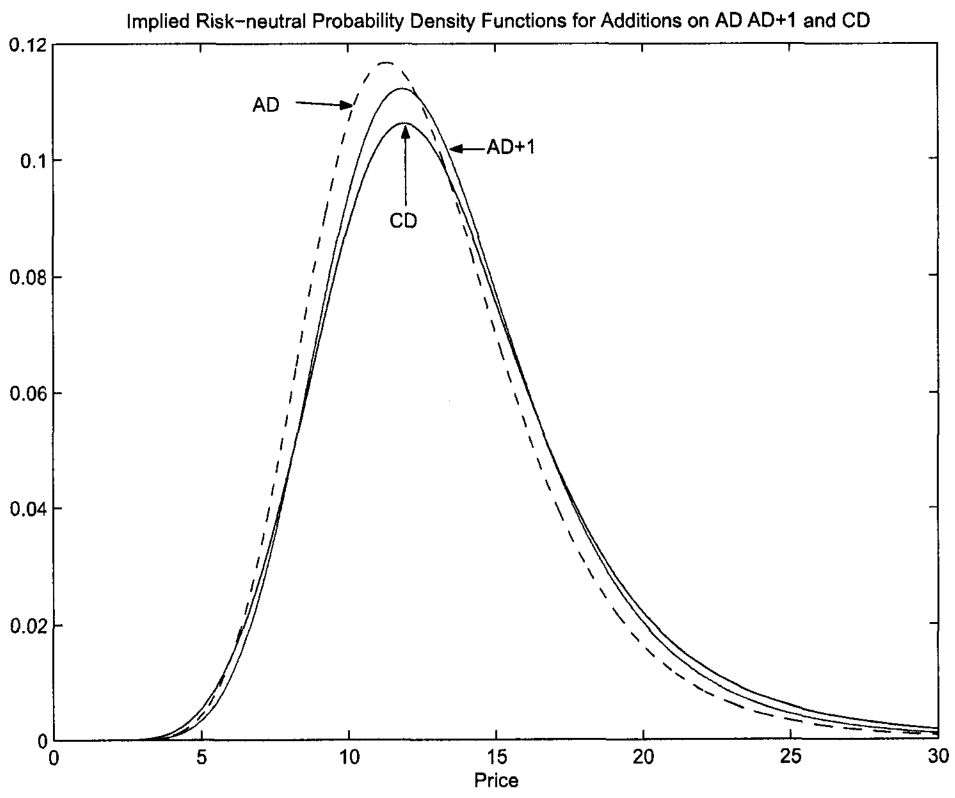

Figure 4.8: Implied Risk-neutral Probability Density Functions Derived from Option Prices for Additions on AD AD+1 and CD

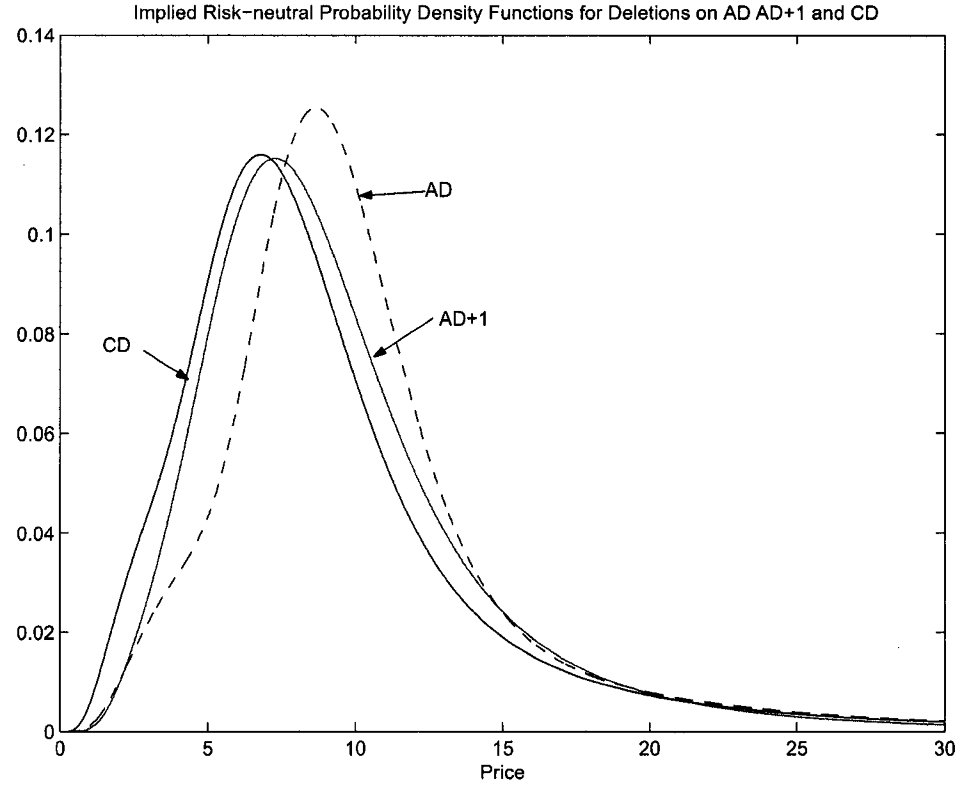

Figure 4.9: Implied Risk-neutral Probability Density Functions Derived from Option Prices for Deletions on AD AD+1 and CD

