The S&P 500 Index Effect in Continuous Time:

Evidence from Overnight, Intraday and Tick-by-Tick Stock Price Performance

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Abstract

The advent of index tracking early in the 1970s and the continuous growth of assets tied to the S&P 500 index have enforced perceptions of the importance of becoming an index-member, due to increased demand by index fund participants for the stocks involved in index composition changes. This study focuses on S&P 500 inclusions and examines the impact of potential overnight price adjustment after the announcement of an S&P 500 index change. We find evidence of a significant overnight price change that diminishes the profits available to speculators although there are still profits available from the first day after announcement until a few days after the actual event. More importantly observing the tick-by-tick stock price performance of the key days of the event window for the first time, we find evidence of consistent trading patterns during trading hours over inclusion event. A separate analysis of two different sub-periods as well as of NASDAQ and NYSE listed stocks allows for a detailed examination of the price and volume effect in continuous time.

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I. Introduction

Over the last 20 years, index funds have become extremely popular, with total worldwide explicitly indexed assets estimated to exceed $1 trillion. Jensen (1968) showed almost four decades ago that active portfolio managers found it hard to beat the index most of the time, and numerous subsequent studies have confirmed that active management is hard pushed to deliver better performance than the index return less transaction costs. When "trackers" follow a benchmark index, their investment decisions are not based on fundamental analysis. In contrast, they make the necessary portfolio adjustments only to reduce tracking error. This behavior ensures that index member stocks will be preferred to non-index members for such funds. Thus, the deletion of an existing member-firm from a widely followed benchmark has a significant implication for fund managers. For pure index trackers, the only reason, apart from changing cash flows, for trading stocks will be index composition reviews; the more money tied to the index, the more will be expended in reducing the tracking error.

The "index effect" refers to the price pressure that is observed when a stock is added to or deleted from an index. If the index is widely tracked, then profits can be made by buying (selling) the shares of the added (deleted) firm ahead of index funds and selling (buying) them at a later stage, when index fund demand (supply) is satisfied. The more money is tied to the index, the more index portfolio managers will be involved in trading the underlying stocks around the index recomposition. Index trackers ensure that demand will increase for added stocks and will reduce for deleted stocks. For many years, "buying additions and selling deletions" has been a lucrative strategy for investors not involved in index tracking.

This study examines the impact of potential overnight price adjustment after the announcement of an S&P 500 index addition as well as the impact of the effect on the price and volume performance of the stocks on a tick-by-tick basis. A separate analysis is also conducted for two different sub-periods as well as for NASDAQ versus NYSE listed stocks. Previous studies have mainly concentrated on a close-to-close abnormal return analysis and showed that there is a significant price increase between the close on the announcement date and the close on the day after. However, the purchase of the added stock cannot be made at the close of trading on the announcement date, because the information is released in the market after the market close. The first trading opportunity arises in the

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morning of the first date after announcement, where the stock opens at a very high price level resulting in lower actual trading profits; our study investigates this issue in detail.

The following analysis differs from previous studies in four important areas. First, the results involve not only close-to-close abnormal returns but also overnight and open-to-close abnormal returns. Second, the tick-by-tick performance of the added stocks is examined for the first time for the years 1999 and 2000. Third, NYSE and NASDAQ samples are examined separately to determine the impact of trading venue on the index effect. Finally, we make use of a more recent and longer run of data on index additions; index changes are examined for a period that comprises both bullish and bearish market trends.

The remainder of this study is organized as follows. Section two provides a full description of the major stock selection criteria and the announcement policies of the Standard and Poor's Index Committee. Section three presents a brief summary of previous relevant studies associated with S&P 500 index changes and the prevailing hypotheses that lie behind the companies' post-event performance. Section four examines the stock performance after addition by using overnight and open-to close data and section five provides results using tick-by-tick abnormal returns. Section six presents an analysis of the index effect in continuous time and section seven concludes.

II. Index Tracking and the S&P 500

The S&P 500 is a value-weighted index, the level of which reflects the market value of all 500 component US stocks relative to a particular base period. Stocks are selected to be representatives of their sector. The selection and management of the index is determined by the Standard and Poor's Index Committee. Changes in index composition are mainly caused by member companies effectively ceasing to exist in their current form through mergers, takeovers, restructuring or bankruptcies. The replacement process for deleted firms is a complicated issue. According to a statement of Standard and Poor's "candidate firms are monitored carefully and the criteria for inclusion are highly stringent". After screening candidate companies, an S&P 500 Replacement Pool is created that contains at least 10 companies. The prevailing company from the Replacement Pool is chosen whenever a new entry to the index is required following the deletion of another company. The selection process for S&P 500 membership does not simply refer to a typical quantitative ranking system based on market capitalisation. Therefore, it is difficult for institutional investors and

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fund managers to anticipate the changes. This is in contrast with the procedures that operate for most other major indices. In general, but not exclusively, S&P member companies have the largest market value in their sector and are chosen to represent their industry in the US market. The selection process entails an examination of the firm's trading activity, such as public float[1] and liquidity/turnover ratios, to ensure high liquidity and to reduce the probability of deviations from the fair stock price. Ownership of the company is also monitored to detect "closely held" companies.

Standard and Poor's changed their announcement policy twice – in September 1976 and more recently in October 1989. The latter change was made in order to alleviate the price pressure on the announcement date that occurred prior to this when index inclusion took place immediately the day after announcement. Changes are now pre-announced an average of five days before the event. The period from the announcement date to the effective date can give enough time for institutional investors and index fund managers to adjust their holdings, if they so wish. The announcement, which takes place after the market close, reveals the name of the firm that will be added (deleted) and the exact date that the event will take place[2]. In some cases, however, the exact date of the event is not announced. In those cases, the announcement states only the names of the firms, and the exact event will happen at a date to be announced. Thus, investors and index fund managers have to wait until the event announcement that will happen at the market close of a future date. The change will then become effective the next morning of the event announcement.

III. Previous Literature

The period during which a change in index composition occurs constitutes a useful laboratory for testing the Efficient Market Hypothesis (EMH). Fama (1970) has defined an efficient market as a market in which security prices reflect all available information. The semi-strong form of the Efficient Market Hypothesis states that all publicly available information is reflected on security prices. Under this theory, the market's historical knowledge of abnormal returns for index additions (deletions) will drive the security's price up (down) to its expected addition (deletion)-day value on the day after the announcement (Cusick, 2002). The profits from buying the stock on the day after

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[1] In March 2004, Standard and Poor's announced that it will convert all major U.S. indices to float-adjusted and in September 2004 it released details for the methodology of free-float calculation. Free-float adjustment is considered to be the "next step" in keeping S&P indices representative of the market and the most relevant solution for investment needs. In March 2005, S&P 500 became half-float adjusted and in September 2005, full-float adjusted.
[2] We would like to thank Milvia Luckenbach and Srikant Dash from Standard and Poor's Corporation for providing information about the new announcement policy.

the announcement and selling it on the effective date should be fully eliminated and the increase in the security's price should happen overnight.

The index effect has been shown in numerous studies to result in stock price behavior during the event period that appears inconsistent with EMH. Consequently, a number of hypotheses have been proposed to justify this performance. These are the Price Pressure Hypothesis, the Imperfect Substitutes/Downward-Sloping Demand Curve for Stocks Hypothesis, the Liquidity Cost Hypothesis, the Information Content/Index Member Certification Hypothesis, and the Market Segmentation/Investor Recognition Hypothesis. Their main differences concern whether the stock price or volume change is temporary or permanent after the event, what kind of information is revealed with an addition or deletion, and what are the main issues for stock and investor behavior. While the number of papers examining whether these hypotheses have received empirical support is large, with the exception of three, all have considered only close-to-close returns. Such research arguably presents a misleading picture of the profitability of trading on changes in index composition since these profits cannot be realized by investors.

Beneish and Whaley (1996) as well as in a later paper (1997) were the first to examine close-to-open returns to measure the extent of the overnight performance that is consistent with market efficiency. The information of a newly added stock is announced at the close of trading, and under the old announcement policy, the change takes place immediately the day after. Therefore, overnight pressure under the old policy is expected to be larger, since there is no interval between announcement and event. The major part of the abnormal close-to-close return of added stocks under the old announcement policy is caused overnight (4.37% with a t-ratio of 11.69) and the open-to-close abnormal return of the following day is -0.62% (with a t-ratio of -2.35) leaving no profitable trading opportunities. Under the new announcement policy however, a significant but substantially smaller in magnitude abnormal return is caused overnight (2.46% with a t-ratio of 5.52) with an insignificant (positive) open-to-close return the next day (0.6%).

Open-to-close returns are also examined by Cusick (2002), who finds evidence of an increase in market efficiency through time, and a decrease in the trading profit available to arbitrageurs who are buying additions and selling deletions. By using the level of the overnight abnormal return from the closing of the announcement date until the following morning as a proxy for investors' interest, he

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shows that the potential trading profits available have decreased over time. His main conclusion is that investors' interest will outweigh the increase in indexing and the available trading profit will be diminished through time.

