Market Reactions to Changes in the Dow Jones Industrial Average Index

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Abstract

This study examines changes in stock returns, liquidity, institutional ownership, analyst following, and investor awareness for companies added to and deleted from the Dow Jones Industrial Average (DJIA) index. Previous studies report conflicting evidence regarding the market reactions to changes in the DJIA index membership. We resolve this inconsistency by documenting different stock price reactions over the 1929 – 2015 period. Focusing on the most recent period, 1990 – 2015, stocks added to (deleted from) the index experience a significant permanent stock price gain (loss). The observed stock price reaction is associated with changes in liquidity proxies. Taken together, the presented evidence provides support for the liquidity hypothesis.

Keywords: Abnormal return, Dow Jones Industrial Average index, Event study, Index changes, Stock prices, Trading volume

JEL Classification G12 · G14

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Does stock market react to changes in the membership of the Dow Jones Industrial Average (DJIA) index? Despite the fact that the DJIA is the oldest and the most recognizable stock market index in the world, academic research on this question is very limited, dated, and, most importantly, contradictory. For example, whereas Varela and Chandy (1989) do not find any significant stock price changes for additions to and deletions from DJIA, Polonchek and Krehbiel (1994) report a significant increase in price and trading volume for additions to the DJIA. In contrast, Beneish and Gardner (1995) do not observe significant changes in price and trading volume for DJIA additions, but document a significant decline in price and trading volume for deletions.

The purpose of this paper is twofold. First, it explains differences in results of earlier studies. Second, and most importantly, the paper presents a comprehensive analysis of various market reactions to DJIA index changes and discusses observed results in the context of competing hypotheses proposed in the S&P 500 index studies. Specifically, we examine changes in stock returns, liquidity, institutional ownership, analyst following, and investor awareness for firms that are added to and deleted from the DJIA index. The results of this analysis should be of interest not only to finance researchers but also to both individual and institutional investors as the number of financial instruments tied to the DJIA index and the amount of money tracking it keeps growing.

Among all stock indexes, the largest body of literatures examines stock market reactions to changes in the S&P 500 (e.g., Elliott, Van Ness, Walker, and Warr, 2006; Platikanova, 2008;

Zhou, 2011). Researchers routinely find a positive stock price reaction to the announcement of addition to the index. However, researchers still disagree on the explanations for observed results and argue for different hypotheses. Brief discussion of these hypotheses is provided below.

Hypotheses on Price Effects of Index Changes

The hypotheses developed to explain abnormal returns associated with index changes differ not only in explanations for the abnormal returns, but also in the predicted duration of these returns. The *price pressure hypothesis*, suggested by Harris and Gurel (1986), is the only hypothesis that predicts a temporary price change for new additions. According to this hypothesis, index funds' purchasing pressure temporary pushes a stock price above its equilibrium level. Harris and Gurel (1986) offer support for this hypothesis by observing a full price reversal for stocks added to the S&P 500 index. Consistent with the price pressure hypothesis, Biktimirov, Cowan, and Jordan (2004) and Shankar and Miller (2006) report a transitory price reaction for both additions to and deletions from the small-cap Russell 2000 and S&P 600 indexes, respectively.

In contrast, the *downward-sloping demand curve (or imperfect substitutes) hypothesis*, advanced by Shleifer (1986), predicts a permanent price change for new additions to the S&P 500 index. This hypothesis assumes that stocks do not have perfect substitutes, and, as a result, the long-run demand for stocks slopes downward. Therefore, increased demand from index funds leads to a permanent stock price gain for new additions to the S&P 500 index. Kaul, Mehrotra, and Morck (2000), Liu (2000), Levin and Wright (2006) provide additional support for the downward-sloping demand curve hypothesis by examining changes to Canadian, Japanese, and UK stock market indexes, respectively.

The *liquidity hypothesis* proposed by Amihud and Mendelson (1986) is another explanation that predicts a permanent stock price gain for new index additions. If a stock's addition to an index leads to higher liquidity, investors will be willing to pay a higher price for this stock. Consistent with the liquidity hypothesis, Erwin and Miller (1998) observe a significant decline in the bid-ask spread for stocks added to the S&P 500 index. Lam, Lin, and Michayluk (2011) provide a more recent support for the liquidity explanation by examining the conversion of the S&P 500 index from market-capitalization weighting to free-float weighting.

According to the *information signaling hypothesis* (e.g., Jain 1987), the announcement about a stock's addition to the index sends a positive signal about the future prospects of a firm. As a result, a new addition to the index is accompanied with a permanent stock price increase. Denis, McConnell, Ovtchinnikov, and Yu (2003) provide evidence consistent with the information signaling hypothesis by observing significant increases in analysts' earnings per share forecasts and significant improvements in realized earnings for companies added to the S&P 500 index. Cai (2007) offers additional support for the information signaling hypothesis by observing a significantly positive price reaction for the industry and size matched firms of the firms added to the S&P 500 index.

The *information cost hypothesis* (e.g., Goetzmann and Garry, 1986) states that investors are willing to pay a premium for a stock with more available information. As addition of a stock to an index increases information availability, stock price rises. Consistent with this hypothesis, Platikanova (2008) reports improvements in earnings quality for firms added to the S&P 500 index. Beneish and Gardner (1995) provide another support for this hypothesis by documenting a significant decline for deletions from the DJIA index, as removal from the index reduces the

amount of available information. In contrast, being prominent and widely followed firms, additions to the DJIA index do not experience significant abnormal returns.

Under the *investor awareness hypothesis*, suggested by Merton (1987), investors buy only those stocks of which they are aware. As more investors become aware of a stock at the time of addition to an index, stock price goes up. Chen, Noronha, and Singal (2004) extend this hypothesis by explaining the asymmetry in stock price reactions for additions to and deletions from the S&P 500 index. The researchers argue that addition to the S&P 500 index results in a permanent stock price gain, as more investors become aware of the newly added stocks. Conversely, deleted stocks show only a temporary stock price loss, as deletion from the S&P 500 index would not quickly decrease the investor awareness of a stock. Zhou (2011) offers another support for investor recognition by observing a permanent price gain for first-time additions to the S&P 500 index, and temporary price changes for stocks upgraded from lesser-known S&P indexes, reentering the S&P 500 index, and deletions from the index.

DJIA index studies

Only three papers examine market reactions to changes to the DJIA index, and they present conflicting evidence. Varela and Chandy (1989) appear to be the first paper to analyze stock prices changes for companies added to or removed from the DJIA index. By examining changes to both DJIA and Dow Jones Transportation Average (DJTA) indexes that took place in the period 1970-1986, the authors find that neither additions to nor deletions from DJIA and DJTA experience significant returns around the announcement date. However, for both indexes, additions gain in value and deletions decline in value three days prior to the announcement date.

In contrast to Varela and Chandy (1989), Polonchek and Krehbiel (1994) report that additions to the DJIA experience an increase in both price and trading volume. No such effects are found for additions to the DJTA and for deletions from either the DJIA or DJTA. The authors also do not document any significant changes in institutional ownership around DJIA and DJIT index changes.

Beneish and Gardner (1995) examine the largest sample size to date of 37 additions to and 31 deletions from DJIA that occurred in the period 1929-1988. In contrast to Polonchek and Krehbiel (1994), the authors do not find significant changes in price and trading volume for additions. Moreover, althoug both Varela and Chandy (1989) and Polonchek and Krehbiel (1994) do not document any significant reactions for deletions from the DJIA index, Beneish and Gardner (1995) report a significant decline in stock price, trading volume, and the quantity of available information for deletions. Given a lower trading volume and the decreased quantity of available information, the authors explain a decline in value for deletions with an increase in trading costs. Taken together, Beneish and Gardner (1995) suggest the information cost/liquidity explanation for the asymmetric results for additions and deletions. Table 1 summarizes studies examining DJIA index changes.