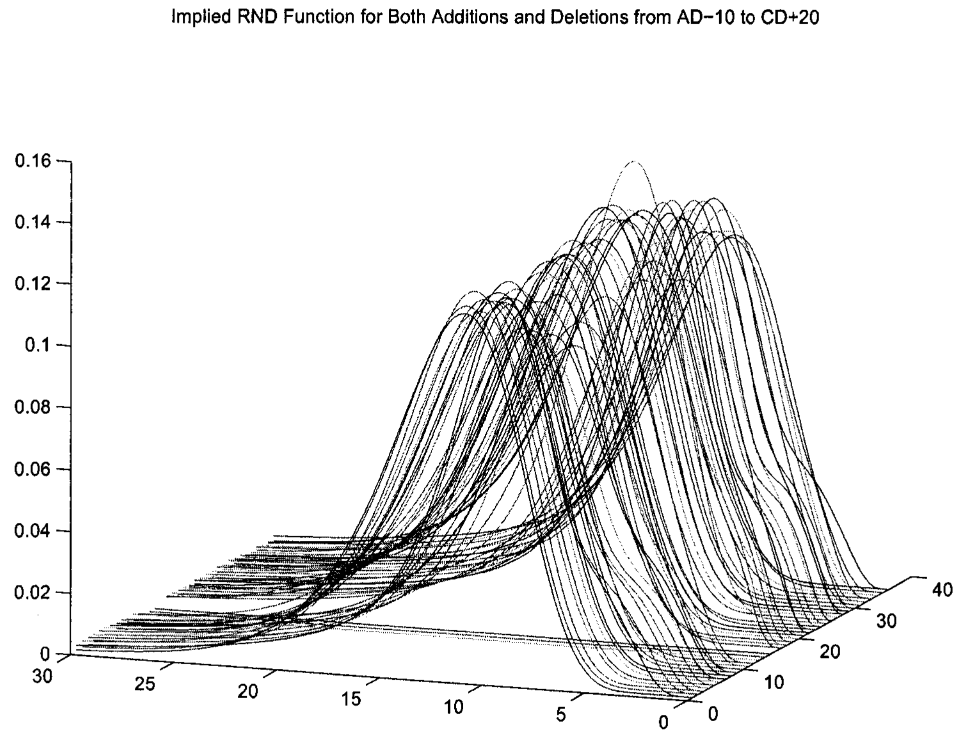

Figure 4.10: 3-D Implied Risk-neutral Probability Density Functions for Both Additions and Deletions from AD-10 to CD+20 (the dates between AD=1 and CD is assumed as three)

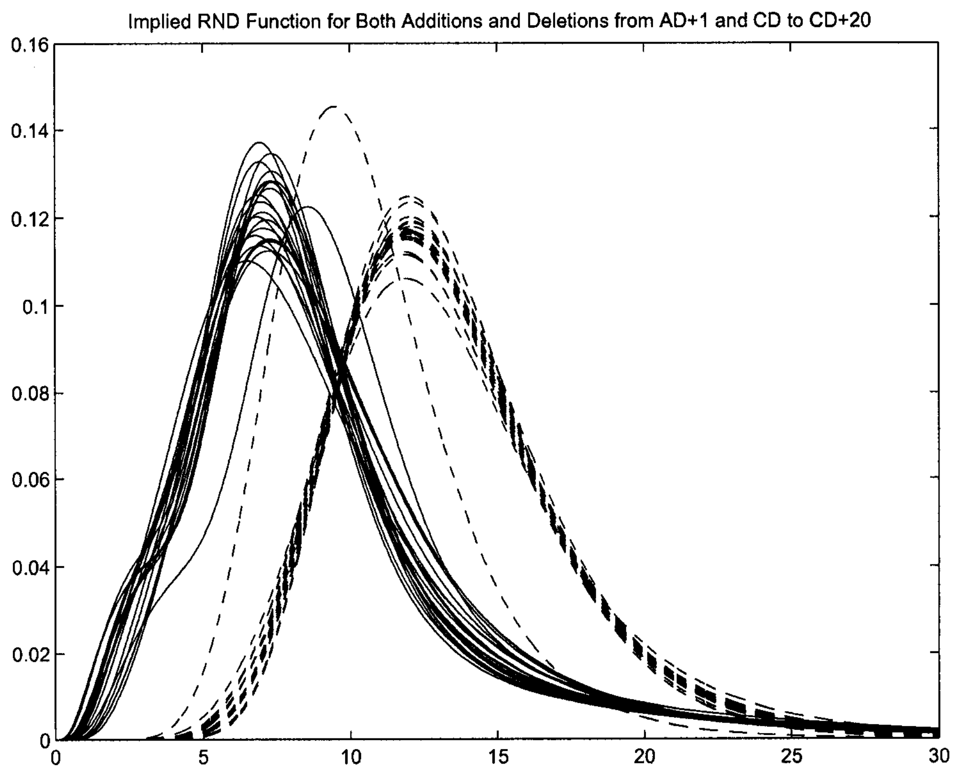

Figure 4.11: 2-D Implied Risk-neutral Probability Density Functions for Both Additions and Deletions after AD (after the information is released)

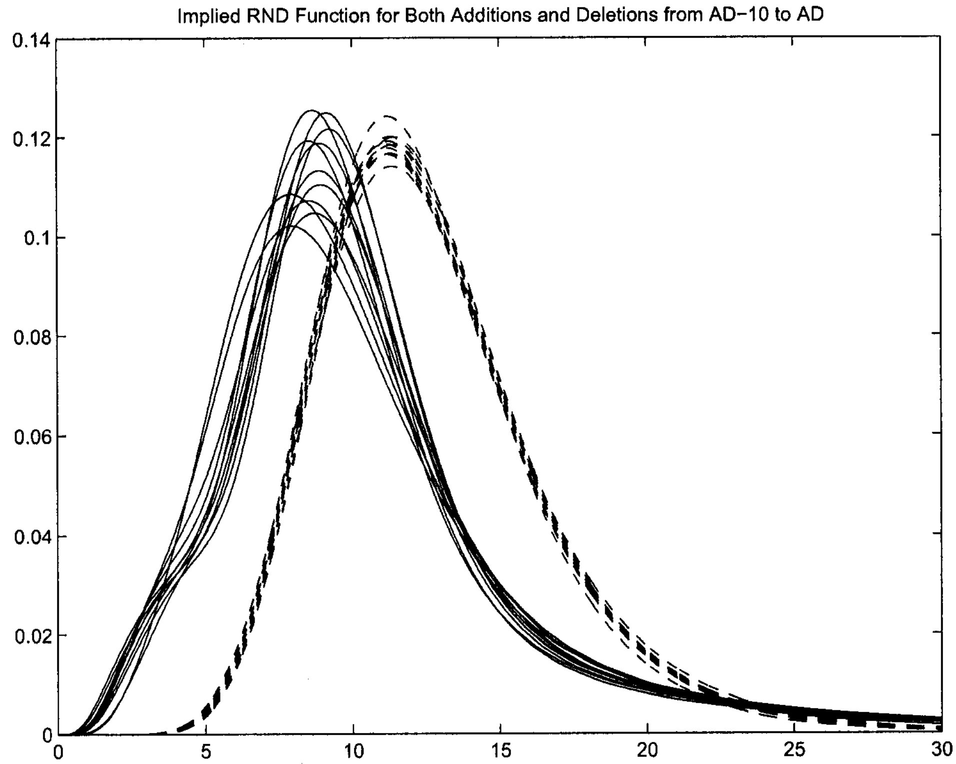

Figure 4.12: 2-D Implied Risk-neutral Probability Density Functions for Both Additions and Deletions before (including) AD (before the information is released)

ing activities. I demonstrated that Standard & Poor prefers to delete stocks which have left-shift implied RNDs and add stocks which have right-shift implied RNDs. Even before the information is released, markets have positive expectations for addition group stocks and negative expectations for deletion group stocks. This may also indicate that the markets have already known which stock has a high probability to be deleted and which stock has a high probability to be added.