There is no previous literature for the S&P 500 index effect that concerns tick-by-tick data. The methodology used in this piece of work to obtain abnormal returns in continuous time is similar to that of Wood, McInish and Ord (1985) who examined the return characteristics of trades at the micro level, although not relating specifically to the index effect. The authors observed a difference in return distributions among overnight trades, trades during the first 30 minutes following the market opening, trades at the market close and trades during the remainder of the day. Moreover, by using a minute-to-minute market return series for a large sample of NYSE stocks during 1972 and 1982, they found high returns and standard deviations of returns at the beginning and at the end of the trading day, providing evidence of U-shaped intraday patterns. In the case of S&P 500 inclusions, new information is been released overnight and increased trading volume is expected at the beginning of the day after announcement. According to Easley and O'Hara (1992), bid-ask spreads should widen upon occurrence of large block transactions to reflect the uncertainty of the future price equilibrium and therefore, high standard deviations of intraday returns should also be expected. However, inclusions are events that require significant index fund rebalancing and specialists as well as market makers can afford to tighten the spread due to increased volumes, and may choose to do so in the short-run (Beneish and Whaley, 1996). In any case, the U-shaped pattern of return variation may not be pronounced since significant trading activity is likely to occur throughout the whole trading day and the evidence of increased liquidity found in previous studies (Edmister, Graham and Pirie, 1996 and Erwin and Miller, 1998) will not adversely affect trading costs.

IV. The Overnight and Open-to-Close Effect

a) Data and Methodology

The stock opening and closing prices were obtained from *Thomson Datastream*. There were insufficient data for the benchmark opening prices before the year 1993 and therefore, the firms that were added to the S&P 500 before that year had to be eliminated; the final sample contains 266 stock additions to the S&P 500 for the period 1993-2002. The abnormal open-to-close return (OTC) for each firm is obtained by subtracting the open-to-close performance of the stock from that of the benchmark on the corresponding date. The same approach is repeated for calculating close-to-close

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abnormal returns (CTC) from the announcement day (AD) close until AD+1 close. The overnight performance is then derived from subtracting the open-to-close performance from the close-to-close performance as shown in the following equations:

$$AR_{CTCit} = R_{CTCit} - R_{CTCmt} \qquad (1)$$

$$AR_{OTCit} = R_{OTCit} - R_{OTCmt} \qquad (2)$$

$$OVR_{it} = AR_{CTCit} - AR_{OTCit} \qquad (3)$$

where, in the case of the first day after the S&P press release, R_{CTCit} and R_{CTCmt} are the close-to-close returns between AD and AD+1 for the stock and the S&P 500 respectively, R_{OTCit} and R_{OTCmt} are the open-to-close returns between AD+1 open and AD+1 close for the stock and the benchmark respectively, AR_{CTCit}, AR_{OTCit} are the abnormal close-to-close and open-to-close returns for each stock respectively, and OVR_{it} is the overnight (non-tradable) abnormal return between AD close and AD+1 open for each firm. This method is repeated for all trading days during the event window until the day after the effective index changes (ED+1).

b) Results

i. The whole sample

Table 1 presents the close-to-close and open-to-close data between announcement date and effective date with their corresponding *t*-statistics. Figures in bold denote significance at the 5% level or better. On the date of announcement (AD), the open-to-close return is insignificant, indicating no pre-emptive trading of the future index change that is going to be announced after the market close. Moreover, despite the 4.06% abnormal return from the close of trading on AD to the close of trading AD+1, it is clear that there are no trading opportunities on AD+1 because the AD+1 open to AD+1 close return is significantly negative at the 1% level (-0.83%). Thus, the first day price increase cannot be traded unless the stock is purchased before the AD market close.

The overall overnight performance reaches 4.89% (significantly different from zero at the 1% level), indicating that market makers have very positive expectations concerning added firms. The level of overnight return of 4.89% is obtained by subtracting the AD+1 open-to-close abnormal return (-0.83%) from the AD+1 close-to-close abnormal return (4.06%). This can be done for all days in the event window by using the data of Table 1, but only the overnight returns on the announcement and event dates are reported since the market receives new information on these dates only.

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Table 2 repeats the above analysis but the sample is now divided into two different sub-periods, for the years 1993-1997 and 1998-2002. Additions to and deletions from the S&P 500 have become more frequent over the last five years and therefore, the sample of firms added to the index during the period 1998-2002 is larger (88 firms in the earlier sub-period and 178 firms in the later one) . The added firms of the first sub-period (1993-1997) experience an overnight price increase of 3.89% after the close of AD and a further marginal and insignificant price increase of 0.02% between AD+1 opening and AD+1 close. By contrast, in the more recent sub-period, the overnight performance between AD close and AD+1 open reaches the level of 5.38% with a highly significant negative return of -1.25% from the opening until the close on the day after (AD+1). This negative open-to-close return suggests that the market overreacted overnight with the result that the price typically falls during trading hours.

It is important to observe what is happening on the event date. The evening of ED is the last point where the S&P 500 has its old composition, and index fund managers have already started rebalancing their portfolios (the new composition and divisor adjustment of the S&P 500 index are based on the ED closing prices). The close-to-close abnormal return between ED-1 and ED is significantly different from zero when looking at the whole sample as well as when looking at both sub-periods. In particular, the ED-1 close to ED close abnormal return is 2.18% for the whole sample (Table 1) and seems to be lower in the more recent period (Table 2). However, the ED open-to-close return remains insignificantly different from zero for the recent period sub-sample, showing that index fund demand does not appear to drive price patterns. This is not the case, though, for the earlier period, where the average stock experiences a significant price increase of 1.49% on an open-to-close basis.

The overnight performance between ED close and ED+1 opening is negative, showing that there is no further price pressure, and this inference is confirmed from the further negative intraday return (between ED+1 open and ED+1 close). Also, comparing the two sub-samples, the overnight ED close to ED+1 open performance has not significantly changed through time (t-statistic = 0.96). On ED+1, the change becomes effective by the market opening, and the average open-to-close abnormal return for the whole sample is -0.36%, which is marginally significant.

It is also worth noting that in the more recent sub-period, the AD+1 close-to-close price increase is higher, although the ED close-to-close price increase is lower. In other words, the abnormal return premium has shifted towards the announcement date. This can be attributed to a potential increase in the number of arbitrageurs through time (since the "S&P Game" has become apparent and the number and financial power of hedge funds has grown enormously) and to the fact that they may be trying to make a profit by buying the stock ahead of index funds. It could be also attributed to an increase of market efficiency (the t-mean for the differences in the overnight performance between AD close and AD+1 open of the two sub-samples is highly significant and higher for the recent sub-sample), where participants are aware of the positive addition effect and thus they drive prices up immediately after the announcement date instead of on the event date. Both of the above explanations would ensure that the demand for added stocks on the event date will be satisfied and the price pressure will be relatively low, given that the added stocks have gained most of their extra value on the first date after announcement.

To conclude, according to all of the above findings, even if the AD+1 close-to-close abnormal return is eliminated, there are still some profitable trading opportunities beyond AD+1 until the date of the actual event. From Table 1, it can be seen that if the added stock is bought at the close of AD+1 and held until the close of ED, a profit of 4.3% can be realized. This level of abnormal return is derived from the cumulative performance of the average firm from AD+1 to ED close-to-close. The results thus far are consistent with those of Beneish and Whaley (1996 and 2002) and Cusick (2002). More information concerning the improvement of this profit will be presented in the following section, where the tick-by-tick stock performance is examined and stronger inferences can be made about the optimal times to buy and sell the added stock.

ii. The Overnight Effect: NASDAQ listed versus NYSE listed stocks

The NYSE and NASDAQ exchanges are very different in the way they operate and these differences could become crucial under certain circumstances. The former is a specialist market, where all trades occur in a physical place, the NYSE trading floor, whereas the latter is a dealer market that is based on a telecommunication network. On the NYSE exchange, individuals are buying and selling from one another and the highest bidding price matches the lowest offering (asking) price in a form of a continuous auction. In the case of the NASDAQ exchange, the dealers are not on the floor and there is direct trading between investors and their market makers (dealers), who are buyers or sellers. Both

the specialists and the dealers are responsible for controlling market orders and the flow of trading. The specialists try to ensure ongoing trading and facilitate trades between individuals, whereas the dealers create markets for each security. Christie and Schultz (1994), Huang and Stoll (1996) and Bessembinder and Kaufman (1997) have examined the differences between dealer and auction markets, and have shed light on the debate concerning the efficiency of a fragmented (centralized) over a decentralized market, showing the prevalence of the NYSE as a more efficient and less costly exchange. The exchanges also differ in the types of the securities that are traded. Stocks listed on the NYSE exchange are typically "blue chips" - i.e., established companies, whereas stocks listed on the NASDAQ are usually considered to be more volatile and to possess significant growth opportunities but with higher levels of risk.

An important role of any stock market is its ability to absorb large demand or supply shocks smoothly, without significantly affecting security prices. If, for some reason, too many orders arrive only on the buy side or only on the sell side, then specialists or dealers have to work together to match as many orders as possible and to use their own inventories if necessary. Both exchanges claim that they are better at minimising the price impact of a large block trade. The main advantage of the NYSE relates to the fact that the market is centralized and the specialist can handle more easily any liquidity problems. In addition, the existence of the limit order book can provide better liquidity in the sense that the specialist has to continuously take offsetting positions. On the other hand, the NASDAQ exchange is relatively decentralized and has a greater market depth, due to the increased competition among dealers and to the capability of direct trading between market participants in the event of demand or supply shocks. LaPlante and Muscarella (1997) showed that the NYSE exchange provides greater liquidity to the market than the NASDAQ exchange in the case of large block trades. The resulting price change difference of the NASDAQ over the NYSE is around 0.14%, revealing the extra cost of trading on the former exchange.

Inferences about the differences between the two exchanges can be more accurately made when comparing open-to-close data, where actual trading is taking place, rather than the close-to-close data used in previous studies. The opening price on the NYSE is determined by the specialist in the form of an auction, based on the orders arriving before the opening bell in the morning. If there is an imbalance in the orders, the specialist seeks to achieve a matching, even if this means buying or selling against the market from the company's own account. Apart from adjusting the opening price

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in the case of a large block trade, the specialist can also halt trading if this is necessary or can delay the opening later than 09.30 until he finds a fair price. In the case of NASDAQ listed stocks, market makers create a market for a particular security and post their two sided quotes in the computer system, which ranks the quotes. The best bid and offer will represent the opening quote.