[Table 1 about here]

Sample

The DJIA index is a price-weighted index that consists of 30 large and well-known U.S. companies to measure the performance of U.S. industrial sector. The index covers all industries except transportation and utilities that are tracked by the Dow Jones Transportation Average

(DJTA) and Dow Jones Utility Average (DJUA), respectively. Being introduced by Charles Dow, a cofounder of Dow Jones & Company, on May 26, 1896, the DJIA index originally consisted of only 12 stocks. The index membership expanded to 20 stocks in 1916 and to 30 stocks in 1928. Since inception in 1896, the DJIA index has changed its composition 49 times, and General Electric is the only original company that is still in the index. Although General Electric was removed and subsequently added twice over its tenure in the index.

The DJIA index membership is managed by the Averages Committees, which currently consists of the managing editor of the Wall Street Journal, the head of Dow Jones Indexes research, and the head of the Chicago Mercantile Exchange (CME) Group research. To avoid frequent index changes, the Committee removes companies only after major corporate events, such as bankruptcies and acquisitions, or significant changes in a company's core business. When an index change is required, the Committee reviews the entire index membership resulting in several membership changes implemented at the same time. Companies added to the index are selected based on their reputation, demonstrated growth, appeal to a large number of investors, and accurate representation of the relevant industry.[1] Currently about two-thirds of the DJIA index constituents are companies that manufacture industrial and consumer goods. The rest of the DJIA index membership consist of the companies that represent other major industries of the U.S. economy, such as technology, financial services, retail, and entertainment.

This study extends from 1929 through 2015. The original sample of 62 additions to and 62 deletions from the index is reduced to a final clean sample of 60 additions and 51 deletions. First, due to missing data, we drop two additions, National Cash Register (1929) and Curtiss-Wright (1929), and one deletion – National Cash Register (1934). Second, we remove six deletions that cease to exist as original public firms. Specifically, Victor Talking Machine

(1929), Anaconda (1976), and General Foods (1995) were taken over, Drug Inc. (1933) was partitioned into five companies, Owens-Illinois Inc. (1987) went private, and Kraft Foods Inc. (2012) split into two firms. Finally, after a check for confounding news releases within five days surrounding the announcement date, we eliminate four deletions. Specifically, USX Corp. (1991) issued separate stocks for its oil and steel operations, American International Group (2008) received government bailout funds, and both Manville Corp. (1982) and General Motors Corp. (2009) announced a bankruptcy filing.

For the period 1929–1999, we define the announcement day (AD) as the day on which an announcement about DJIA index changes appears in the Wall Street Journal. However, in three cases (1985, 1997, and 1999), we specify AD as one day prior to the publication date, because the Wall Street Journal or another publication reports that a DJIA index change announcement was made one day earlier. For the period 2000–2015, we determine AD from the DJIA index change announcements retrieved from the S&P Dow Jones Indices web site.[2] We define the effective day (ED) as the first trading day on which an index change becomes effective.

In 1991 Dow Jones company changed its procedure for index changes announcements. Namely, prior to 1990, the effective day of a DJIA index change was the next day after the announcement day. In contrast, since 1990 there was at least one day before the announcement and effective days of DJIA index changes. Specifically, the number of days between the announcement and effective days ranged from 1 to 8 days, with the mean (median) of 3.71 (3.50) days.

Analyses

Abnormal returns

To determine if additions to and deletions from the DJIA index experience significant stock price changes, we conduct abnormal return analysis. We collect all security and market data required for the abnormal return analysis from the Center for Research in Security Prices (CRSP) database. The return on the CRSP value-weighted index serves as a proxy for the return on the market portfolio. We estimate abnormal returns by using the Fama and French (1993) three-factor model[3] and a 180-trading day post-event estimation period that runs from ED+61 to ED+240.[4] To assess the significance of abnormal returns, in addition to a parametric *t*-test statistic, use use two non-parametric statistics, a sign test described by Corrado and Zivney (1992) and Cowan (1992), and a rank test suggested by Corrado (1989).

Table 2 presents abnormal returns for additions to and deletions from DJIA index in the period 1929-2015. Additions experience a positive abnormal return of 0.59% on the announcement day (AD), which is significant at least at the 5% level under all three test statistics. They gain additional 1.45% over the following period from AD+1 to ED–1. The average cumulative abnormal return (CAR) remains significant for at least 10 days after AD.

[Table 2 about here]

In contrast to additions, deletions experience a significant negative abnormal return of –1.31% on AD. They also lose –1.10% over the subsequent period form AD+1 to ED–1, which is significant under the rank test, and –0.96% on ED, which is significant under the *t*-test. A negative CAR stays significant for at least 5 days after AD.

Taken together, the observed gain for additions is consistent with Polonchek and Krehbiel (1994) who report a positive significant abnormal return of 0.94% on the announcement day and

inconsistent with Varela and Chandy (1989) and Beneish and Gardner (1995) who do not find significant changes in stock prices for DJIA additions. Conversely, the documented losses for deletions are consistent with Beneish and Gardner (1995) who find a significant decline of 2.31% over the three-day period from AD–1 to AD+1, and inconsistent with Varela and Chandy (1989) and Polonchek and Krehbiel (1994) who do not observe significant changes in value for deletions from the DJIA index.

Different sample periods of prior DJIA studies might explain inconsistent results regarding market reactions to changes the index.[5] Specifically, while Beneish and Gardner (1995) study a sample of DJIA index changes that occurred from 1929 to 1988, Polonchek and Krenbiel (1994) examine DJIA index changes that happened in a later period, from 1962 to 1991.

To examine if stock market reactions to changes in the DJIA index differ over the 1929-2015 period, we divide the total period into three sub-periods: 1929–1933 (19 additions and 17 deletions), 1934–1990 (18 additions and 14 deletions), and 1991–2015 (24 additions and 20 deletions). The first sub-period, 1929–1933, considers the impact of the Great Depression, while the last sub-period, 1991–2015, assesses the influence of a new announcement policy and growth in index funds. Specifically, while prior to 1990, the effective day of a DJIA index change was the next day after the announcement day, since 1991 there was at least one day before the announcement and effective days of DJIA index changes. Specifically, the number of days between the announcement and effective days ranged from 1 to 8 days, with the mean (median) of 3.71 (3.50) days. Besides a change in the announcement policy, in late 1990s several DJIA-based index funds were introduced. For example, the SPDR Dow Jones Industrial Average ETF was launched in January 1998, and TD DJIA Index fund – in November 1999. Since then, the

SPDR Dow Jones Industrial Average ETF has become one of the most popular ETFs, with almost $14 billion in assets as of December 2016.

Table 3 presents CARs for stocks added to or deleted from the DJIA index in three sub-periods. As shown in Panel A (1929–1933), in the period of Great Depression additions do not show any significant abnormal returns around the DJIA index change announcement, while deletions experience significant declines in value of –1.51% and –2.28% on AD–1 and AD, respectively. Results are completely reversed in the following period 1934–1989. Specifically, Panel B shows a significant gain of 0.96% on AD for additions and no significant abnormal returns around AD for deletions.

[Table 3 about here]

Turning to Panel C (1990–2015), additions show a positive abnormal return of 1.19% on AD that is significant at least at the 1% level according to all three test statistics. Moreover, additions gain an abnormal 1.40% from AD+1 to ED–1. An abnormal positive return of 0.66% on ED-1, which is significant under three test statistics, may be attributed to purchase orders of index fund that try to buy new additions on the last day before index changes become effective to minimize tracking error. The analysis of trading volume changes in the next section sheds more light on this possible explanation.