Chapter 5

Conclusion

This research investigates both equity and option markets behavior for firms added to or deleted from the S & P 500 index.

In this study, I used the underlying stock markets data to analyze the post-1989 market behavior of index changes. I examined price and volume history for firms added to or deleted from the S&P 500 index from January 1990 through December 2002. I found a mean cumulative abnormal return from announce day to change day of 8.44% for additions and -11.10% for deletions. The abnormal returns still remain at 6.19% for additions and -6.20% for deletions 20 days after the change day. I found an arbitrage space of 3.2% for additions and -6.7% for deletions which use the strategy of buying/selling at the open of AD+1 and covering these positions at the close of CD. I found direct evidence rejecting the downward-sloping long-run demand curves hypothesis which has been supported by most of the prior studies for decades. I demonstrated that the demand curves are only downward-sloping in short-run and horizontal in the long-run. I also focused my research on the dynamic evolution of this effect from 1990 to 2002 which indicated markets are becoming more efficient. Markets need time to adjust to semi-strong form market efficiency when there are some structural changes or new information comes in. I used this sample to demonstrate the relationship between volume, return and information. My outcome indicates volume does not predict direction, but only price volatility. It is the nature of information (good or bad) that causes the abnormal volume which decides the direction of stock movements. Information plays an important role in the relationship between abnormal volume and abnormal return. The volume is only a proxy of information flow in some cases. This paper also shows how human behaviors such as risk aversion and irrationality can influence market efficiency in the short-run and how market evolves from inefficiency to efficiency in the long-run. I worry about the long-run performance of the index funds, because the total premium paid by index fund will accumulate to a significant amount as time goes on. This is one of the increasing problems of index funds.

This study also investigated option markets behavior for firms added to or deleted from the S & P 500 index. Although a lot of research on the equity markets has been done by both academia and Wall Street, this is the first research focusing on the option markets of these addition and deletion effects. Option markets provide a rich source of information for studying market sentiment. Due to their forward-looking nature, option prices indicate market perceptions about underlying asset prices in the future.More importantly, index funds only change their portfolio on equity markets. Therefore, the option markets will be able to release markets attention and information changes without the influence of index funds.

I presented the behavior of option markets of S&P 500 index changes in this paper. I examined option price, volume, open interest and some sensitive information for firms added to or deleted from the S & P 500 from January 1996 through December 2002. I also estimated implied risk-neutral probability density functions (RND) from these option prices to analyze the option markets reaction to these changes. From this option markets empirical research, I found that the option volume for both addition group and deletion group tend to increase in some degree after the change information is released, which consists with Chen, Noronha and Singal's explanation of the asymmetric price response and supports the liquidity hypothesis. I found differences between the addition group RNDs and deletion group RNDs exist even before the announcement. This finding supports the information hypothesis. I found people may construct arbitrage positions by operating on both equity markets and option markets. From both option prices and option volumes, I found evidence of inside trading activities. I demonstrated that Standard & Poor prefers to delete stocks which have left-shift implied RNDs and add stocks which have right-shift implied RNDs. Even before the information is released, markets have positive expectations for addition group stocks and negative expectations for deletion group stocks. This may also indicate that the markets have already known which stock has a high probability to be deleted and which stock has a high probability to be added.

This research contributes to the literature in several ways. On the equity markets side, first, I presented evidence against the down-ward sloping long-run demand curve hypothesis and offered a new explanation for the S&P 500 addition and deletion effect. Second, I revealed the dynamic evolution of this effect from 1990 to 2002. Third, I showed how human behaviors such as risk aversion and irrationality can influence market efficiency in the short-run. On the option markets side, first, I presented the behavior of option markets of S&P 500 index changes for the first time. Second, I found evidence supporting the liquidity hypothesis and information hypothesis from the option side. Third, I found that Standard & Poor prefers to delete stocks which have left-shift implied RNDs and add stocks which have right-shift implied RNDs. Fourth, I found evidence of active arbitrage activities and heavy inside trading activities for the index changes.

Appendix A

Tables

Event Day	N	MAR	P-Value	% AR>0
AD-10	189	-0.27%	0.8269	%48
AD-9	189	0.29%	0.1244	%51
AD-8	189	0.02%	0.4623	%50
AD-7	189	-0.04%	0.5719	%49
AD-6	189	-0.05%	0.5867	%49
AD-5	189	-0.14%	0.7256	%47
AD-4	190	0.28%	0.2199	%59
AD-3	191	0.28%	0.1145	%54
AD-2	191	0.37%*	0.0425	%54
AD-1	192	-0.10%	0.6678	%48
AD	192	0.18%	0.2108	%51
# AD1	192	4.31%**	0	%90
## AD1	192	5.12%**	0	%91
### AD1	192	−0.81%**	0	%39
AD2		0.65%		
AD3		0.65%		
AD4		0.65%		
AD5		0.65%		
CD	192	1.65%**	0	%63
CD1	192	-0.97%**	0	%38
CD2	192	-0.33%	0.0966	%43
CD3	192	-0.71%*	0.0050	%45
CD4	192	-0.21%	0.1861	%46
CD5	192	0.27%	0.8641	%55
CD6	192	-0.38%	0.6799	%45
CD7	192	0.24%	0.8282	%50
CD8	192	-0.17%	0.2103	%48
CD9	192	0.11%	0.6921	%50
CD10	192	-0.14%	0.2728	%45
CD11	192	-0.06%	0.4218	%48
CD12	192	-0.34%	0.1006	%45
CD13	192	0.22%	0.8144	%49
CD14	192	0.06%	0.6037	%52
CD15	192	0.37%	0.9384	%54
CD16	192	-0.13%	0.3174	%52
CD17	192	0.17%	0.7606	%45
CD18	192	-0.09%	0.3457	%45
CD19	192	-0.31%	0.1139	%45
CD20	192	0.03%	0.5512	%50

Table A.1: Mean Abnormal Return(MAR) for Firms Added to S&P 500, 1990-2002. * significant at 5%, ** significant at 1%. # is the close to close MAR. ## is the percentage change overnight, this cannot be captured by trader. ### is the MAR during the day, this is the trading profit of the first day from the open price.