Table 3 presents the average daily performance of NASDAQ and NYSE listed stocks separately. The exchange effect is of interest at this stage. Even if on a close-to-close basis the exchanges seem to produce different average abnormal stock return levels on the first trading day after the announcement, most of the difference occurs overnight. NASDAQ listed stocks experience higher overnight abnormal returns upon announcement of addition to the S&P 500. In particular, the level of overnight abnormal return for the NASDAQ sample between AD close and AD+1 open is 6.65% on average, relative to 4.20% for the NYSE sample. This difference is significant at the 1% level (t-statistic = 4.63). It would appear that investors perceive a NASDAQ stock inclusion to be more positive news than the addition of a NYSE stock. The exchange effect is confirmed by the open-to-close data. The overnight reactions were exaggerated and the prices of the stocks partially reverse from the opening until the closing of AD+1. The price reversal is more intense and significant for NASDAQ stocks (-1.95% with a t-statistic of -5.28), than for the NYSE stocks (-0.34% with a t-statistic of -1.7), showing an advantage of the specialist market. This result echoes that of Elliott and Warr (2003), who used daily data to investigate differences in the index effect across the two markets.

Comparable differences between the two markets take place between the opening and the closing on ED, where NYSE stocks experience a positive open-to-close abnormal return of only 0.48% relative to a figure of 1.05% for NASDAQ stocks. It might be that index fund rebalancing on the NASDAQ market is more costly than on the NYSE market. A difference could arise from differential levels of transaction costs as well as differing levels of liquidity of NASDAQ versus NYSE added stocks. The overnight abnormal return between ED close and ED+1 open is significantly negative on both NASDAQ and NYSE stocks (-1.15% and -0.4% respectively) and statistically different for the two samples (t-statistic = 2.69, with the NASDAQ sub-sample realising a higher price reversal). However, on an open-to-close basis, only the NYSE abnormal returns are significant during ED+1. Even when looking at the two exchanges separately, the actual trading opportunities are limited to

the days from AD+1 close until ED close, with the NASDAQ sample experiencing higher overall cumulative profits.

V. Tick-by-Tick Performance of the Stocks that are Added to the S&P 500 Index
a) Data and Methodology - The Trade and Quote Database (TAQ)

The *TAQ Database* contains intraday transactions data for all securities listed on the New York Stock Exchange (NYSE), the NASDAQ National Market System (NMS) and SmallCap issues as well as the American Stock Exchange (AMEX). This analysis uses the reported trades on each day of the event window for the S&P 500 added firms, but tick-by-tick data is only employed for the years 1999 and 2000. The final sample consists of 91 firms. In order to be able to connect the previous findings for close-to-close and open-to-close returns, that analysis is repeated for this sample separately. By doing that, continuous price behavior of the average added firm can be traced over the event window and the optimal times to trade the stock can be identified.

In estimating tick-by-tick abnormal returns, the S&P 500 index cannot be used directly as a benchmark, because the intraday changes of the index are significantly less frequent than the intraday changes for the added stocks. The closest substitute for the S&P 500 index that is traded as a stock and is also very liquid is the SPIDER (SPY) fund[3]. All the trades recorded on each day are collected from the *TAQ Database* for the sample of firms and for the SPY. A typical entry records the time of the trade, the number of shares traded, and the price at which these shares were traded. The official US starting time is 09.30 and the official ending time is 16.00. There are also Pre- and Post-Market Close Trades reported before and after this interval. These trades occurred between 08.00 and 09.30 or between 16.00 and 17.16. Since they are executed outside the current market hours (but within the market reporting hours), they are not included in the analysis. Extensive information concerning the systems and trading procedures of the New York Stock Exchange can be found in the study of Hasbrouck, Sofianos and Sosebee (1993).

The firms that were added to the index over the years 1999-2000 differ in terms of liquidity and the number of trades recorded. Therefore, for a particular interval, e.g. two minutes, one firm's stock may have traded 100 times and another only 10 times. To confront this problem, the following steps are performed. First, a *reference time* in seconds from 09.30 to 16.00 is created, since all the trades

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[3] The SPDR (SPY) fund is an ETF (Exchange Traded Fund) that holds all the components of the S&P 500 index.

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are downloaded from the database in seconds. Second, the recorded trades (one series for the prices and one series for the number of shares) for each firm are allocated according to their reported times. The more liquid firms cover all the seconds of the *reference time* and in some cases, there is more than one trade per second which occurred at the same price. To overcome this, for those particular seconds, the total number of shares traded at the same price is reported as one trade. On the other hand, the less liquid firms have failed to report a trade for some seconds of the day and there are gaps in the *reference time*. However, this is not a problem, since the final chosen time interval is longer than a single second and consequently, all firms report at least one trade per time interval.

The final interval selected is five minutes and therefore, the intraday price and volume performance between 09.30 and 16.00 for each stock has 78 observations per day. In order to compress the *reference time* in seconds into five-minute intervals, in the case of firms with more than one reported trade per five minutes, the sum of the reported quantities of shares over that interval is used as the number of shares traded, and the last reported price is used as the price over that interval. This is done because the best information concerning the fair price of the stock is given from the last reported price of each interval and not from the average price of the interval. In the same way, stock markets record the last price[4] as the closing price of the day and not the weighted average price of the trades throughout the whole day. In the case where the firm has not reported any trades over a five-minute interval, the sum of the number of shares traded in that interval is zero and the price for that interval is the same as that of the previous one. Again, this procedure is followed because the previous interval price is the latest available information in the market concerning the stock.

The same approach is employed to obtain tick-by-tick prices of the SPIDER (SPY) index fund, which also comprises 78 observations per day. Logarithmic returns are then obtained for each stock and for the SPY by taking the log of the difference among the five-minute intervals, consistent with the method of Wood, McInish and Ord (1985). Abnormal returns are also derived by taking the difference between the stock return and the benchmark return for all 78 observations each day:

$$AR_{i,\,j} = R_{i,\,j} - R_{SPY,\,j} \tag{4}$$

where, R_i and R_{SPY} are the interval returns during the trading hours for each stock i and for the SPY respectively and $AR_{i,j}$ is the abnormal stock return for each interval j.

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[4] In reality, an auction occurs over the last few minutes of the trading day to estimate the final closing price.

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Concerning the intraday trading volume during each day of the event window, the number of shares traded per five-minute interval is expressed as a percentage of the total daily traded shares of each firm in order to allow comparison among firms of different liquidities. These percentages are then averaged across firms for each five-minute interval and are free of any bias that might have occurred due to the differences in the total absolute trading volumes of the stocks. This approach can show which part of the total daily trading volume is happening over each interval and may reveal the timing of index fund rebalancing. The results presented below concern the most important dates of the event window, starting from the morning of announcement date (AD), where the market is not yet aware of the future S&P 500 index re-composition.

b) Results

i. Intraday Firm Performance on the Announcement Date (AD)

Figure 1 presents the cumulative abnormal tick-by-tick performance of the average added stock on the date of announcement (AD). It can be seen that the overall open-to-close return for the sample of 91 firms is not more that 0.2%. On the morning of announcement date, there is no information revealed to the market about the forthcoming S&P 500 index change, and thus price and volume behavior should be not driven by this event. Indeed, there is no particular trend in the average tick-by-tick price performance of the 91 stocks (Figure 1), and prices may be driven only by the corresponding market tick-by-tick trend. The average cumulative abnormal return is generated around a positive mean. Although this analysis involves only 91 firms, we would argue that the results are representative of the larger sample used earlier since the average performance of these stocks is very similar to the open-to-close results reported in the previous section for the added firms over the longer sample period. The open-to-close abnormal return reported in Section IV is marginally positive (0.12%) though insignificant.

The volatility of the above average performance is due to the fact that there is no information released to the market, and in each five-minute interval, the stock behavior is interpreted as being highly dependent on the S&P 500 tick-by-tick trend reflected in the SPY. In addition, this volatility may be attributed to the bid-ask bounce; i.e. the trades are filled either on the bid or on the ask side and therefore, the average firm performance is affected by the continuous up-down price movement, due to the bid-ask spread. Given that the pattern is traced every five minutes, these fluctuations should be expected. Since additions are not happening at a single point in time but throughout the

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whole 1999-2000 period, where the S&P could be bullish or bearish, there is no trend in the pattern of intraday AD performance.

To check whether there is any anticipation of the S&P press release (that will be posted after the close of trading), we show the volume figures over the last minutes of that trading day. Figure 2 presents the total number of shares traded per five minutes for the average firm. The total number of shares for each interval is expressed as a percentage of the total daily volume. These percentages are then averaged for each interval against the number of firms. For a typical trading day, a higher volume is expected over the first few minutes after the market opening as well as over the last few minutes before the market close and usually, intraday volumes trace out a "smile pattern" (Wood, McInish and Ord, 1985). However, the average volume observed over the last five minutes of AD, expressed as a percentage of the total volume occurred during the day, is surprisingly high. This may indicate leakage of information that will be officially released soon after the close of trading. Investors who were actually capable of buying the added stock before the AD close, due to potential leakage of information, could enjoy a highly significant abnormal return until the next day's closing. Those who did not buy the stock on AD close will have to suffer the huge overnight price increase and buy the next day (AD+1) at a higher price. The tick-by-tick performance of the first day after announcement is described in the following section.

ii. Intraday Firm Performance on the First Day After Announcement (AD+1)

After the close of AD, S&P releases information about the future change in the index composition and the market is now aware of the names of the stocks involved and of the future event date. There is a significant price increase overnight, and the next morning the stock opens at a higher price (4.89%, reported in Table 1 for the firms added over the longer sample period). According to the close-to-close analysis, the stock price change is expected to reverse during the day, because the close-to-close abnormal return is roughly 4%. The open-to-close performance is significantly negative and investors or arbitrageurs who want to be involved in any arbitrage opportunities must buy the stock on that date. Since the average stock price reverses during the day, it is worth checking whether there is an optimal time to buy the stock, i.e. when the lowest price level occurs on average.