Deletions experience an abnormal decline of –1.02% on AD. They also seem to lose an additional 1.18%, which is significant at the 5% level under the rank test. Importantly, the observed gains for additions and losses for deletions seem to be permanent, as CARs remain significant for 13 trading days after AD for additions and for 9 trading days after AD for deletions.

Taken together, Table 3 shows that sample period matters, as both additions and deletions show significantly different price reactions in three sub-periods. Given these results, in the next section we examine trading volume changes for additions and deletions in three sub-periods. According to Cready and Hurtt (2002), complementing abnormal return analysis with trading volume analysis increases the power of the tests aimed to detect market reaction.

Trading volume

To analyze trading volume behavior around the DJIA index changes, we use methods similar to those in Campbell and Wasley (1996). First, we compute the log-transformed percentage of shares outstanding:[6]

$$V_{i,t} = \ln\left(\frac{100n_{i,t}}{S_{i,t}} + 0.000255\right) \tag{1}$$

where $n_{i,t}$ is the number of shares traded for stock i on day t, and $S_{i,t}$ is the number of shares outstanding on day t.

Then we estimate market model abnormal trading volume as:

$$AV_{i,t} = V_{i,t} - (\alpha_i + \beta_i V_{m,t}) \tag{2}$$

where α_i and β_i are ordinary least squares estimates computed over a 180-day pre-event estimation window (AD–210, AD–31).[7] The market volume for day t is calculated by using all NYSE and AMEX stocks:

$$V_{m,t} = \frac{1}{N_t}\sum_{i=1}^{N_t} V_{i,t} \tag{3}$$

where N_t is the number of NYSE and AMEX stocks on day t.

Table 4 presents trading volume changes around DJIA index changes. We use a non-parametric rank test to test the significance, as Campbell and Wasley (1996) report that the nonparametric test statistic is more powerful in detecting abnormal trading volume than the parametric test statistic.

[Table 4 about here]

Trading volume behavior differs among three sub-periods. Namely, neither additions nor deletions exhibit significant trading volume changes in a three-day period around AD in the 1929-1933 sub-period. In contrast, in the following, 1934-1989 sub-period, additions show significant abnormal trading volume increases of 19.69% and 15.13% on AD and AD+1, respectively. Similarly to the previous sub-period, deletions do not experience significant trading volume changes. In the 1990-2015 sub-period, both additions and deletions exhibit positive abnormal volumes on AD and ED, which are significant at least at the 5% level. An abnormal trading volume increase of 32.88% (35.58%) on AD for additions (deletions) is about twice as large as an abnormal trading volume increase of 19.22% (16.02%) on ED. However, the largest abnormal trading volume increases of 66.13% and 61.62% happen on ED-1 for additions and deletions, respectively. These increases in trading volume on ED-1 can be attributed to the trading behavior of index funds that buy additions and sell deletions on the last trading day before index changes become effective to minimize tracking error. A similar explanation has been offered in studies that examine S&P 500 (e.g., Kappou, Brooks, and Ward, 2010; Geppert, Ivanov, and Karels, 2011) and FTSE SmallCap index changes (e.g., Biktimirov and Li, 2014).

To summarize, the results of both abnormal return and trading volume analyses show that stock market reaction to changes in the DJIA index differs among the three sub-periods. The

third, 1990–2015, sub-period exhibits the strongest abnormal return reaction, which is accompanied with the largest increase in trading volume. To avoid any potential confounding effects related to different announcement policies and amount of institutional funds following the DJIA index, this study focuses entirely on the most recent, 1990–2015, sub-period for all subsequent analyses.

Testing the price pressure hypothesis

Under the price pressure hypothesis, the announcement day stock price change should be reversed over the following days. The CARs reported in Panel C of Table 3 suggested a permanent reaction for both additions and deletions in the 1990–2015 periods. Even though a larger standard error decreases the power of the test over longer periods, CARs remain significant for additions and deletions for 13 and 9 days after AD, respectively. Moreover, a positive average CAR of 2.70% at the end of day 40 does not indicate any reversal for additions following the initial gain of 1.19% on AD. Similarly, a negative CAR of −1.52% after 40 days does not suggest any reversal for deletions following the initial loss of −1.02% on AD.

To directly examine if the observed abnormal gains (losses) for additions to (deletions from) the 1990–2015 period are temporary as consistent with the price-pressure hypothesis or permanent as predicted by other hypotheses, we follow Kaul, Mehrotra, and Morck (2000) and run the cross-sectional regressions of cumulative abnormal returns for different post-announcement periods starting from AD+1 ($CAR_{1-T,i}$) on the abnormal return on the announcement day ($AR_{AD,i}$). Under the price pressure hypothesis, the slope should be –1 and the intercept should be zero. Table 5 presents the results of these regressions.

[Table 5 about here]

As shown in Table 5 (Panel A), we reject the prediction of the price pressure hypothesis of a complete price reversal for additions to the DJIA index through the first 12 days. Specifically, the coefficient estimate on $AR_{AD,i}$ is significantly different from –1 at least at the 5% level for all 12 days following the announcement day. As a standard error increases with longer periods, the power of the test to reject the complete price reversal declines.

To examine if there is a partial price reversal of the announcement day abnormal return, we test if the coefficient estimate β on $AR_{AD,i}$ is equal to zero. As shown in Table 6, the coefficient is significantly different from zero only after 4 days and only at the 10% level, suggesting the absence of any price reversal for additions to and deletions from the DJIA index.

Turning to deletions (Panel B), we reject the prediction of the price pressure hypothesis of a complete price reversal through the first 14 days. Moreover, the full price reversal is rejected 40 days after AD. In addition, coefficient estimate β on $AR_{AD,i}$ is not significantly different from zero for any of the periods, implying the absence of any price reversal as well.

To summarize, the significant CARs following AD for additions and deletions (Table 3, Panel C) and the formal rejection of price reversal (Table 5) suggest a permanent stock price gain for additions and a permanent stock price decline for deletions from the DJIA index. Taken together, the presented evidence is not consistent with the price pressure hypothesis.

Testing the Downward-sloping Demand Curve Hypothesis

Under the downward-sloping demand curve hypothesis additions to (deletions from) an index experience a permanent price gain (loss) due to an increased (decreased) demand by

institutional investors. Indeed, researchers consistently find significant increases (decreases) in institutional ownership for firms added to (removed from) major stock indexes, such S&P 500 (e.g., Chen, Noronha, and Singal, 2004), S&P 600 (e.g., Shankar and Miller, 2006), and FTSE SmallCap (e.g., Biktimirov and Li, 2014). To examine changes in institutional ownership around the DJIA index reconstitutions, we follow the method used by Chen, Noronha, and Singal (2004). Specifically, we compare the number of institutional shareholders and percentage of shares owned by institutional shareholders in the quarter immediately before the announcement day with those at least one quarter after the effective day. To test for significant differences, we use a parametric t-test, and two non-parametric tests: a sign test and a Wilcoxon signed-rank test. Institutional ownership data are collected from the 13F filings available from Thomson Financial.

Table 6 presents some descriptive statistics and test results for the number of institutional investors and percentage of institutional holdings for additions and deletions prior and after DJIA index changes in the period 1990–2015. Additions have a significantly larger number of institutional shareholders than deletions. Specifically, before DJIA index changes, the mean (median) of 889.57 (837.00) for additions is almost twice as large as the mean (median) of 555.25 (439.00) for deletions. In contrast, the percentage of shares held by institutions is almost identical (around 60%) for the two groups.