Event Day	N	MAR	P-Value	% AR>0
AD-10	62	-1.91%*	0.0356	%41.94
AD-9	62	0.51%	0.7406	%53.23
AD-8	62	-0.82%	0.0703	%48.39
AD-7	62	-0.58%	0.1471	%62.90
AD-6	62	-0.17%	0.4174	%61.29
AD-5	62	0.49%	0.7530	%64.52
AD-4	62	-1.12%	0.0612	%37.10
AD-3	62	-0.99%	0.0620	%38.71
AD-2	62	-0.52%	0.1387	%43.55
AD-1	62	-0.4%	0.2220	%61.29
AD	62	0%	0.5099	%48
# AD1	62	-6.48%**	0	%15
## AD1	62	−4.71%**	0	%8
### AD1	62	−1.79%*	0.0043	%35
AD2		-0.67%		
AD3		-0.67%		
AD4		-0.67%		
CD	62	-2.74%**	0.0002	%25.81
CD1	62	-1.96%	0.8684	%59.68
CD2	62	0.05%	0.4614	%54.84
CD3	62	-0.03%	0.5265	%51.61
CD4	62	-0.09%	0.5485	%59.68
CD5	62	-0.06%	0.5637	%51.61
CD6	62	0.99%	0.0417	%51.61
CD7	62	0.16%	0.4003	%48.39
CD8	62	0.01%	0.4953	%43.55
CD9	62	0.14%	0.3678	%50.00
CD10	62	0.57%	0.1356	%51.61
CD11	62	0.72%	0.0812	%50.00
CD12	62	0.57%	0.1725	%40.32
CD13	62	-0.03%	0.5331	%48.39
CD14	62	0.40%	0.2151	%50.00
CD15	62	1.11%**	0.0008	%69.35
CD16	62	0.69%*	0.0391	%54.84
CD17	62	1.16%*	0.0401	%59.68
CD18	62	-0.12%	0.6145	%43.55
CD19	62	0.45%	0.2140	%54.84
CD20	62	0.30%	0.2309	%51.61

Table A.2: Mean Abnormal Return(MAR) for Firms deleted from S&P 500, 1990-2002. * significant at 5%, ** significant at 1%. # is the close to close MAR. ## is the percentage change overnight, this cannot be captured by trader. ### is the MAR during the day, this is the trading profit of the first day from the open price.

Event Day	N	MAV	P-Value	% AV>0
AD-10	189	-5.65%	0.8793	%37
AD-9	189	-5.26%	0.9038	%38
AD-8	189	-10.35%	0.9950	%35
AD-7	189	-10.70%	0.9987	%35
AD-6	189	-4.68%	0.8658	%38
AD-5	189	-10.40%	0.9988	%33
AD-4	190	-2.61%	0.7418	%38
AD-3	191	-8.78%	0.9442	%36
AD-2	191	-5.32%	0.9287	%36
AD-1	192	-10.17%	0.9984	%33
AD	192	-0.53%	0.5488	%42
AD1	192	290%**	0	%90
AD2		93.92%		
AD3		93.92%		
AD4		93.92%		
AD5		93.92%		
CD	192	1442%**	0	%98
CD1	192	267.5%**	0	%85
CD2	192	220.8%*	0.0282	%73
CD3	192	186.7%*	0.0458	%71
CD4	192	211.4%	0.0792	%64
CD5	192	142.8%	0.0653	%59
CD6	192	114.2%*	0.0263	%59
CD7	192	98.6%	0.0614	%57
CD8	192	149.9%	0.0956	%48
CD9	192	116.5%	0.0764	%51
CD10	192	124.2%*	0.0424	%52
CD11	192	111.9%*	0.0384	%54
CD12	192	117.8%*	0.0336	%55
CD13	192	105.1%	0.0508	%58
CD14	192	95.9%	0.0668	%49
CD15	192	66.1%*	0.0378	%50
CD16	192	65.7%	0.0695	%46
CD17	192	62.7%	0.0936	%49
CD18	192	70.2%	0.0602	%48
CD19	192	125.6%	0.1124	%44
CD20	192	77.8%	0.0809	%46

Table A.3: Mean Abnormal Volume(MAV) for Firms Added to S&P 500, 1990-2002 (* significant at 5%, ** significant at 1%)

Event Day	N	MAV	P-Value	% AV>0
AD-10	62	4.20%	34.50	%38.71
AD-9	62	-6.24%	79.94	%38.71
AD-8	62	-10.04%	92.32	%37.10
AD-7	62	-12.76%	98.51	%32.26
AD-6	62	-9.09%	91.74	%40.32
AD-5	62	-7.41%	85.45	%43.55
AD-4	62	-20.39%	99.94	%27.42
AD-3	62	-6.27%	75.65	%33.87
AD-2	62	-7.44%	0.8670	%40.32
AD-1	62	-0.2696%	1	%22.58
AD	62	-15.47%	0.9814	%34
AD1	62	254.07%**	0	%84
AD2		126.38%		
AD3		126.38%		
AD4		126.38%		
CD	62	2013.67%**	0	%98.39
CD1	62	406.15%**	0	%91.94
CD2	62	177.32%**	0	%77.42
CD3	62	146.03%**	0	%72.58
CD4	62	136.55%**	0.0002	%67.74
CD5	62	107.53%**	0.0001	%62.90
CD6	62	84.70%**	0.0003	%66.13
CD7	62	62.67%**	0.0012	%53.23
CD8	62	62.80%**	0.0016	%61.29
CD9	62	77.31%**	0.0021	%56.45
CD10	62	59.00%*	0.0190	%53.23
CD11	62	26.36%*	0.0459	%58.06
CD12	62	25.51%*	0.0362	%54.84
CD13	62	28.21%*	0.0252	%45.16
CD14	62	28.38%*	0.0201	%46.77
CD15	62	31.00%*	0.0309	%51.61
CD16	62	-6.59%	0.7181	%38.71
CD17	62	-1.32%	0.5454	%41.94
CD18	62	25.70%	0.0660	%46.77
CD19	62	10.75%	0.2277	%41.94
CD20	62	18.05%	0.1194	%41.94

Table A.4: Mean Abnormal Volume(MAV) for Firms Deleted from S&P 500, 1990-2002 (* significant at 5%, ** significant at 1%)

Event Day	1.0	1.05	0.95
AD-10	10.46	10.62	10.32
AD-9	10.67	10.86	10.53
AD-8	10.64	10.97	10.45
AD-7	10.90	11.22	10.60
AD-6	10.70	10.92	10.48
AD-5	10.29	10.40	10.21
AD-4	10.53	10.64	10.38
AD-3	10.66	10.87	10.55
AD-2	10.74	10.86	10.53
AD-1	10.50	10.53	10.41
AD	10	10	10
AD1	12.36**	13.00**	12.33**
CD	12.60**	13.43**	12.71**
CD1	12.08**	12.58**	12.22**
CD2	11.68**	11.93**	11.79**
CD3	11.97**	12.34**	12.03**
CD4	11.49*	11.86*	11.57*
CD5	11.47*	11.64*	11.59*
CD6	11.71*	11.93*	11.85*
CD7	11.76*	12.08*	11.90**
CD8	11.62*	11.89*	11.79*
CD9	11.68*	11.68*	11.82*
CD10	11.52*	11.43	11.69*
CD11	11.56*	11.42	11.74*
CD12	11.44	11.25	11.61*
CD13	11.84*	11.68*	12.01**
CD14	11.89*	11.66*	12.06**
CD15	12.32**	12.09*	12.50**
CD16	12.20**	12.01*	12.40**
CD17	12.09**	11.90*	12.29**
CD18	12.08*	11.93*	12.29**
CD19	11.65*	11.48*	11.88*
CD20	12.09*	11.94*	12.35**