Figure 3 presents the tick-by-tick cumulative performance of the average added stock on the first date after announcement. It can be seen that the price experiences a continuous negative trend, losing

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part of the overnight price increase. The price correction of AD+1 shows that investors have realized the positive effect of addition, but the reflection of this future event on the stock price was overshot overnight. Under the assumption that arbitrageurs and other market participants have realized that during AD+1, trading the price drops monotonically, they should wait and buy the stock at the market close. However, according to the volume levels presented in Figure 4, it is evident that high trading activity occurs at the opening price. This is reasonable given the overnight change of almost 5% (reported in Section IV), an increase which is significantly high and therefore, market participants may assume a reversal within the day and start selling the stock short at the opening.

Figure 4 shows how the total daily volume is allocated to the five-minute intervals between 09.30 and 16.00. Indeed, there is selling pressure at the market opening and during the first half hour, because volume figures are at their highest levels relative to total daily trading, and the price decreases. The price of the firm that will soon be added to the index seems to partially lose its significant overnight increase during the first day after the revision announcement. In Section IV, it was shown that the overall open-to-close return for that day is significant.

The buy side of these trades may be provided by participants who aim to hold the added stock in the long run. The best time to buy the stock is a few minutes before the close, when the price is at its lowest level. However, since the stock opens at a considerably higher level than that of the previous close, one could enhance the tradable return by starting to sell short the stock at the opening of AD+1 and then buying it back again at the close of trading when it hits its lowest level, and then taking a long position in the stock until the event date (ED).

The firm's intraday performance may be affected by the market's overall trend during that period. In an attempt to check whether there is a difference in the tick-by-tick performance between the firms affected by the trading environment, two sub-samples for an S&P 500 "bullish day" and an S&P 500 "bearish day" are examined separately. The sample of firms at the AD+1 date for which the S&P 500 has a negative open-to-close performance is larger. In the case of these two sub-samples, the intraday returns are not adjusted against the SPY since the market effect is taken into account in a different way.

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Figure 5 reports the intraday performance of the first day after announcement for the stocks with a positive S&P 500 open-to-close return and for the stocks with a negative S&P 500 open-to-close return. It is apparent that although the average cumulative returns of the two sub-samples move in tandem until 12.30, beyond this point, the prices of the stocks with a bullish S&P 500 day reverse partly until the close. However, in both cases the open-to-close return is negative and there is an opportunity to buy the stock at a relatively low price and to unwind this position on the event date. Again, a short position at the open with a reverse long position at the close will enhance total trading profits, especially in the cases where the S&P 500 index experiences a price fall on that day.

To complete the AD+1 intraday analysis, it is also worth examining firms listed on the NASDAQ and NYSE exchanges separately. On the first day after announcement, the cumulative abnormal intraday performance of NASDAQ listed stocks is slightly worse than that of the NYSE listed stocks. The pattern observed is, however, the same (Figure 6), and there is no obvious exchange effect. This difference, especially towards the close of the trading day, may be attributed to the fact that NASDAQ listed stocks had stronger overnight performances than stocks listed on the NYSE (as reported in Section IV), and therefore the AD+1 price reversal is more for the former than the latter.

iii. Intraday Firm Performance on the Event Date (ED)

The date where the change in the S&P 500 re-composition becomes effective is the most important date in terms of index fund rebalancing. The change takes place after the close of trading on ED and Standard and Poor's makes the index divisor adjustment by using ED closing prices. Therefore, index fund managers have to complete their purchases as close to the stock's closing price as possible if they wish to minimize their tracking errors. If they postpone part of their investment in the added stock until next day's morning, then they bear the risk of realizing a substantial tracking error, since the overnight price change may be considerable.

Figure 7 presents the tick-by-tick performance of the average added stock on the event date (ED). The graph shows that the stock price falls during the day until around lunchtime, but closes at a positive level, probably caused by index fund demand. There is no apparent buying pressure until 12.00, but after that time, the price has a positive trend until the close, and becomes volatile over the last hour. The stock price reaches its highest level (which is marginally positive) at the market close. There are two possible explanations for this result. The first is that index funds might have started

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their purchases earlier, by choosing to potentially enhance their portfolio returns at the possible expense of tracking error. The second explanation may be attributed to the fact that market is no longer adding value to the stock, since it rallied from the date of announcement until the event and therefore, the open-to-close return of ED is close to zero. Arbitrageurs can now unwind their positions by selling to index fund participants without upwardly affecting the price.

The trading volume on that date is also of great interest. Figure 8 confirms that index funds are completing their purchases a few minutes before the close. The volume reported over the last five minutes, expressed as a percentage of the total volume for that day, is more than 10%. It is worth noting that the volume figures are very smooth throughout the day and there is no increased trading at the market opening. Moreover, there is no increased volume even after 12.00 when the stock price begins a positive trend as shown in Figure 7. Volume figures become significantly high only for the last two intervals with levels of 6.4% and 10.2% respectively. If it is taken into account that the overall trading volume is 16 times higher than that of a typical day, then the numbers become even more extreme. There is strong evidence that most index funds are waiting to buy the added stock as close to 16.00 as possible, and hence that they are concerned with tracking error.

To complete the analysis for the event day, the sample is divided into firms that are added on a "bullish S&P 500 day" and firms that are added on a "bearish S&P 500 day". Figure 9 confirms that even in the case where there is a positive daily market trend, the stock does not have a good performance on the Event day. Although the bullish sub-sample consistently out-performs the bearish sub-sample, particularly over the last half hour, it does not result in a significantly positive abnormal return. However, when the exchange effect is taken into account, the NYSE and NASDAQ sub-samples behave differently. As expected, the NASDAQ stocks' prices are driven up by more than 1.5% on an open-to-close basis, while NYSE firms close down 1%. The performance of the NYSE firms is not even affected by the increased volume during the last ten minutes and the average return remains at negative levels (relative to the market opening) throughout the whole event day (Figure 10). The tick-by-tick analysis therefore confirms that from an arbitrageur's perspective, NASDAQ stocks might be more profitable. However, it is surprising that NYSE listed stocks achieve only negative returns on that day, given the increased demand caused by index funds.

The event date is the last profitable day for non-index trackers who are trading the added stocks, since the close-to-close returns reported after that day are significantly negative. Not only is the price pressure exhausted by the event date, but there are three consecutive and significant close-to-close price reversals for ED+1, ED+2 and ED+3. These reversals can be exploited by selling the stock short, a strategy that will be explained in detail in a later section. The following sub-section concentrates on the intraday price behavior when the stock is actually a member of the S&P 500 index.

v. Intraday Firm Performance on the First Day after the Event (ED+1)

On the first day after the event, the average added firm experiences a continuous price drop. The volumes at the beginning of the day are high, perhaps indicating that index fund rebalancing may still be happening or that arbitrageurs are still unwinding their positions. However, the price does not seem to be positively affected by index fund demand. Figure 11 presents the cumulative intraday firm performance on the first day after the event, in conjunction with the volumes that occurred at each interval. Over the first ten minutes of the trading day, almost 9% of the total trading occurs. The price pattern, though, is not consistent when the sub-samples of firms added on a bullish ED+1 day and of firms added on a bearish ED+1 day are examined separately. Figure 12 shows that the overall open-to-close market trend matters and firms added on a bullish S&P 500 day experience positive tick-by-tick returns of 0.7% and firms added on a bearish S&P 500 day lose -1.4% on an open-to-close basis. The exchange effect, on the other hand, appears irrelevant on that date and hence the analysis is not presented here.

vi. Intraday Firm Performance on the Second and Third Days after the Event

According to our previous study, the close-to-close abnormal return remains significant and marginally negative on ED+2 and ED+3, which can also be seen from Table 1. The added stocks appear to have a notable trend over those two days and are different between bullish and bearish days as well when NYSE and NASDAQ samples are examined separately. However, they do not allow us to infer firm conclusions about further index fund trading behavior and hence are not reported.[5] In addition, beyond ED+3, the performance of the stocks starts to depend mostly on the corresponding

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[5] Results for the tick-by-tick stock price and volume performance for the second and third day after the event, as well as other analysis described but not presented, are available by the authors upon request.

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overall market trend and the price patterns start to look similar to those reported in Figure 1 where AD is examined.

VI. An Analysis of the Index Effect in Continuous Time

The above intraday analysis has captured the stock pattern from the market open until the close on the important key dates of the event window. The figures of the tick-by-tick cumulative abnormal return of the average stock were plotted under the assumption of an opening return of 0% relative to the previous close i.e. the open-to-close return on a particular day was isolated. The results of the previous section, where open-to-close returns are adjusted using the SPIDER index fund, do not contradict those obtained in Section IV that refer to the longer sample period. This section will describe a continuous price pattern taking into account close-to-close, open-to-close, and overnight abnormal returns and will determine the total actual profits from trading the added stocks, using the 266 firms added to the S&P 500 index over the years 1993-2002.