[Table 6 about here]

Turning to changes in institutional ownership, additions experience a mean (median) increase of 22.65 (16.00) in the number of institutional shareholders, which is significant under

all three tests. However, this increase in the number of institutional shareholders is not accompanied with an increase in the percentage of shares held by institutions. Moreover, additions show a less than 1% decline in the percentage of institutional shareholdings, but this decline is not significant. Polonchek and Krehbiel (1994) also report a statistically insignificant decrease in the proportion of shares held by institutional investors for additions to the DJIA index in the period from 1962 to 1991. As for deletions, they do not exhibit significant changes in the number of institutional shareholders or the percentage of shares held by institutions.

To test predictions of the downward sloping demand curve hypothesis, we also analyze correlations between a proxy for arbitrage risk *A1* and the abnormal return on AD, AR_{AD}, and cumulative abnormal returns for 40 days after AD, *CAR(AD, AD+40)*. *A1* is the variance of the error term from a regression of the stock's excess return on the market's excess return over the 180 trading estimation period from AD−210 to AD−31. Wurgler and Zhuravskaya (2002) argue that a stock with a high *A1* is more difficult to arbitrage, as the stock lacks close substitutes. Therefore, under the downward sloping demand curve hypothesis, stocks with high *A1* are expected to experience a permanent stock price change associated with addition to or deletion from an index. Table 7 presents correlations between *A1* and abnormal returns. None of the correlation coefficients is statistically significant for either additions or deletions. Taken together, the results of the institutional ownership and arbitrage risk analyses do not offer support for the downward-sloping demand curve hypothesis.

[Table 7 about here]

Testing the Liquidity Hypothesis

Erwin and Miller (1998) and Becker-Blease and Paul (2006) report significant increases in stock liquidity for companies added to the S&P 500 index. In addition, Hedge and McDermott (2003) find not only improvement in liquidity for additions to the S&P 500 index, but also decline in liquidity for deletions from the index. In this section we examine changes in liquidity for companies added to or removed from the DJIA index. Several liquidity proxies have been suggested in the literature, with each proxy capturing a different side of liquidity. Thus, we employ three proxies for stock liquidity: dollar volume, relative bid-ask spread, and illiquidity ratio.

Dollar volume is the natural logarithm of daily trading volume in dollars.

Relative bid-ask spread is the difference between the daily closing ask and bid prices divided by the mid-point of closing ask and bid prices.

The illiquidity ratio, *ILLIQ*, is the average of the daily ratio of absolute stock return to its daily dollar trading volume:

$$ILLIQ_i = \frac{1}{T_i}\sum_{t=1}^{T_i}\frac{\left|R_{i,t}\right|}{VOLD_{i,t}} \tag{4}$$

where $R_{i,t}$ is the return of stock i on day t, $VOLD_{i,t}$ is the daily dollar trading volume for stock i, and T_i is total number of days for stock i during the pre-event and post-event periods. Amihud (2002) suggests the illiquidity ratio as a measure of price impact. A more liquid stock is expected to have a smaller illiquidity ratio.

We calculate the average of each liquidity proxy over a 180-day period before the announcement date and after the effective date and then test for significant differences. Thus, the pre-change period runs from AD–210 to AD–31, and, similar to Chen, Noronha, and Singal (2004) and Becker-Blease and Paul (2010), the post-change period starts 61 days after the effective date and lasts from ED+61 to ED+240.

To test for significant differences between the pre-change and post-change levels, we use a parametric paired *t*-test and two non-parametric tests, sign and Wilcoxon signed-rank tests. Table 9 presents the mean (median) of changes in four liquidity proxies following addition to or deletion from the DJIA index in the 1990-2015 period.

[Table 8 about here]

Additions show gains in liquidity following their inclusion in the DJIA index. Specifically, they experience an increase in trading volume and a decrease in the illiquidity ratio. Both liquidity measures are significant at least at the 5% level under all three tests. In contrast, deletions do not exhibit significant changes in any of the three liquidity measures. Taken together, significant improvements in two liquidity proxies for additions is consistent with the liquidity hypothesis, while the absence of significant changes in liquidity for deletions does not lend support for the liquidity hypothesis.

Testing the Information Cost hypothesis

Under the information cost hypothesis, deletion from an index reduces the amount of available information about a stock. As a result, deletions should experience a permanent decline in stock price. In contrast, being well-known and widely followed, additions to the DJIA index are not necessarily expected to experience an increase in the amount of available information. We use the I/B/E/S database to collect values for two proxies for the amount and quality of information available about a stock: number of analysts and forecast error. Specifically, the number of analysts is defined as the number of analysts' forecasts comprised in the consensus

forecast of earnings per share (EPS). The forecast error is computed as the absolute difference between the consensus median forecast earnings per share ($EPS_{i,t}$) for stock *i* for quarter *t* and the actual EPS of the stock *i* divided by the actual EPS:

$$Forecast\ Error_{i,t} = \left| \frac{Median\ Forecast\ EPS_{i,t} - Actual\ EPS_{i,t}}{Actual\ EPS_{i,t}} \right| \quad (5)$$

We calculate the mean (median) of both the number of analysts and forecast error over a period of four fiscal quarters prior to the fiscal quarter of the effective day. We then calculate the same means (medians) over four fiscal quarter after the fiscal quarter of the effective day and test for significant differences.

Table 9 presents some descriptive statistics and test results for the number of analysts and forecast error for additions and deletions around DJIA index changes in the period 1990-2015. A significantly larger number of analysts follow additions than deletions. For example, prior to DJIA index changes, the mean (median) of the number of analysts of 21.30 (20.00) for additions is almost 1.5 times larger than the mean (median) of 14.64 (13.38) for deletions. The quality of analysts' forecast is also higher for additions. Specifically, the mean (median) of forecast error of 0.15 (0.07) for additions is 2 times smaller than the mean (median) of forecast error of 0.30 (0.15) for deletions.

[Table 9 about here]

Addition to the DJIA index is accompanied with an increase in the number of analysts and a decline in forecast error. In contrast, deletion to the DJIA index is associated with a decrease in the number of analysts and an increase in forecast error. However, none of these changes are statistically significant. To summarize, compared to deletions, additions tend to have more available information as reflected in significantly larger number of analysts and lower

forecast error. Nevertheless, stock's addition to or deletion from the DJIA is not seem to be associated with significant changes in the amount and quality of available information about the stock.

Testing the Investor Awareness Hypothesis

According to the investor awareness hypothesis investors invest only in those stocks of which they are aware. Therefore, an addition to an index should show a permanent stock price increase, as more investors become aware of the stock. In contrast, a deletion from an index should experiences only a temporary price decline, as the awareness of the stock does not decline quickly. The permanent decline in value for deletions from the DJIA index is not consistent with the prediction of this hypothesis. Nevertheless, to provide additional evidence regarding the investor awareness hypothesis, in this section we examine changes in two proxies for investor awareness: total number of shareholders and Merton's shadow cost (Merton, 1987).

To analyze changes in the total number of shareholders, we use procedures similar to those in Chen, Noronha, and Singal (2004). Namely, we obtain the number of shareholder in a quarter as close as possile prior to the announcement day and at least nine months after the effective day from Standard and Poor's COMPUSTAT, and then test for significant differences. To examine changes in Merton's shadow cost, we follow the method of Kadlec and McConnell (1994) and Chen, Noronha, and Singal (2004) and compute it as:

$$Shadow\ Cost = \frac{Residual\ Standard\ Deviaion}{DJIA\ Market\ Cap} \times \frac{Firm\ Size}{Number\ of\ Shareholders} \qquad (5)$$

where the Pre-Event (Post-Event) Residual Standard Deviation is calculated as the standard deviation of the difference between the firm's return and the DJIA total return in the 252-trading day period before (after) the announcement (effective) day. Firm Size (the market value of

equity) and the DJIA Market Cap are measured on the announcement day. As Bloomberg provides the market capitalization of DJIA index only staring from December 31, 1999, the sample size in the analysis of shadow cost is reduced to 12 additions and 9 deletions.