Table A.5: Mean prices of call option contracts whose strike prices are closest to 1, 1.05 and 0.95 times of the underling stock's closing price on AD for addition group. From AD-10 to AD-1, we test the significance of prices smaller than AD-10 prices or not. For AD, we test the significance of prices smaller than AD-1 prices or not. After AD, we test the significance of prices smaller than AD prices or not. (* significant at 5%, ** significant at 1%)

Event Day	1.0	1.05	0.95
AD-10	14.62	14.45	14.63
AD-9	14.57	14.11	14.57
AD-8	14.35	13.75	14.33
AD-7	13.61	13.33	13.61
AD-6	13.16	13.08	13.15
AD-5	12.41*	12.38*	12.36*
AD-4	11.72**	11.62**	11.69**
AD-3	10.65**	10.54**	10.61**
AD-2	10.29**	10.14**	10.25**
AD-1	10.25**	10.14**	10.23**
AD	10**	10**	10**
AD1	8.64**	8.56**	8.62**
CD	8.94*	8.74*	9.03
CD1	8.84*	8.72*	8.99*
CD2	9.14	9.09	9.29
CD3	9.24	9.22	9.34
CD4	10.03	10.04	10.15
CD5	10.02	10.03	10.01
CD6	9.65	9.66	9.52
CD7	8.81*	8.79*	8.66*
CD8	8.76*	8.63*	8.62*
CD9	8.79	8.54*	8.66*
CD10	8.72*	8.49*	8.62*
CD11	8.56*	8.20**	8.47*
CD12	8.80	8.44*	8.67
CD13	8.19*	7.88**	8.04*
CD14	8.04**	7.83**	7.88**
CD15	7.46**	7.34**	7.31**
CD16	7.13**	7.10**	6.95**
CD17	7.06**	7.07**	6.87**
CD18	6.75**	6.76**	6.54**
CD19	6.69**	6.71**	6.47**
CD20	6.18**	6.27**	5.98**

Table A.6: Mean prices of put option contracts whose strike prices are closest to 1, 1.05 and 0.95 times of the underling stock's closing price on AD for addition group. From AD-10 to AD-1, we test the significance of prices smaller than AD-10 prices or not. For AD, we test the significance of prices smaller than AD-1 prices or not. After AD, we test the significance of prices smaller than AD prices or not. (* significant at 5%, ** significant at 1%)

Event Day	1.0	1.05	0.95
AD-10	13.53	13.62	13.25
AD-9	13.10	13.24	12.91
AD-8	11.83	12.16	11.68
AD-7	11.69	11.93	11.60
AD-6	11.96	12.13	11.96
AD-5	11.30**	11.29**	11.25**
AD-4	10.05**	10.16**	10.07**
AD-3	9.82**	9.94**	9.84**
AD-2	9.60**	9.69**	9.70**
AD-1	9.44**	9.53**	9.52**
AD	10	10	10
AD1	7.50**	7.42**	7.62**
CD	6.38**	6.38**	6.57**
CD1	6.50*	6.44**	6.71**
CD2	6.78**	6.42**	6.65**
CD3	6.11**	6.04**	6.31**
CD4	6.10**	6.01**	6.32**
CD5	6,14**	6.09**	6.34**
CD6	6.53**	6.44**	6.74**
CD7	6.04**	5.94**	6.27**
CD8	6.26**	6.10**	6.50**
CD9	6.03**	5.94**	6.27**
CD10	6.36**	6.20**	6.62**
CD11	6.93*	6.80*	7.18
CD12	7.46	7.30	7.67
CD13	7.25	7.14	7.49
CD14	7.40	7.21	7.64
CD15	7.30	7.10	7.56
CD16	8.66	8.45	8.93
CD17	9.93	9.74	10.20
CD18	9.62	9.42	9.90
CD19	10.25	10.14	10.53
CD20	10.42	10.22	10.71

Table A.7: Mean prices of call option contracts whose strike prices are closest to 1, 1.05 and 0.95 times of the underling stock's closing price on AD for deletion group. From AD-10 to AD-1, we test the significance of prices smaller than AD-10 prices or not. For AD, we test the significance of prices smaller than AD-1 prices or not. After AD, we test the significance of prices smaller than AD prices or not. (* significant at 5%, ** significant at 1%)

Event Day	1.0	1.05	0.95
AD-10	12.00	11.94	11.97
AD-9	11.67	11.67	11.62
AD-8	11.74	11.73	11.70
AD-7	11.27	11.29	11.30
AD-6	10.47	10.47	10.56
AD-5	10.34	10.38	10.40
AD-4	11.17	11.16	11.30
AD-3	11.25	11.31	11.34
AD-2	11.92	11.01	11.06
AD-1	10.56	10.62	10.64
AD	10	10	10
AD1	13.94**	13.89**	13.91**
CD	18.80**	18.37**	19.14**
CD1	20.20**	19.86**	20.63**
CD2	22.48**	22.30**	23.88**
CD3	20.50**	20.48**	21.81**
CD4	21.00**	21.08**	22.46**
CD5	20.64**	20.71**	22.31**
CD6	18.46**	18.46**	19.69**
CD7	19.16**	19.22**	20.04**
CD8	19.43**	19.60**	20.13**
CD9	19.82**	20.05**	20.49**
CD10	20.69*	20.96*	21.32*
CD11	22.88*	23.14*	24.14*
CD12	21.55*	21.82*	22.31*
CD13	21.03*	21.30*	21.80*
CD14	19.33*	19.53*	20.17*
CD15	18.19*	18.37*	18.66*
CD16	18.05*	18.23*	18.56*
CD17	17.98*	18.18*	18.49*
CD18	19.11*	19.28*	19.79*
CD19	18.44*	18.54*	18.95*
CD20	16.91*	17.15*	17.64*

Table A.8: Mean prices of put option contracts whose strike prices are closest to 1, 1.05 and 0.95 times of the underling stock's closing price on AD for deletion group. From AD-10 to AD-1, we test the significance of prices bigger than AD-10 prices or not. For AD, we test the significance of prices bigger than AD-1 prices or not. After AD, we test the significance of prices bigger than AD prices or not. (* significant at 5%, ** significant at 1%)