Table 4 presents a summary of the actual profits that can be made during S&P 500 index addition events based on the abnormal return levels that were found in Section IV. The timing of buying and selling the stocks will be based on the tick-by-tick analysis presented in Section V. The strategy involves three basic steps: First, being short the added stock from the opening of the first day after the announcement until the close, since the tick by tick results showed that the lowest price level was at the market close. Second, the reversal of the position until the close of the event date and third, being short the stock again from the close of the event date until the close of the third day after the event. From Table 4 it can be seen that the first part of the tradable abnormal return is -0.83%.

At this point, it is important to mention the way that the cumulative abnormal return between AD+1 and ED is calculated. The number of days between announcement and event varies among the added firms and the average period is 5.06 days. As shown in Figure 13, most intervals are around four and five days and it would be difficult to derive strong conclusions about the price performance after AD+7, since the number of observations becomes very small.

There are two possible ways of calculating the cumulative abnormal performance until the close of the event date. The first method is to calculate the cumulative return from AD+1 close to ED close and divide it by the number of days in the interval from AD+1 to ED, to obtain the average rest-of-

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the-window daily abnormal return for each stock. Then this average daily abnormal return should be multiplied by the average interval length which is 4.06 days (because AD+1 is not included). The sum of all these returns divided by the number of additions will give the final estimate of the average cumulative abnormal return from AD+1 close until ED close. By that way, the estimated returns are adjusted for the different intervals, i.e. a 10% cumulative abnormal return of an added stock realised over a 2-day window between AD+1 close and ED close has a different magnitude than a 10% return of another added stock realised over a longer interval.

The second and simpler way to calculate an average window return from AD+1 close to ED close is to take the sum of the cumulative realised returns for each firm from AD+1 close to ED close and divide it by the number of firms. This method does not account for the differences in the interval lengths. However, when both methods are employed, the results are not significantly different and therefore, only the results from the simpler (second) method are reported.

The cumulative abnormal return from AD+1 close to ED close that constitutes the second part of the strategy is 3.75% and is highly significant. Finally, a short position at the stock from ED close until ED+3 close will result in another profit of 2.26%. The total tradable profit is 6.84% on average. The arrows in Figure 14 show the optimal times to buy and sell the added stock after the announcement of addition. The negative intraday AD+1 abnormal return, the positive cumulative AD+1 close to ED close abnormal return as well as the negative cumulative ED close to ED+3 close abnormal return are all significant.[6]

Finally, it is worth mentioning that the negative intraday return of AD+1 represents the price correction after the large overnight performance from AD close to AD+1 opening. It was also shown that the positive overnight return (non-tradable) between AD close and AD+1 opening tended to increase through time, as did the price reversal on the next day (AD+1 open-to-close). Therefore, the profits captured from selling the stock at the AD+1 opening and buying it back at the AD+1 close would also have increased through time.

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[6] Transactions costs have not been accounted for in calculating these trading profits. Also, the short selling rule that applies to US securities may affect the profitability of the short positions since the "up-tick rule" will prevent speculators from talking enormous positions on the stocks.

VII. Conclusions

The first part of this study disaggregated the close-to-close abnormal returns into overnight and open-to-close abnormal returns, showing that the close-to-close positive effect observed one day after the announcement of addition cannot be traded. Upon announcement, there is an overnight overreaction of 4.89% for the average firm with the price reversing significantly (-0.83%) from the opening until the closing of the next day (AD+1). Therefore, the first day price increase cannot be traded, since the stock cannot be bought in the evening of AD. However, profitable trading opportunities occur between the first day after announcement and the date of the actual event. The overnight price change seems to have increased over time, indicating an improvement in the level of market efficiency and a decrease in the profits available to arbitrageurs. In addition, the event date abnormal return caused mainly by index fund rebalancing has diminished over time, because most of the positive effect of being added to the S&P 500 index is reflected in the stock price in advance of the actual event.

When looking at the overnight performance of NASDAQ and NYSE listed stocks separately, the NASDAQ sample experiences higher overnight abnormal returns between AD close and AD+1 opening. Only the AD+1 open-to-close abnormal returns can provide evidence of potential exchange effects and NASDAQ stocks have a highly significant price reversal on that date, while the price reversal of NYSE stocks is insignificant, showing that the specialist market may be able to better absorb large demand shocks.

The second part of this study analysed the tick-by-tick performance of the firms that were added to the S&P 500 index over the years 1999-2000. The benchmark for estimating abnormal returns was the SPIDER exchange traded fund that has a similar liquidity to the average S&P 500 stock and behaves like a stock which tracks the S&P 500 index. To summarize the main findings of the tick-by-tick analysis, the intraday stock price pattern of AD appears to be random, because information about the future index change has not been released to the market at that time. However, a relatively high volume is observed over the last five minutes of this trading day, indicating a potential leakage of information before the S&P press release. During the trading hours of the first day after announcement (AD+1), the stock experiences a price drop without reversing at all, a behavior explained mostly by an overshoot in the overnight price increase that occurred between AD close and AD+1 open.

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It is also worth noting the huge trading volume occurring over the last ten minutes of the event date, which constitutes the last possible opportunity for index fund managers to rebalance their portfolios before the change becomes effective. This abnormal volume level provides evidence that most index funds seek to rebalance their portfolios as close to 16.00 as possible, and that they are concerned with tracking error. However, this increase in volume is not accompanied by a price increase, perhaps showing that other market participants, especially arbitrageurs, are unwinding their long positions in the added stock. Therefore, there is enough supply to satisfy index fund demand. After the event date, there is no further price pressure and the stock price drops significantly both on an open-to-close and overnight basis. The overall reported profit from AD close until ED close cannot be all tradable. The first opportunity to trade the stock is during the trading hours of AD+1.

From the tick-by-tick analysis, it was shown that the optimal strategy for trading the stock is to sell it short on AD+1 at the market opening and to buy it back at the market close. At the same time, a further long position on the stock should be taken at AD+1 close until the close of ED. Finally, a further short position should be taken on the stock between ED close and ED+3 close. The profits from these trades are all significant and total almost 7%. Therefore, we conclude that the perceived reduction over time in the index effect based on daily price series masks the considerable profits that are available to arbitrageurs who are willing to trade on an intra-daily basis.

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Table 1: Close-to-close and open-to-close average daily firm performance between AD and ED+1

Days	AD	AD+1	AD+2	AD+3	AD+4	AD+5	ED	ED+1	ED+2	ED+3
				Close-to-close						
AR	0.40%	4.06%	0.33%	0.60%	0.60%	0.59%	2.18%	-0.96%	-0.52%	-0.78%
t-stat	1.67	**16.30**	1.66	**2.48**	**2.36**	1.41	**6.57**	**-4.05**	**-2.64**	**-3.62**
				Open-to-Close						
AR	0.12%	-0.83%	0.19%	0.20%	0.22%	0.00%	0.64%	-0.36%	-0.32%	-0.62%
t-stat	0.68	**-4.50**	1.05	0.92	0.91	0.01	**2.39**	**-1.96**	-1.78	**-3.22**

Overnight Performance on the Announcement and Event Dates

AD close to AD+1 open	**4.89%*****	**ED close to ED+1 open -0.60%*****

Notes: Figures in bold denote statistics that are significant at the 5% level or better. Three asterisks in the case of overnight returns denote significance at 1% level.

Table 2: Close-to-close and open-to-close average daily firm performance between AD and ED+1 over two different sub-periods

Days	AD	AD+1	AD+2	AD+3	AD+4	AD+5	ED	ED+1
				1993-1997				
Close-to-Close AR	-0.05%	3.91%***	0.41%*	0.03%	0.27%	0.60%	3.10%***	-0.79%***
Open-to-Close AR	0.02%	0.02%	0.16%	0.10%	0.11%	0.38%	1.49%***	-0.37%*

Overnight Performance on the Announcement and Event Dates

AD close to AD+1 open	**3.89%*****	**ED close to ED+1 open -0.42%*****

Days	AD	AD+1	AD+2	AD+3	AD+4	AD+5	ED	ED+1
				1998-2002				
Close-to-Close AR	0.62%*	4.13%***	0.28%	0.89%**	0.84%**	0.59%	1.73%***	-1.04%***
Open-to-Close AR	0.17%	-1.25%***	0.20%	0.25%	0.31%	-0.17%	0.23%	-0.36%

Overnight Performance on the Announcement and Event Dates

AD close to AD+1 open	**5.38%*****	**ED close to ED+1 open -0.68%*****

t-Statistic for the Overnight Differences Between the Two Sub-Periods

AD to AD+1 overnight	**2.85*****	**ED to ED+1 overnight** 0.96

Notes: ***, ** and * denote significant at the 1%, 5%, and 10% levels respectively.

Table 3: Close-to-close and open-to-close average daily firm performance between AD and ED+1 for NASDAQ and NYSE listed stocks

Days	AD	AD+1	AD+2	AD+3	AD+4	AD+5	ED	ED+1
NASDAQ listed stocks								
Close to Close AR	0.00%	4.70%***	0.13%	1.17%*	1.94%***	1.24%	3.53%***	-1.48%**
Open-to-close AR	-0.28%	-1.95%***	0.17%	-0.09%	1.34%**	-0.10%	1.05%	-0.33%

Overnight Performance on the Announcement and Event Dates

AD close to AD+1 open	**6.65%***		**ED close to ED+1 open**	**-1.15%***	

NYSE listed stocks

Days	AD	AD+1	AD+2	AD+3	AD+4	AD+5	ED	ED+1
Close to Close AR	0.55%**	3.86%***	0.42%*	0.37%	0.09%	0.22%	1.65%***	-0.77%***
Open-to-close AR	0.27%	-0.34%	0.20%	0.26%	-0.21%	-0.04%	0.48%*	-0.37%**

Overnight Performance on the Announcement and Event Dates

AD close to AD+1 open	**4.20%***		**ED close to ED+1 open**	**-0.40%***	

t-Statistic for the Overnight Differences Between the Two Sub-Samples

AD close to AD+1 open	**4.63***		**ED close to ED+1 open**	**2.69***	

Notes: ***, ** and * denote significant at the 1%, 5%, and 10% levels respectively.