Table 10 reports changes in the number of shareholders and Merton's shadow cost for additions to and deletions from the DJIA index in the period 1976-2015. As shown in Table 9, additions do not experience signficant changes in the number of shareholders or shadow cost. In contrast to additions, deletions experience a mean (median) decline of 29,079 (5,524) shareholders, which is significant under two non-parametric tests at the 1% level. Similarly to additions, changes in the shadow cost are not significant. Overall, the absence of significant changes in the number of shareholders and shadow cost for additions, as well as a significant decline in the number of shareholders for deletions are not consistent with the investor awareness hypothesis, which predicts an increase in awareness for additions and no significant changes for deletions.

[Table 10 about here]

Regression analysis

To perform a simultaneous analysis of the various hypotheses discussed in previous sections, we run multivariate regressions. The dependent variable is the abnormal return on the announcement day. Independent variables are changes in proxies for liquidity, institutional ownership, available information, and investor awareness,[8] as well as two control variables: a dummy variable for additions and firm size.

Addition dummy is equal to 1 if a stock is a member of the additions group and zero otherwise. Given the opposite expected reaction for additions and deletions with high values of

A1, addition dummy is included in regressions twice: Addition dummy x A1 and (1 – Addition dummy) x A1. As a result, a coefficient for Addition dummy x A1 shows the relation between A1 and the announcement day abnormal return for additions, while a coefficient for (1 – Addition dummy) x A1 reflects this relation for deletions. The firm size is a stock's market value (MV) calculated on day AD–30.

To allow for different proxies for liquidity, Table 11 presents three regressions. All three measures of liquidity are significant and have expected signs. A positive coefficient for changes in dollar trading volume, and negative coefficients for changes in the relative bid-ask spread and illiquidity ratio imply that improvements in liquidity are related to a positive abnormal return on the announcement day, whereas decreases in liquidity are associated with a negative abnormal return.

The only other variable with a statistically significant coefficient is a change in forecast error. A negative coefficient suggest that an increase in forecast error associated with a negative abnormal return on the announcement day. However, this coefficient is statistically significant only in one out of three regressions.

Overall, the regression analysis supports a positive relation between changes in liquidity and stork returns on the announcement day of DJIA index changes. These results are consistent with observed improvements in liquidity for additions to the S&P 500 index (e.g., Becker-Blease and Paul, 2006; Hedge and McDermott, 2003) and to small-cap indexes, such as Russell 2000 (Madhavan, 2003), S&P 600 (Becker-Blease and Paul, 2010), and FTSE SmallCap (Biktimirov and Li, 2014).

[Table 11 about here]

Conclusion

Mixed results observed in previous studies of changes to the DJIA index can be attributed to different sample periods. Specifically, observed abnormal returns for additions and deletions differ in the 1929–1933, 1934–1989, and 1990–2015 sub-periods. These differences can be explained by the Great Depression in the 1929–1933 period as well as by growth in index funds and a change in the announcement policy in the 1990–2015 period.

In the most recent period of 1990–2015, stock market shows strong reaction to announcement of changes in the DJIA index. Specifically, additions experience a permanent gain, while deletions exhibit a permanent loss. These significant abnormal returns are accompanied with significant increases in trading volume on the announcement day and prior and on the effective day. Additions also show a significant increase in trading volume and a significant decline in illiquidity ratio. Moreover, changes in trading volume, bid-ask spread, and illiquidity ratio are significantly related to abnormal returns observed on the announcement day. Taken together, the observed results provide support for the liquidity hypothesis.

Notes

1. “Dow Jones Averages Methodology,” (May 2016), p. 5.

2. http://www.djindexes.com/

3. As a robustness check, we also use a single-factor market model and market-adjusted model. The results are qualitatively unchanged.

4. The use of a pre-event estimation period may produce biased results, as stocks added to (removed from) the DJIA index tend to experience superior (inferior) performance prior to entering (leaving) the index. For more discussion, see Edmister, Graham, and Pirie (1994).

5. To ensure that inconsistencies in results are not caused by differences in the method for estimation of abnormal returns, we replicate the calculation of abnormal returns of the previous three DJIA studies by using the same Fama and French (1993) three-factor model and a 180-trading day post-event estimation period. We receive the same results as those in the previous studies.

6. Ajinkya and Jain (1989) and Cready and Ramanan (1991) recommend log transformation of the volume data to approximate a normal distribution. Following Cready and Ramanan, we add 0.000255 to the daily percentage of shares outstanding to accommodate zero volume.

7. To check for robustness, we also use a post-event estimation period. The results are qualitatively the same. Following Chakrabarti, Huang, Jayaraman, and Lee (2005), Shankar and Miller (2006), and Mase (2007), we use the pre-event estimation period to report the main results.

8. As values for shadow cost start only from 2000, it is not included in the final regression analysis. When shadow cost is added to regressions, its coefficient is not statistically significant.

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Table 1. Summary of studies that examine changes to the Dow Jones Industrial Average Index arranged by the publication year

Paper	Period	Final Sample	Analyzed Data	Main Results
Varela and Chandy (1989)	1970 -1986	6(6) and 17(10) additions(deletions) to Dow Jones Industrial and Transportation Averages, respectively	Abnormal returns	Neither additions to nor deletions from DJIA and DJTA experience significant returns around the announcement date. However, for both indexes, additions gain in value and deletions decline in value three days prior to the announcement date
Polonchek and Krehbiel (1994)	1962 -1991	11(6) and 36(10) additions(deletions) to Dow Jones Industrial and Transportation Averages, respectively	Abnormal returns Trading volume Institutional ownership	Additions to the DJIA experience an increase in price and trading volume. No such effects are found for additions to the DJTA and for deletions from either the DJIA or DJTA
Beneish and Gardner (1995)	1929 -1988	37 additions and 31 deletions	Abnormal returns Trading volume Earnings/Assets/Market value Valuation–related announcements Bid–ask spreads	Additions do not experience significant changes in price, trading volume, and the quantity of available information. In contrast, deletions show a significant decline in value, trading volume, and the quantity of available information. The evidence is consistent with the information cost/liquidity explanation.

Table 2. Cumulative average abnormal returns for stocks added to or deleted from the DJIA index from 1929 to 2015.