Event Day	IVCA	F	IVCD	F
AD-10	0.4933		0.5067	
AD-9	0.4932	1.0043	0.5057	1.0070
AD-8	0.4933	1.0088	0.5056	1.0121
AD-7	0.4884	1.0258	0.5015	1.0261
AD-6	0.4854	1.0383	0.4997	1.0346
AD-5	0.4834	1.0509	0.4939	1.0611
AD-4	0.4852	1.0499	0.4951	1.0528
AD-3	0.4853	1.0505	0.4946	1.0560
AD-2	0.4806	1.0681	0.4928	1.0690
AD-1	0.4817	1.0655	0.4917	1.0787
AD	0.4878	1.0381	0.4966	1.0606
AD1	0.49452	1.0168	0.5042	1.0352
CD	0.5037	0.9806	0.5300	0.9569
CD1	0.5020	1.0058	0.5132	1.0212
CD2	0.5010	1.0091	0.5140	1.0202
CD3	0.5014	1.0079	0.5143	1.0181
CD4	0.5078	0.9837	0.5175	1.0046
CD5	0.5070	0.9890	0.5161	1.0104
CD6	0.5073	0.9838	0.5153	1.0087
CD7	0.5011	1.0063	0.5068	1.0423
CD8	0.4925	1.0395	0.5033	1.0591
CD9	0.4941	1.0334	0.5034	1.0584
CD10	0.4973	1.0217	0.5069	1.0462
CD11	0.4958	1.0292	0.5050	1.0537
CD12	0.4974	1.0225	0.5048	1.0530
CD13	0.4956	1.0338	0.5017	1.0700
CD14	0.4955	1.0313	0.5008	1.0705
CD15	0.4919	1.0444	0.4997	1.0698
CD16	0.4888	1.0547	0.4970	1.0809
CD17	0.4869	1.0607	0.4965	1.0831
CD18	0.4819	1.0782	0.4923	1.0947
CD19	0.4830	1.0703	0.4897	1.1004
CD20	0.4807	1.0824	0.4909	1.0966

Table A.9: Mean implied volatilities on "standard" (interpolated) options with expirations of 91 calender days at-the-money for addition group. IVCA: mean implied volatilities of call options for firms added to S&P 500; IVPA: mean implied volatilities of put options for firms added to S&P 500; F: test statistics (* significant at 5%, ** significant at 1%, Goldfeld-Quandt F test, the square of those implied volatilites compared to the AD-10 level)

Event Day	IVCA	F	IVCD	F
AD-10	0.4557		0.4538	
AD-9	0.4497	0.9368	0.4483	0.9598
AD-8	0.4494	0.9378	0.4566	0.9987
AD-7	0.4604	1.0051	0.4604	1.0318
AD-6	0.4634	1.0095	0.4578	1.0216
AD-5	0.4625	1.0423	0.4619	1.0678
AD-4	0.4694	1.0732	0.4659	1.0754
AD-3	0.4680	1.0684	0.4699	1.0952
AD-2	0.4656	1.0368	0.4601	1.0590
AD-1	0.4637	1.0404	0.4603	1.0568
AD	0.4598	1.0406	0.4497	0.9946
AD1	0.4792	1.0856	0.4703	1.0443
CD	0.5195	1.2687	0.5031	1.2010
CD1	0.5275	1.2609	0.5154	1.2191
CD2	0.5560	1.4231	0.5127	1.2036
CD3	0.5382	1.3228	0.5205	1.2489
CD4	0.5233	1.2111	0.5169	1.2336
CD5	0.5282	1.2462	0.5274	1.3018
CD6	0.5264	1.2499	0.5101	1.1978
CD7	0.5175	1.2092	0.5117	1.2164
CD8	0.5167	1.2040	0.5093	1.2813
CD9	0.5133	1.1629	0.5147	1.2376
CD10	0.5244	1.2367	0.5089	1.3161
CD11	0.5256	1.2297	0.5140	1.3086
CD12	0.5173	1.1799	0.5166	1.2557
CD13	0.5177	1.1883	0.5106	1.2646
CD14	0.5149	1.1779	0.5004	1.2536
CD15	0.5137	1.1685	0.4979	1.2435
CD16	0.5140	1.1753	0.5007	1.2508
CD17	0.5121	1.1728	0.5064	1.2481
CD18	0.5038	1.1221	0.5070	1.2167
CD19	0.5034	1.1335	0.4935	1.1372
CD20	0.4997	1.1245	0.4995	1.1706

Table A.10: Mean implied volatilities on "standard" (interpolated) options with expirations of 91 calender days at-the-money for deletion group. IVCD: mean implied volatilities of call options for firms deleted from S&P 500; IVPD: mean implied volatilities of put options for firms deleted from S&P 500; F: test statistics (* significant at 5%, ** significant at 1%, Goldfeld-Quandt F test, the square of those implied volatilites compared to the AD-10 level)

Event Day	MAOV	P-Value	%MAOV>0
AD-10	13.4%	0.1633	36.67%
AD-9	-12.65%	0.8682	24.44%
AD-8	8.64%	0.2751	34.44%
AD-7	-11.48%	0.8600	32.22%
AD-6	8.14%	0.2545	33.33%
AD-5	-16.49%	0.9808	32.22%
AD-4	12.83%	0.1798	34.44%
AD-3	7.35%	0.2882	32.22%
AD-2	0.13%	0.4957	30.00%
AD-1	-9.19%	0.7960	31.11%
AD	22.13%	0.1169	32.22%
AD1	1779.32%**	0.0017	65.56%
AD2-7	1615.85%		
CD	1594.11%**	0.0001	75.56%
CD1	702.77%**	0.0044	67.78%
CD2	203.92%**	0.0061	48.89%
CD3	121.25%	0.0617	45.56%
CD4	189.12%*	0.0179	44.44%
CD5	167.41%	0.0701	37.78%
CD6	42.63%*	0.0244	35.56%
CD7	167.03%	0.0774	45.56%
CD8	249.31%*	0.0241	44.44%
CD9	15.81%	0.2423	25.56%
CD10	20.33%	0.1145	41.11%
CD11	70.54%*	0.0316	38.89%
CD12	142.46%**	0.0084	44.44%
CD13	99.34%*	0.0123	40.00%
CD14	288.94%	0.0993	42.22%
CD15	82.41%**	0.0009	47.68%
CD16	60.93%*	0.0255	37.78%
CD17	67.21%	0.0682	32.22%
CD18	96.77%*	0.0323	35.56%
CD19	72.30%*	0.0372	38.89%
CD20	100.12%	0.1210	30.00%

Table A.11: Mean abnormal option volume (MAOV) for call options of firms added to S&P 500, 1996-2002. (* significant at 5%, ** significant at 1%, one tail test)