Table 4: Actual Profits from trading Index inclusions over the years 1993-2002

	AD	AD+1	Interval Return AD+1close to ED close	ED+1	ED+2	ED+3
Close to close			3.75%**	-0.96%***	-0.52%***	-0.78%***
Open to close		-0.83%***				
Cumulative Actual Trading Profits		0.83%	4.58%			**6.84%**

Notes: ***, ** and * denote significance at the 1%, 5%, and 10% levels respectively

Figure 1: Tick-by-tick cumulative abnormal performance of the average added stock on the date of announcement
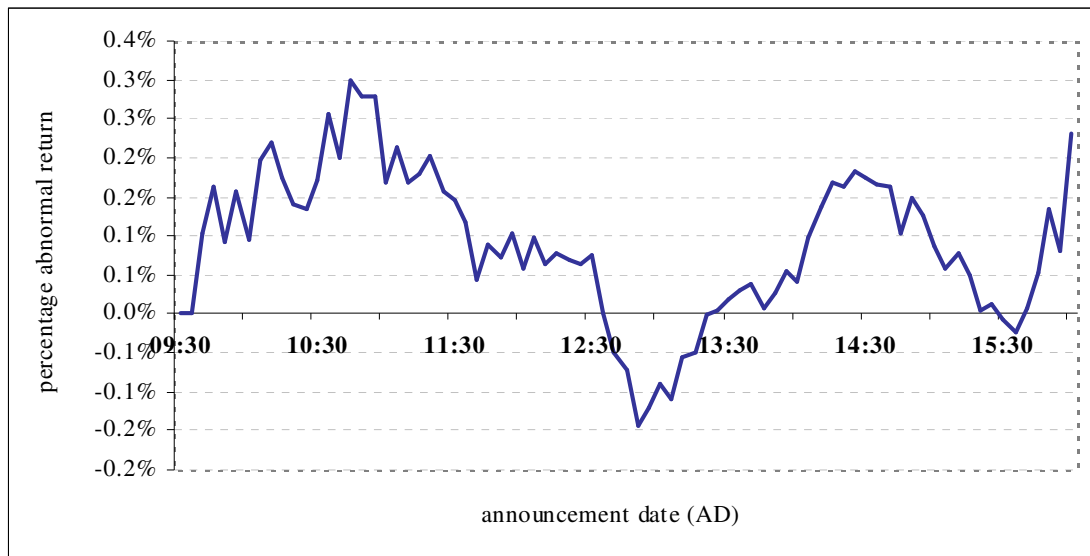

Figure 2: Number of shares traded over each five-minute interval expressed as a percentage of the total daily volume on the date of announcement
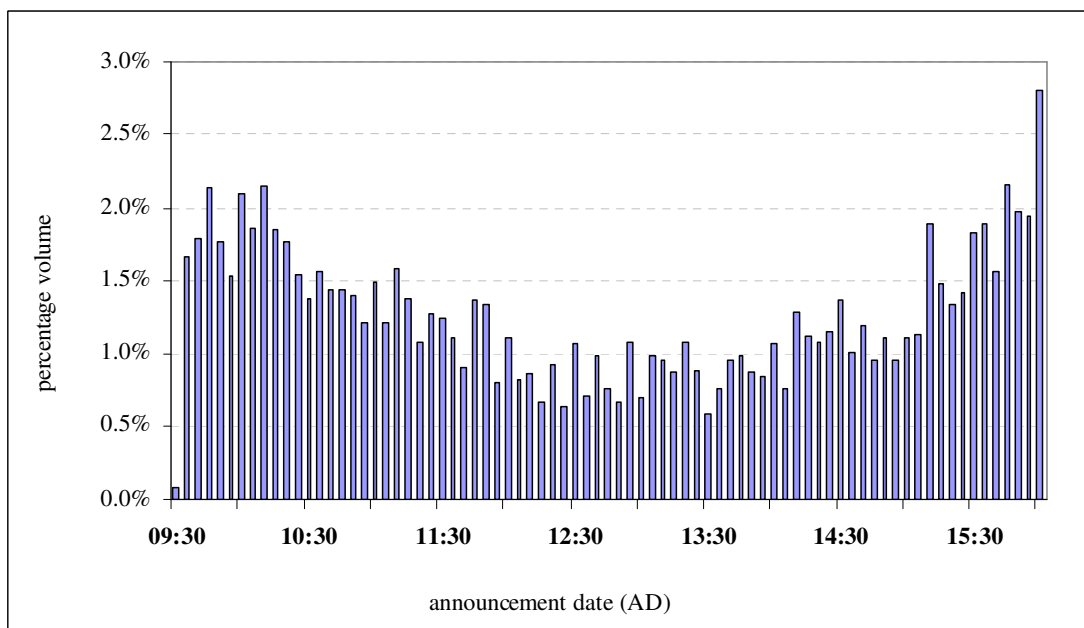