Period (Additions/ Deletions)	Additions (N = 61)				Deletions (N = 51)			
	CARs	*t* test	Sign test	Rank test	CARs	*t* test	Sign test	Rank test
AD–30, AD–1	0.19%	0.15	0.25	0.02	–2.41%	–1.14	–1.00	–0.60
AD–5	–0.39%	–1.67*	–1.03	–0.21	–0.16%	–0.42	0.4	0.55
AD–4	0.10%	0.42	0.50	0.29	0.26%	0.67	–1.00	–0.80
AD–3	0.20%	0.86	2.04**	1.51	–0.02%	–0.06	0.40	–0.33
AD–2	–0.07%	–0.30	–0.52	–0.64	0.42%	1.08	–0.44	0.18
AD–1	–0.27%	–1.18	–0.78	–0.97	–0.55%	–1.43	–1.00	–1.63
AD	0.59%	2.53**	2.30**	3.29***	–1.31%	–3.40***	–2.12**	–3.29***
AD+1, ED–1	1.45%	2.34**	2.86***	1.32	–1.10%	–1.27	–1.31	–2.18**
AD, ED	1.25%	3.05***	2.30**	1.97*	–1.95%	–2.91***	–2.40**	–2.85***
ED–4 (N=13/10)	0.62%	1.44	1.42	1.83*	–0.56%	–1.02	–1.10	–1.13
ED–3 (N=17/14)	–0.25%	–0.55	–0.17	–0.80	–0.16%	–0.29	–0.32	–0.38
ED–2 (N=21/18)	0.56%	1.51	1.66*	2.20**	–0.56%	–1.15	–1.18	–0.95
ED–1 (N=26/21)	0.77%	2.32**	2.07**	2.91***	0.05%	0.11	0.44	0.39
ED	–0.13%	–0.54	–0.26	–0.49	–0.96%	–2.50**	–0.16	–1.42
ED+1	0.12%	0.52	0.76	0.52	0.74%	1.92*	–0.44	–0.43
ED+2	–0.20%	–0.84	–1.80*	–1.06	–0.51%	–1.33	0.40	0.02
ED+3	–0.26%	–1.13	0.50	0.36	0.25%	0.64	–1.28	–0.31
ED+4	0.59%	2.54**	0.76	1.60	0.07%	0.17	–1.00	–0.77
ED+5	0.08%	0.35	1.02	0.21	0.81%	2.11**	0.96	1.66*
AD, AD+5	1.41%	2.48**	2.30**	3.58***	–0.43%	–0.45	–1.84*	–1.84*
AD, AD+10	1.12%	1.45	1.79*	2.08**	–0.27%	–0.21	–1.28	–1.40
AD, AD+20	0.95%	0.89	1.53	1.11	0.71%	0.40	0.68	–0.76
AD, AD+40	0.25%	0.17	1.27	0.63	0.44%	0.18	0.12	–1.31

Abnormal returns are estimated by using the Fama-French three factor model and a 180-trading day post-event estimation period that runs from ED+61 to ED+240. The CRSP value-weighted index serves as a proxy for the return on the market portfolio. AD is the announcement day, and ED is the effective day. ***,**, and * indicate statistical significance at the 0.1%, 1%, and 5% level, respectively, using a two-tail test

Table 3. Cumulative average abnormal returns for stocks added to or deleted from the DJIA index in three sub-periods.

Panel A: 1929 – 1933

	Additions (N = 19)				Deletions (N = 17)			
Period	CARs	*t* test	Sign test	Rank test	CARs	*t test*	Sign test	Rank test
AD–30, AD–1	0.81%	0.29	–0.29	0.29	–5.66%	–1.19	–1.22	–1.1
AD–5	–0.49%	–0.97	–1.21	–0.15	–1.09%	–1.25	–1.22	–1.2
AD–4	0.34%	0.68	1.54	1.07	–1.06%	–1.23	–1.70*	–2.14**
AD–3	0.81%	1.62	1.08	1.41	0.03%	0.04	1.21	0.17
AD–2	0.24%	0.47	0.62	0.61	2.37%	2.72***	1.69*	2.40**
AD–1	–0.64%	–1.27	–0.75	–1.18	–1.51%	–1.74*	–1.22	–1.95*
AD	–0.52%	–1.04	–1.21	–1.17	–2.28%	–2.63***	–2.19**	–2.46**
AD+1	0.17%	0.34	0.62	0.23	2.04%	2.35**	–0.25	0.72
AD+2	–0.82%	–1.62	–2.13**	–1.82*	–1.28%	–1.47	–0.73	–0.47
AD+3	–0.62%	–1.23	0.62	0.47	1.33%	1.53	0.24	0.43
AD+4	1.27%	2.52**	1.54	2.36**	1.88%	2.16**	1.69*	2.51**
AD+5	0.12%	0.23	0.62	–0.24	1.96%	2.26**	0.72	1.53
AD, AD+5	–0.40%	–0.33	0.17	–0.07	3.66%	1.72*	1.69*	0.93
AD, AD+10	–2.08%	–1.25	–1.21	–1.28	4.49%	1.56	1.21	0.37
AD, AD+20	–0.82%	–0.36	–0.29	–0.09	5.99%	1.51	1.69*	0.36
AD, AD+40	–4.11%	–1.27	–0.29	–0.48	6.31%	1.13	0.24	0.23

Panel B: 1934 – 1989

	Additions (N = 18)				Deletions (N = 14)			
Period	CARs	*t* test	Sign test	Rank test	CARs	*t* test	Sign test	Rank test
AD–30, AD–1	–0.87%	–0.52	0.62	–0.33	1.04%	0.38	0.74	0.64
AD–5	–0.20%	–0.64	–0.80	0.03	0.12%	0.23	0.20	0.67
AD–4	–0.39%	–1.28	–0.32	–0.81	2.26%	4.51***	0.20	0.66
AD–3	0.00%	–0.01	1.09	0.72	–0.10%	–0.20	0.20	–0.19
AD–2	–0.44%	–1.44	–2.21**	–1.96*	–0.64%	–1.28	–1.94*	–1.55
AD–1	0.15%	0.48	–0.32	0.16	–0.47%	–0.94	–0.33	–0.62
AD	0.96%	3.12***	1.56	2.51**	–0.54%	–1.08	0.20	–0.52
AD+1	0.16%	0.52	–0.32	0.01	–0.36%	–0.72	0.20	–0.51
AD+2	–0.02%	–0.05	–0.32	0.30	0.35%	0.69	0.20	–0.51
AD+3	–0.18%	–0.58	–0.32	–0.52	–0.36%	–0.71	0.20	–0.33
AD+4	0.04%	0.14	–0.32	–0.19	–1.18%	–2.36**	–2.47**	–2.63***
AD+5	0.10%	0.32	0.15	0.43	0.01%	0.01	1.28	0.81
AD, AD+5	1.07%	1.42	0.62	1.04	–2.09%	–1.70*	–2.47**	–1.51
AD, AD+10	2.06%	2.02**	1.09	1.59	–3.19%	–1.92*	–2.47**	–1.58
AD, AD+20	2.40%	1.70*	1.56	1.50	–3.74%	–1.63	–1.94*	–1.23
AD, AD+40	1.52%	0.77	1.56	0.73	–4.02%	–1.25	–1.40	–1.34