Event Day	MAOV	P-Value	%MAOV>0
AD-10	2.37%	0.4315	37.78%
AD-9	-4.05%	0.6062	27.78%
AD-8	-18.75%	0.9049	25.56%
AD-7	3.27%	0.4168	32.22%
AD-6	-0.47%	0.5134	33.33%
AD-5	-22.02%	0.9957	30.00%
AD-4	-12.26%	0.8710	33.33%
AD-3	8.89%	0.3093	30.00%
AD-2	30.75%	0.0537	36.67%
AD-1	12.27%	0.2462	31.11%
AD	58.95%**	0.0005	27.78%
AD1	3048.36%**	0.0084	63.33%
AD2-7	4518.47%		
CD	1026.51%**	0.0012	65.56%
CD1	979.56%**	0.0022	62.22%
CD2	538.84%**	0.0098	48.89%
CD3	420.32%**	0.0736	46.67%
CD4	225.88%**	0.0094	48.89%
CD5	188.49%**	0.0049	45.56%
CD6	247.00%**	0.0065	44.44%
CD7	100.86%*	0.0117	42.22%
CD8	170.12%*	0.0255	36.67%
CD9	341.51%*	0.0107	41.11%
CD10	513.96%*	0.0216	45.56%
CD11	178.87%*	0.0196	36.67%
CD12	241.97%**	0.0004	43.33%
CD13	354.04%	0.0856	34.44%
CD14	118.15%*	0.0120	38.89%
CD15	379.19%*	0.0215	42.22%
CD16	1193.02%	0.1067	37.78%
CD17	143.99%	0.0628	37.78%
CD18	95.90%*	0.0102	38.89%
CD19	125.18%	0.1060	35.56%
CD20	366.26%	0.0982	35.56%

Table A.12: Mean Abnormal Option Volume (MAOV) of Put Options for Firms Added to S&P 500, 1996-2002. (* significant at 5%, ** significant at 1%, one tail test)

Event Day	MAOV	P-Value	%MAOV>0
AD-10	56.08%	0.0701	45.71%
AD-9	-34.23%	0.9898	25.71%
AD-8	-9.16%	0.6533	25.71%
AD-7	2.18%	0.4595	37.14%
AD-6	56.02%	0.0627	54.29%
AD-5	16.84%	0.2939	42.86%
AD-4	-25.70%	0.9767	28.57%
AD-3	22.94%	0.1661	42.86%
AD-2	41.31%	0.9973	17.14%
AD-1	-43.67%	0.9999	22.86%
AD	-11.54%	0.6843	25.17%
AD1	5386.76%**	0.0116	80.00%
AD2-4	7051.84%		
CD	636.76%*	0.0281	40.00%
CD1	319.51%**	0.0016	48.57%
CD2	183.25%	0.0563	34.29%
CD3	90.09%	0.0971	48.57%
CD4	278.36%**	0.0434	40.00%
CD5	122.07%	0.0906	25.71%
CD6	3488.69%	0.1333	48.57%
CD7	102.19%	0.0553	40.00%
CD8	479.67%**	0.0465	40.00%
CD9	52.88%	0.2462	25.71%
CD10	389.52%	0.1262	34.29%
CD11	175.00%	0.1233	25.71%
CD12	140.26%	0.1744	37.14%
CD13	-4.83%	0.5575	17.14%
CD14	227.31%	0.0650	31.43%
CD15	161.66%	0.0879	40.00%
CD16	679.92%	0.0901	34.29%
CD17	14.80%	0.3629	17.14%
CD18	18.03%	0.2744	34.14%
CD19	189.83%	0.1470	25.71%
CD20	555.04%	0.1272	34.29%

Table A.13: Mean Abnormal Option Volume (MAOV) of Call Options for Firms Deleted from S&P 500, 1996-2002. (* significant at 5%, ** significant at 1%, one tail test)

Event Day	MAOV	P-Value	%MAOV>0
AD-10	49.59%	0.1113	29.41%
AD-9	-14.83%	0.7604	32.35%
AD-8	33.06%	0.2148	32.35%
AD-7	-1.20%	0.5167	29.41%
AD-6	-40.21%	0.9936	17.65%
AD-5	13.24%	0.3242	32.35%
AD-4	-11.34%	0.6886	38.24%
AD-3	-8.58%	0.6287	26.47%
AD-2	-24.25%	0.9352	32.35%
AD-1	4.50%	0.4513	20.59%
AD	51.78%	0.1723	32.35%
AD1	3936.73%**	0.0015	82.86%
AD2-4	7645.37%		
CD	573.35%*	0.0417	55.88%
CD1	174.65%*	0.0245	38.24%
CD2	14.20%	0.3316	29.41%
CD3	153.07%	0.0700	35.29%
CD4	-30.15%	0.9766	29.41%
CD5	-8.29%	0.6288	26.47%
CD6	-11.08%	0.6195	23.53%
CD7	-2.34%	0.5305	17.65%
CD8	-39.28%	0.9485	14.71%
CD9	60.93%	0.2003	17.65%
CD10	-48.85%	0.9987	20.59%
CD11	-23.43%	0.7938	14.71%
CD12	958.98%	0.1774	11.76%
CD13	524.43%	0.1710	20.59%
CD14	245.73%	0.2000	17.65%
CD15	560.12%	0.1499	20.59%
CD16	-37.59%	0.9775	20.59%
CD17	-16.42%	0.7191	20.59%
CD18	-12.94%	0.5881	8.82%
CD19	-31.01%	0.8212	20.59%
CD20	50.28%	0.2295	23.53%

Table A.14: Mean Abnormal Option Volume (MAOV) of Put Options for Firms Deleted from S&P 500, 1996-2002. (* significant at 5%, ** significant at 1%, one tail test)

Event Day	MAOI	P-Value	%MAOI>0
AD-10	-1.35%	0.7081	50.00%
AD-9	1.11%	0.2015	51.11%
AD-8	-0.72%	0.6398	56.67%
AD-7	1.31%	0.2626	60.00%
AD-6	2.51%	0.0707	63.33%
AD-5	1.12%	0.2315	66.67%
AD-4	0.12%	0.4831	65.56%
AD-3	2.4%	0.1779	70.00%
AD-2	0.44%	0.4471	65.56%
AD-1	0.52%	0.4314	62.22%
AD	4.88%	0.0605	65.56%
AD1	378.15%**	0.0028	38.89%
AD2-7	591.61%		
CD	51.18%**	0.0002	73.33%
CD1	53.01%**	0.0003	71.11%
CD2	63.84%**	0	74.44%
CD3	56.23%**	0.0001	74.44%
CD4	64.88%**	0	74.44%
CD5	63.91%**	0	74.44%
CD6	61.14%**	0.0001	73.33%
CD7	57.91%**	0.0001	72.22%
CD8	59.32%**	0.0001	71.11%
CD9	59.02%**	0.0001	73.33%
CD10	58.27%**	0.0002	72.22%
CD11	51.42%**	0.0003	66.67%
CD12	56.59%**	0.0001	66.67%
CD13	60.58%**	0.0002	67.78%
CD14	51.22%**	0.0003	65.56%
CD15	54.62%**	0.0038	64.44%
CD16	53.79%**	0.0045	63.33%
CD17	46.02%**	0.0074	58.89%
CD18	35.43%**	0	62.22%
CD19	31.27%**	0.0001	61.11%
CD20	29.06%**	0.0005	61.11%