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Figure 3: Tick-by-tick cumulative abnormal performance of the average added stock on the first day after
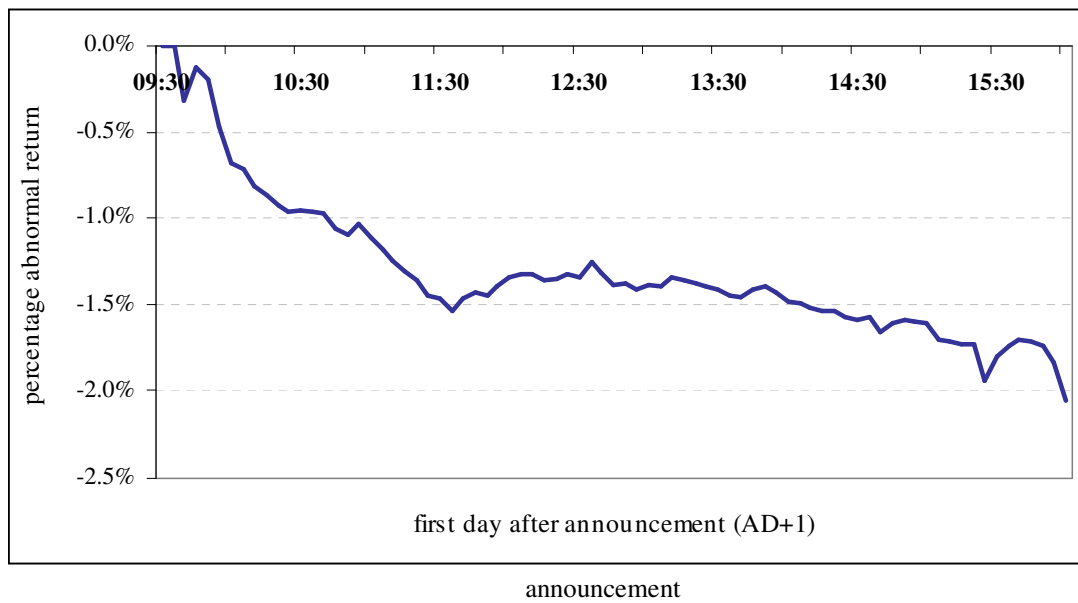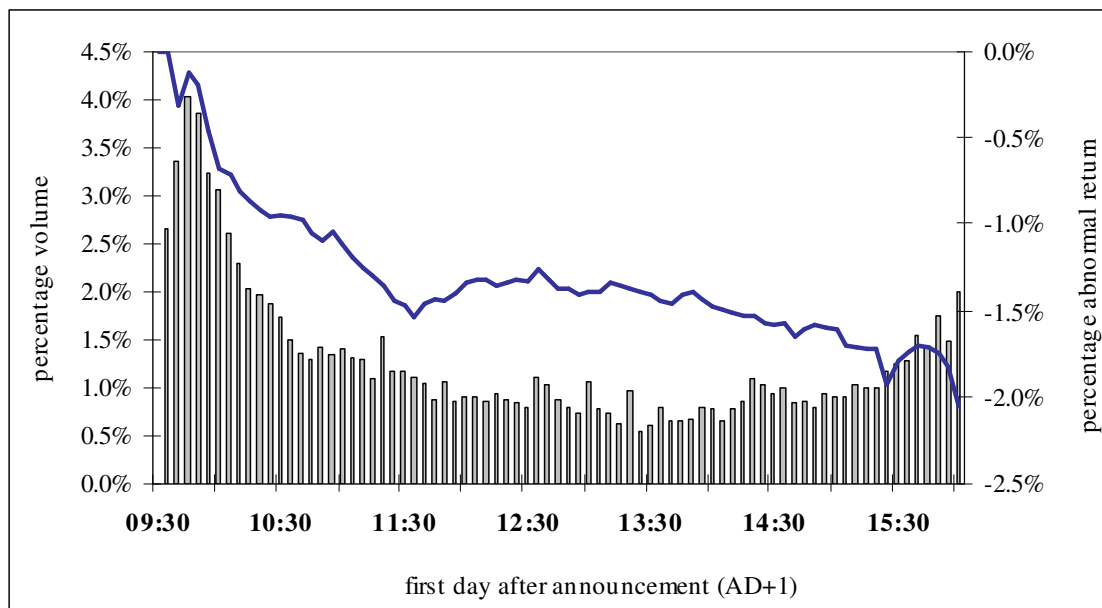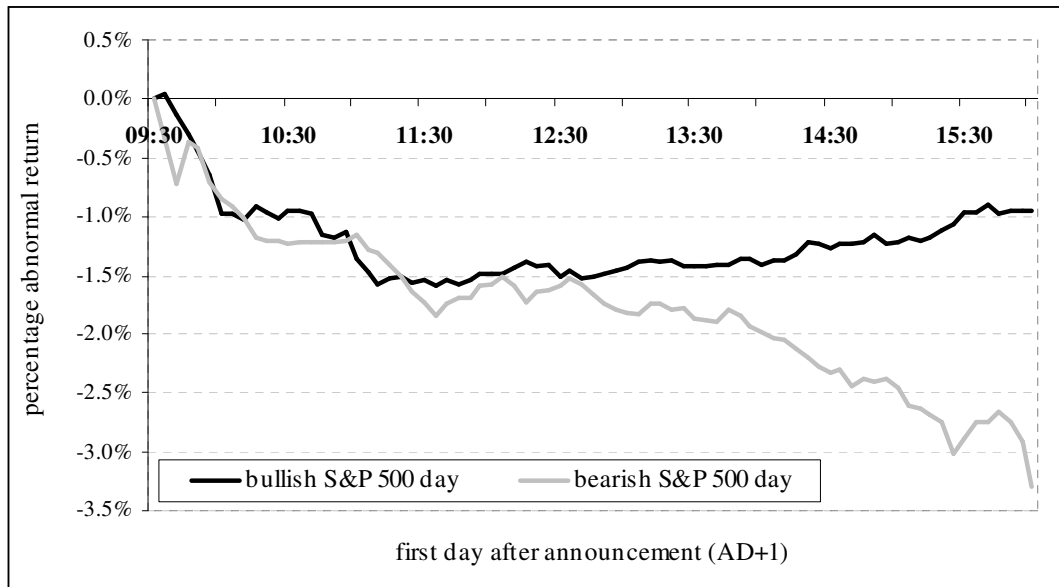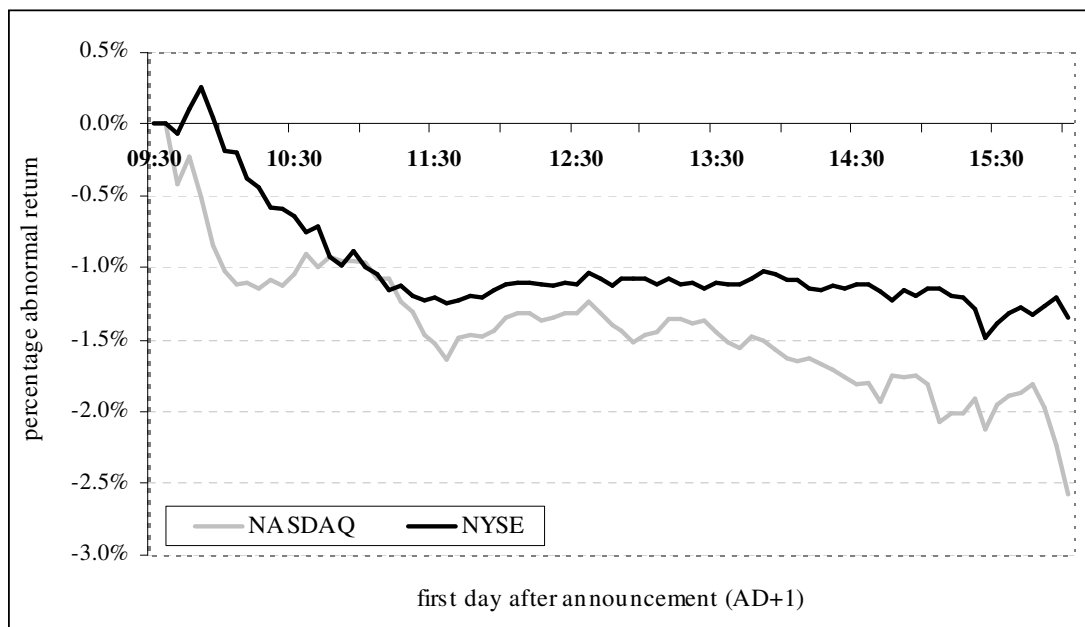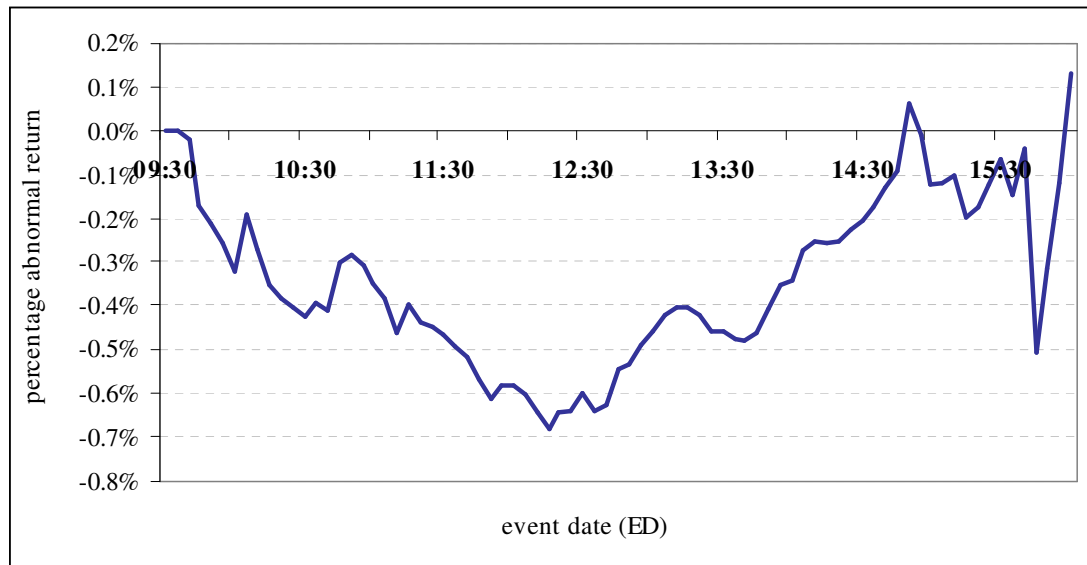

first day after announcement (AD+1)

announcement

Figure 4: Number of shares traded over each five-minute interval expressed as a percentage of the total daily volume on the first day after announcement
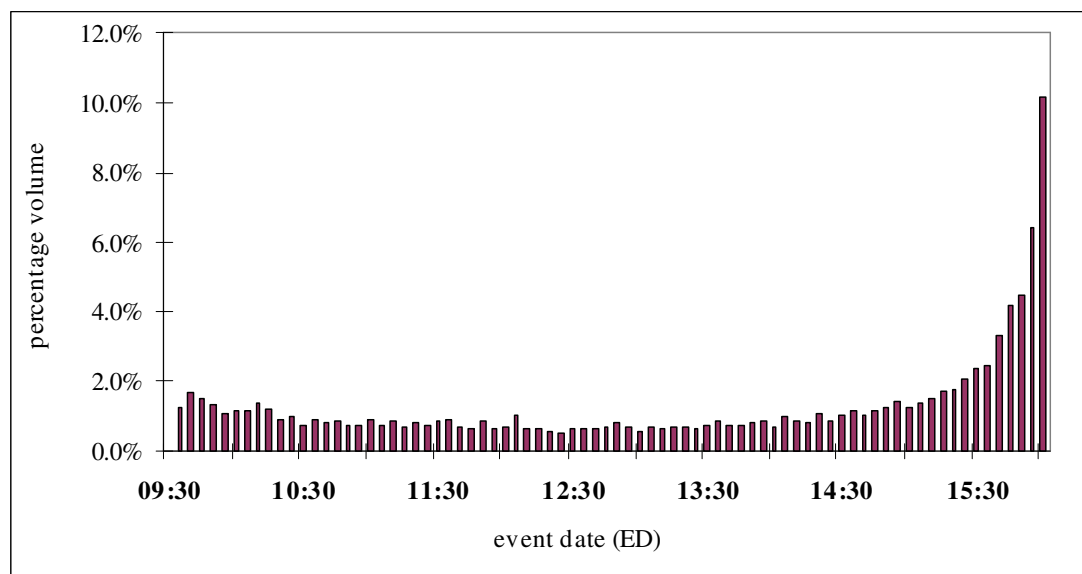

first day after announcement (AD+1)

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Figure 5: Tick-by-tick cumulative abnormal performance of the average added stock of the bullish and bearish sub-samples on the first day after announcement

Figure 6: Tick-by-tick cumulative abnormal performance of the average NASDAQ vs. NYSE added stock on the first day after announcement

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Figure 7: Tick-by-tick cumulative abnormal performance of the average added stock on the event date

Figure 8: Number of shares traded over each five-minute interval expressed as a percentage of the total daily volume on the event date