Table 3 continues

Table 3 continued

Panel C: 1990 – 2015 Period (Additions/ Deletions)	Additions (N = 24)				Deletions (N = 20)			
	CARs	*t* test	Sign test	Rank test	CARs	*t* test	Sign test	Rank test
AD–30, AD–1	0.45%	0.25	0.12	0.01	–2.11%	–0.82	–1.10	–0.48
AD–5	–0.45%	–1.36	0.12	–0.21	0.43%	0.92	1.58	1.44
AD–4	0.27%	0.81	–0.28	0.17	–0.02%	–0.05	–0.21	0.17
AD–3	–0.14%	–0.41	1.35	0.49	–0.02%	–0.05	–0.65	–0.55
AD–2	–0.04%	–0.11	0.53	0.07	–0.50%	–1.06	–0.21	–0.67
AD–1	–0.30%	–0.91	–0.29	–0.60	0.21%	0.44	–0.21	–0.31
AD	1.19%	3.56***	3.39***	3.98***	–1.02%	–2.16**	–1.55	–2.58**
AD+1, ED–1	1.40%	2.17**	2.57**	1.24	–1.18%	–1.27	–1.55	–2.16**
ED–4 (N=13/10)	0.62%	1.44	1.42	1.83*	–0.56%	–1.02	–1.10	–1.13
ED–3 (N=17/14)	–0.25%	–0.55	–0.17	–0.80	–0.16%	–0.29	–0.32	–0.38
ED–2 (N=21/18)	0.56%	1.51	1.66*	2.20**	–0.56%	–1.15	–1.18	–0.95
ED–1	0.66%	1.96**	1.76*	2.51**	0.03%	0.06	0.24	0.27
ED	0.19%	0.56	0.94	0.41	–0.66%	–1.40	–0.21	–1.3
ED+1	0.31%	0.92	1.76	1.16	–0.13%	–0.27	–0.65	–0.83
ED+2	–0.04%	–0.12	–1.51	–0.76	0.30%	0.64	2.03	1.54
ED+3	–0.14%	–0.42	0.12	–0.04	–0.28%	–0.59	–1.55	–0.57
ED+4	0.24%	0.72	–1.10ss	–0.44	–0.49%	–1.03	–1.55	–1.27
ED+5	0.03%	0.08	0.94	0.24	0.65%	1.38	1.14	1.78*
AD, AD+5	3.10%	3.79***	2.98***	4.67***	–2.75%	–2.37**	–2.45**	–2.57**
AD, AD+6	2.93%	3.32***	2.98***	3.99***	–2.71%	–2.17**	–2.45**	–2.33**
AD, AD+7	2.90%	3.07***	3.39***	3.84***	–2.81%	–2.10**	–2.00**	–2.24**
AD, AD+8	3.28%	3.28***	2.98***	4.04***	–2.93%	–2.07**	–1.55	–2.06**
AD, AD+9	3.15%	2.98***	3.80***	3.39***	–3.06%	–2.05**	–1.55	–2.09**
AD, AD+10	2.94%	2.65***	2.98***	2.98***	–2.29%	–1.46	–1.10	–1.32
AD, AD+11	2.74%	2.37**	2.98***	2.71***	–1.69%	–1.03	–1.10	–0.83
AD, AD+12	2.81%	2.34**	2.98***	2.73***	–2.05%	–1.20	–1.55	–1.03
AD, AD+13	2.51%	2.01**	2.16**	2.28**	–2.03%	–1.15	–1.55	–1.10
AD, AD+14	1.63%	1.26	2.16**	1.41	–1.60%	–0.87	–0.65	–0.75
AD, AD+15	1.11%	0.83	2.16**	0.88	–1.04%	–0.55	–0.21	–0.36
AD, AD+20	1.23%	0.80	1.35	0.53	–0.71%	–0.33	1.14	–0.57
AD, AD+40	2.70%	1.26	0.94	0.76	–1.52%	–0.50	1.14	–1.21

Abnormal returns are estimated by using the Fama-French three factor model and a 180-trading day post-event estimation period that runs from ED+61 to ED+240. The CRSP value-weighted index serves as a proxy for the return on the market portfolio. AD is the announcement day, and ED is the effective day. ***,**, and * indicate statistical significance at the 0.1%, 1%, and 5% level, respectively, using a two-tail test

Table 4. Abnormal trading volume for stocks added to or deleted from the Dow Jones Industrial Average Index in three sub–periods.

Panel A: 1929 – 1933					Panel B: 1934 – 1989					Panel C: 1990 – 2015				
Additions (N = 19)			Deletions (N = 17)		Additions (N = 18)			Deletions (N = 14)		Additions (N = 24)			Deletions (N = 20)	
Day	$\overline{AV}_t$	Rank test	$\overline{AV}_t$	Rank test	Day	$\overline{AV}_t$	Rank test	$\overline{AV}_t$	Rank test	Day	$\overline{AV}_t$	Rank test	$\overline{AV}_t$	Rank test
AD–5	62.93%	1.30	1.43%	0.20	AD–5	11.31%	0.76	–15.91%	–0.17	AD–3	–1.27%	–0.18	–10.91%	–1.08
AD–4	22.52%	0.28	–30.76%	–0.68	AD–4	–16.18%	–1.53	–0.12%	–0.59	AD–2	–8.43%	–1.30	–11.47%	–1.13
AD–3	25.70%	0.45	–48.48%	–1.03	AD–3	0.32%	–0.25	12.20%	–0.69	AD–1	–13.72%	–1.92*	–7.18%	–0.88
AD–2	54.80%	1.91*	–61.38%	–0.87	AD–2	–6.59%	–0.75	11.01%	–0.37	AD	32.88%	3.43***	35.58%	2.52**
AD–1	32.93%	0.61	–78.67%	–0.52	AD–1	–13.54%	–1.50	–24.59%	–0.95	ED–4	4.24%	0.68	4.14%	1.03
AD	33.61%	0.70	–35.25%	–0.11	AD	19.69%	1.68*	–4.09%	0.05	ED–3	11.04%	0.95	0.13%	0.02
AD+1	17.49%	0.15	–46.13%	–1.52	AD+1	15.13%	1.75*	28.55%	1.19	ED–2	32.91%	2.93***	24.66%	2.25**
AD+2	59.26%	2.05**	–48.35%	–0.93	AD+2	–7.89%	–0.49	1.78%	0.67	ED–1	66.13%	5.60***	61.62%	4.43***
AD+3	34.43%	0.88	–63.44%	–1.49	AD+3	–8.29%	–0.56	–72.09%	–1.50	ED	19.22%	2.67***	16.02%	2.04**
AD+4	44.73%	1.29	–54.45%	–0.92	AD+4	5.40%	0.62	–32.59%	–0.89	ED+1	5.05%	0.49	1.47%	0.28
AD+5	39.32%	1.26	–86.48%	–1.28	AD+5	9.01%	0.92	–1.84%	–0.01	ED+2	4.33%	0.53	–2.92%	–0.41

Average abnormal trading volume ($\overline{AV}_t$) is estimated using an equally-weighted market index with all NYSE/AMEX stocks as a proxy for market trading volume and a 180-day pre-event estimation period (AD–210, AD–31). AD is the announcement day, and ED is the effective day.
***,**, and * indicate statistical significance at the 0.1%, 1%, and 5% level, respectively, using a two-tail test

Table 5. Cross-sectional regressions of post–announcement cumulative abnormal returns on the announcement day abnormal return for stocks added to or deleted from the DJIA index in 1990-2015.