Table A.15: Mean Abnormal Option Open Interest (MAOI) for Call Options of Firms Added to S&P 500, 1996-2002. (* significant at 5%, ** significant at 1%, one tail test)

Event Day	MAOI	P-Value	%MAOI>0
AD-10	0.30%	0.4570	43.33%
AD-9	1.83%	0.1331	53.33%
AD-8	-0.98%	0.6625	55.56%
AD-7	0.24%	0.4577	56.67%
AD-6	2.19%	0.1335	57.78%
AD-5	1.37%	0.2033	58.89%
AD-4	-0.51%	0.5707	57.78%
AD-3	1.94%	0.2365	65.56%
AD-2	-0.49%	0.5576	66.67%
AD-1	1.65%	0.3032	63.33%
AD	5.59%*	0.0384	64.44%
AD1	1981.97%*	0.0186	50.00%
AD2-7	3529.96%		
CD	61.59%*	0.0446	63.33%
CD1	71.72%*	0.0282	67.78%
CD2	91.54%*	0.0131	72.22%
CD3	86.12%*	0.0174	71.11%
CD4	89.56%*	0.0136	72.22%
CD5	89.04%**	0.0093	70.00%
CD6	86.88%**	0.0074	72.22%
CD7	88.43%*	0.0107	70.00%
CD8	88.98%**	0.0104	70.00%
CD9	92.82%**	0.0080	73.33%
CD10	92.14%**	0.0085	74.44%
CD11	87.16%*	0.0136	67.78%
CD12	97.00%**	0.0079	63.33%
CD13	92.89%*	0.0102	62.22%
CD14	92.13%*	0.0110	62.22%
CD15	93.18%*	0.0105	63.33%
CD16	84.49%*	0.0166	63.33%
CD17	73.76%*	0.0119	58.89%
CD18	68.85%*	0.0112	63.33%
CD19	67.45%**	0.0097	67.78%
CD20	65.32%*	0.0119	64.44%

Table A.16: Mean Abnormal Option Open Interest (MAOI) of Put Options for Firms Added to S&P 500, 1996-2002. (* significant at 5%, ** significant at 1%, one tail test)

Event Day	MAOI	P-Value	%MAOI>0
AD-10	-3.16%	0.8189	37.14%
AD-9	2.38%	0.1220	42.86%
AD-8	-0.63%	0.5702	40.00%
AD-7	-6.81%	0.9002	34.29%
AD-6	-4.82%	0.8730	48.57%
AD-5	0.44%	0.4454	74.29%
AD-4	4.17%	0.0005	80.00%
AD-3	4.44%	0.0037	88.57%
AD-2	1.20%	0.3030	80.00%
AD-1	2.79%	0.1348	80.00%
AD	3.50%	0.0772	80.00%
AD1	2606.58%**	0.0070	68.57%
AD2-4	5657.12%		
CD	30.38%*	0.0218	77.14%
CD1	26.76%	0.0722	71.43%
CD2	45.14%**	0.0081	77.14%
CD3	41.34%*	0.0178	80.00%
CD4	49.61%**	0.0052	85.71%
CD5	46.39%*	0.0105	82.68%
CD6	55.08%**	0.0035	82.68%
CD7	52.51%**	0.0063	80.00%
CD8	59.57%**	0.0030	82.68%
CD9	55.27%**	0.0081	77.14%
CD10	59.54%**	0.0045	77.14%
CD11	60.33%**	0.0090	77.14%
CD12	63.98%*	0.0105	77.14%
CD13	64.43%*	0.0113	77.14%
CD14	62.12%*	0.0143	74.29%
CD15	64.30%*	0.0122	74.29%
CD16	59.42%*	0.0194	71.43%
CD17	67.02%**	0.0096	74.29%
CD18	67.46%**	0.0095	71.43%
CD19	67.13%*	0.0106	71.43%
CD20	70.12%**	0.0078	74.29%

Table A.17: Mean Abnormal Option Open Interest (MAOI) of Call Options for Firms Deleted from S&P 500, 1996-2002. (* significant at 5%, ** significant at 1%, one tail test)

Event Day	MAOI	P-Value	%MAOI>0
AD-10	2.54%	0.3545	47.06%
AD-9	7.97%	0.0937	55.88%
AD-8	5.66%	0.2010	55.88%
AD-7	-7.60%	0.8950	47.06%
AD-6	-5.92%	0.8821	55.88%
AD-5	-1.74%	0.6636	61.76%
AD-4	2.09%	0.2313	76.47%
AD-3	0.50%	0.4336	70.59%
AD-2	-1.87%	0.7081	0.6471%
AD-1	-1.62%	0.6830	0.6471%
AD	1.61%	0.3619	0.6471%
AD1	2695.76%*	0.0119	71.43%
AD2-4	3699.48%		
CD	44.24%	0.0654	61.76%
CD1	59.09%	0.1472	58.82%
CD2	74.73%	0.0916	64.71%
CD3	66.58%	0.1191	55.88%
CD4	76.21%	0.0883	58.82%
CD5	58.01%	0.0931	55.88%
CD6	62.39%	0.0776	52.94%
CD7	58.42%	0.0923	52.94%
CD8	62.30%	0.0788	52.94%
CD9	60.09%	0.0871	55.88%
CD10	65.26%	0.0705	55.88%
CD11	63.49%	0.0767	55.88%
CD12	62.11%	0.0819	52.94%
CD13	66.44%	0.0691	50.00%
CD14	66.23%	0.0723	47.06%
CD15	70.68%	0.0602	50.00%
CD16	68.33%	0.0703	47.06%
CD17	74.48%	0.0548	52.49%
CD18	73.46%	0.0564	52.49%
CD19	71.04%	0.0630	52.49%
CD20	74.66%	0.0532	52.49%

Table A.18: Mean Abnormal Option Open Interest (MAOI) of Put Options for Firms Deleted from S&P 500, 1996-2002. (* significant at 5%, ** significant at 1%, one tail test)

Appendix B

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