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Figure 9: Tick-by-tick cumulative abnormal performance of the average added stock of the bullish and bearish sub-samples on the event date
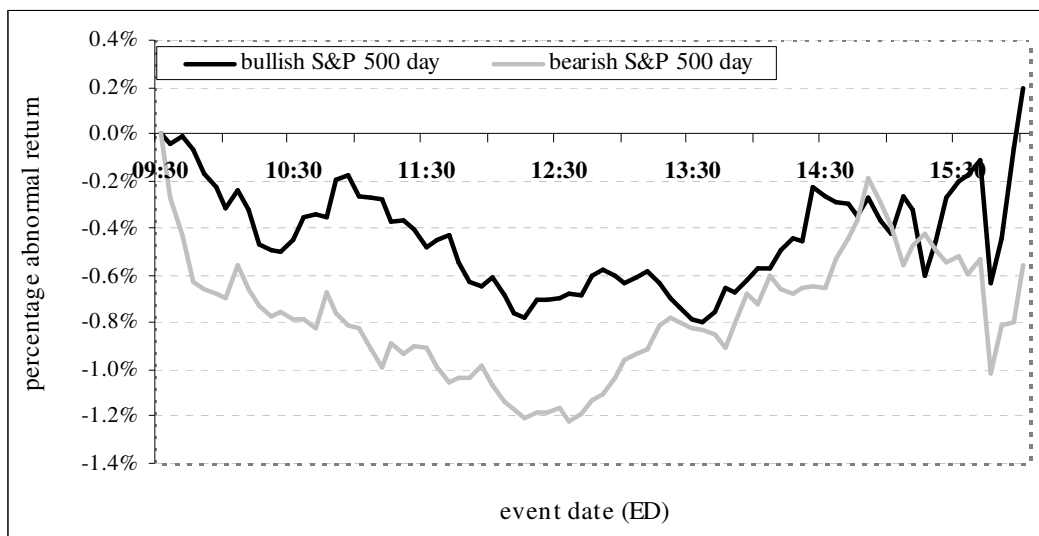

Figure 10: Tick-by-tick cumulative abnormal performance of the average NASDAQ vs. NYSE added stock on the event date

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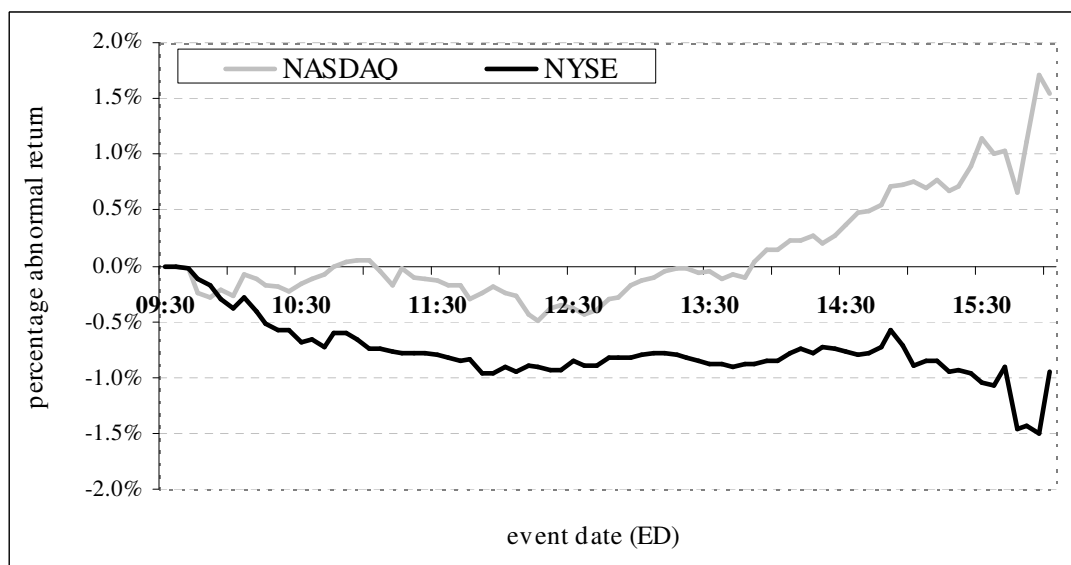
Figure 11: Tick-by-tick average cumulative firm abnormal performance and number of shares traded over each five-minute interval expressed as a percentage of the total daily volume on the first day after the event
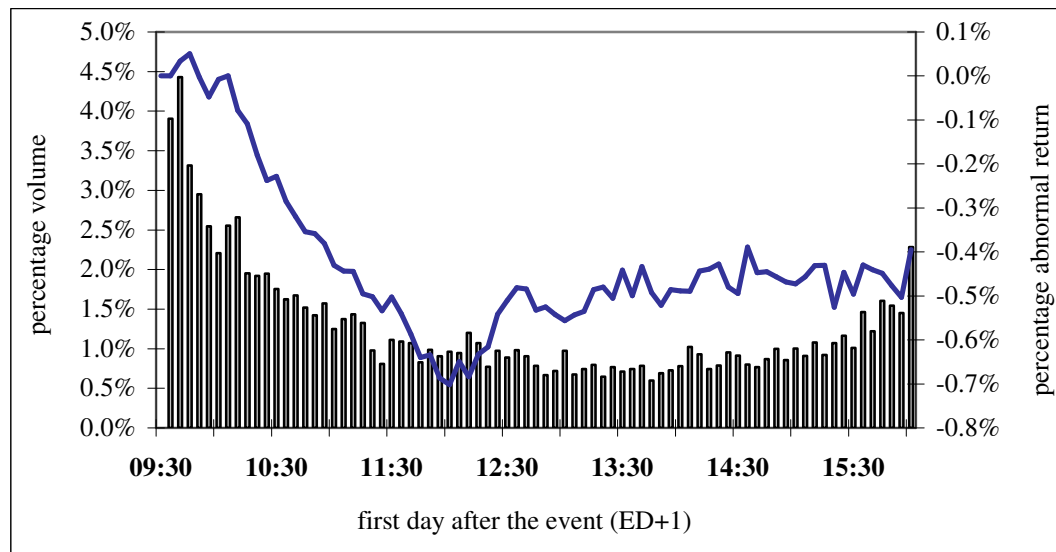

first day after the event (ED+1)

Figure 12: Tick-by-tick cumulative abnormal performance of the average added stock of the bullish and bearish

first day after the event (ED+1)

sub-samples on the first day after the event

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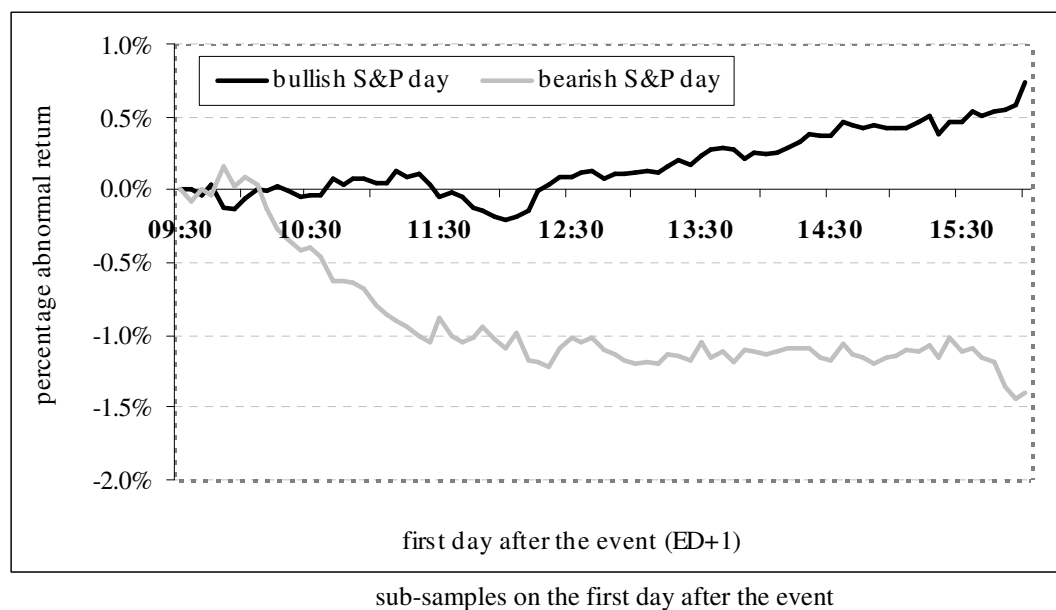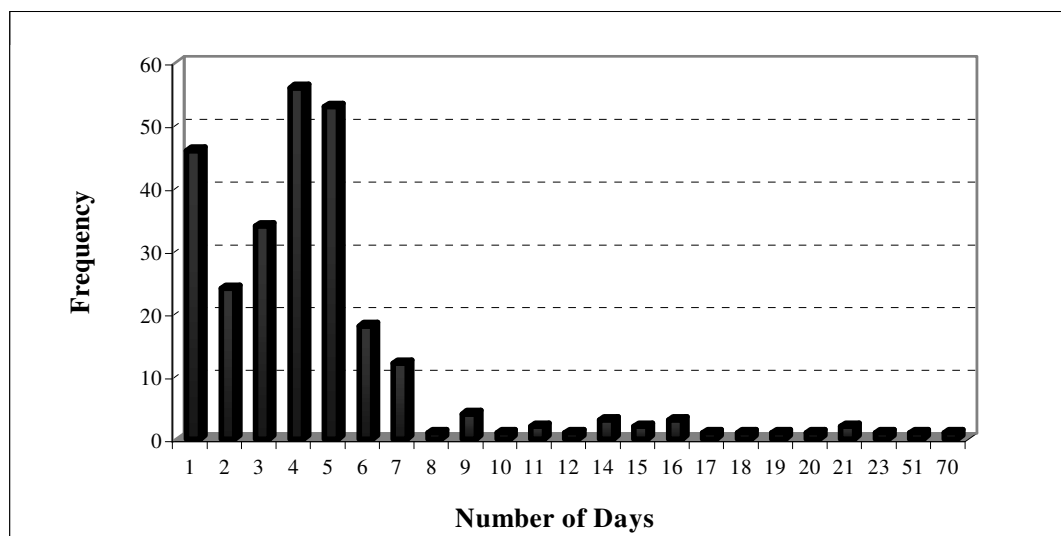**Figure 13:** Number of trading days between announcement and event

Figure 14: Actual profits from trading S&P 500 inclusions for the years 1993-2002

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