Panel: Additions (N = 24)					
Dependent Variable	α	β	*p*-value: $\beta = -1$	*p*-value: $\beta = 0$	R^2
$CAR_{1-1,i}$	0.0015	0.4430	0.00***	0.12	0.1052
$CAR_{1-2,i}$	–0.0007	0.6248	0.00***	0.16	0.0865
$CAR_{1-3,i}$	–0.0001	0.6034	0.00***	0.11	0.1097
$CAR_{1-4,i}$	0.0041	0.8759	0.00***	0.06*	0.1565
$CAR_{1-5,i}$	0.0108	0.6956	0.00***	0.10	0.1181
$CAR_{1-6,i}$	0.0090	0.7125	0.00***	0.15	0.0914
$CAR_{1-7,i}$	0.0079	0.7710	0.00***	0.12	0.1050
$CAR_{1-8,i}$	0.0137	0.6093	0.00***	0.21	0.0693
$CAR_{1-9,i}$	0.0151	0.3825	0.01**	0.45	0.0262
$CAR_{1-10,i}$	0.0094	0.6829	0.01***	0.22	0.0668
$CAR_{1-11,i}$	0.0077	0.6596	0.01**	0.29	0.0500
$CAR_{1-12,i}$	0.0084	0.6584	0.01**	0.31	0.0477
$CAR_{1-13,i}$	0.0124	0.0739	0.16	0.92	0.0004
$CAR_{1-14,i}$	0.0004	0.3416	0.10*	0.67	0.0087
$CAR_{1-15,i}$	–0.0019	0.0948	0.18	0.90	0.0007
$CAR_{1-16,i}$	–0.0048	0.2168	0.18	0.81	0.0028
$CAR_{1-17,i}$	–0.0032	0.0266	0.27	0.98	0.0000
$CAR_{1-18,i}$	–0.0076	0.2687	0.16	0.76	0.0042
$CAR_{1-19,i}$	–0.0079	0.3429	0.15	0.71	0.0064
$CAR_{1-20,i}$	–0.0042	0.3889	0.12	0.66	0.0091
$CAR_{1-21,i}$	–0.0025	0.5555	0.05*	0.47	0.0236
$CAR_{1-22,i}$	0.0017	0.4038	0.11	0.64	0.0100
$CAR_{1-23,i}$	0.0023	0.3475	0.15	0.70	0.0067
$CAR_{1-24,i}$	0.0042	0.1698	0.20	0.85	0.0017
$CAR_{1-25,i}$	0.0065	0.3027	0.16	0.74	0.0053
$CAR_{1-26,i}$	0.0062	0.2898	0.17	0.75	0.0046
$CAR_{1-27,i}$	0.0075	0.2512	0.21	0.80	0.0030
$CAR_{1-28,i}$	0.0127	0.0194	0.34	0.99	0.0000
$CAR_{1-29,i}$	0.0049	0.4246	0.22	0.71	0.0064
$CAR_{1-30,i}$	0.0036	0.2020	0.34	0.87	0.0012
$CAR_{1-35,i}$	0.0270	–0.5375	0.74	0.70	0.0068
$CAR_{1-40,i}$	0.0217	–0.5543	0.78	0.74	0.0055

Table 5 continues

Table 5 continued

Panel B: Deletions (N = 20)					
Dependent Variable	α	β	p-value: $\beta = -1$	p-value: $\beta = 0$	R^2
$CAR_{1-1,i}$	–0.0068	–0.0422	0.00***	0.77	0.0048
$CAR_{1-2,i}$	–0.0077	0.2911	0.00***	0.20	0.0880
$CAR_{1-3,i}$	–0.0077	0.1040	0.00***	0.65	0.0120
$CAR_{1-4,i}$	–0.0161	0.2294	0.00***	0.46	0.0306
$CAR_{1-5,i}$	–0.0158	0.1505	0.01***	0.69	0.0094
$CAR_{1-6,i}$	–0.0134	0.3469	0.00***	0.40	0.0397
$CAR_{1-7,i}$	–0.0144	0.3357	0.01***	0.46	0.0312
$CAR_{1-8,i}$	–0.0146	0.4408	0.01***	0.35	0.0494
$CAR_{1-9,i}$	–0.0189	0.1465	0.03**	0.77	0.0048
$CAR_{1-10,i}$	–0.0099	0.2757	0.03**	0.61	0.0147
$CAR_{1-11,i}$	–0.0022	0.4334	0.01**	0.40	0.0397
$CAR_{1-12,i}$	–0.0065	0.3697	0.05*	0.58	0.0174
$CAR_{1-13,i}$	–0.0061	0.3913	0.03**	0.51	0.0240
$CAR_{1-14,i}$	–0.0026	0.3085	0.05**	0.62	0.0139
$CAR_{1-15,i}$	–0.0004	–0.0198	0.12	0.97	0.0001
$CAR_{1-16,i}$	–0.0002	–0.1002	0.18	0.88	0.0013
$CAR_{1-17,i}$	0.0103	0.3565	0.03**	0.55	0.0206
$CAR_{1-18,i}$	0.0045	0.2515	0.05*	0.68	0.0097
$CAR_{1-19,i}$	0.0090	0.4498	0.03**	0.47	0.0293
$CAR_{1-20,i}$	0.0099	0.6678	0.01**	0.29	0.0615
$CAR_{1-21,i}$	0.0171	0.7896	0.01**	0.22	0.0810
$CAR_{1-22,i}$	0.0091	0.6567	0.02**	0.31	0.0579
$CAR_{1-23,i}$	–0.0012	0.2445	0.07*	0.71	0.0076
$CAR_{1-24,i}$	–0.0012	–0.0458	0.22	0.95	0.0002
$CAR_{1-25,i}$	0.0057	0.0695	0.21	0.93	0.0004
$CAR_{1-26,i}$	0.0052	0.2188	0.16	0.80	0.0038
$CAR_{1-27,i}$	–0.0001	0.1619	0.20	0.85	0.0019
$CAR_{1-28,i}$	–0.0058	0.0994	0.27	0.92	0.0006
$CAR_{1-29,i}$	–0.0038	0.2710	0.19	0.77	0.0047
$CAR_{1-30,i}$	0.0127	1.0720	0.03**	0.24	0.0768
$CAR_{1-35,i}$	0.0044	1.1452	0.07*	0.31	0.0568
$CAR_{1-40,i}$	0.0103	1.5002	0.04**	0.19	0.0932

The following cross–sectional regression is estimated for stocks added to or removed from the DJIA index:

$$CAR_{1-T,i} = \alpha + \beta AR_{AD,i} + \varepsilon_{1-T,i}$$

The dependent variable $CAR_{1-T,i}$ is the cumulative abnormal return beginning on day +1 through day +T inclusive. The independent variable $AR_{AD,i}$ is the abnormal return on the announcement day. Under the complete price reversal, the coefficient on $AR_{AD,i}$ is equal to –1. Under the hypothesis of no reversal, the coefficient on $AR_{0,i}$ is equal to 0.

***,**, and * indicate statistical significance at the 0.1%, 1%, and 5% level, respectively, using a two-tail test.

Table 6. Changes in institutional ownership for stocks added to or deleted from the DJIA index in 1990–2015.

Panel A. Additions (N = 23)

Measure	Parameter	Pre-Event	Post-Event	Change	t test (p-value)	Sign test (p-value)	Wilcoxon signed-rank test (p-value)
Number of institutional shareholders	Mean	889.57	912.22	22.65	2.61** (0.02)	4.50* (0.09)	74.00** (0.02)
	Median	837.00	906.00	16.00			
Percentage of shares held by institutions	Mean	59	59	–0.55	–1.11 (0.28)	–0.50 (1.00)	–20.00 (0.55)
	Median	60	60	–0.09			
Panel B. Deletions (N = 20)							
Number of institutional shareholders	Mean	555.25	555.50	0.25	0.01 (0.99)	–1.00 (0.82)	5.00 (0.86)
	Median	439.00	418.50	–7.00			
Percentage of shares held by institutions	Mean	63	63	–0.43	–0.75 (0.46)	–1.00 (0.82)	–6.00 (0.84)
	Median	64	63	–0.15			

Pre-Event values show institutional ownership in the quarter immediately before the announcement day, and Post-Event values report institutional ownership at least one quarter after the effective day.
***,**, and * indicate statistical significance at the 0.1%, 1%, and 5% level, respectively, using a two-tail test.

Table 7. Correlations between a proxy for arbitrage risk *A1* and abnormal returns for stocks added to or deleted from the DJIA index in 1990-2015.

Group	Correlations	
	A1 and AR_{AD} (*p*-value)	*A1* and *CAR(AD, AD+40)* (*p*-value)
Additions (*N* = 24)	0.0432 (0.8411)	0.0199 (0.9264)
Deletions (*N* = 20)	0.0241 (0.9196)	–0.1841 (0.4372)

A proxy for arbitrage risk *A1* is defined as the variance of the error term from a regression of the stock's excess return on the market's excess return over the 180 trading estimation period from AD−210 to AD−31. Abnormal returns are estimated by using the Fama-French three factor model and a 180-trading day post-event estimation period that runs from ED+61 to ED+240. The CRSP value-weighted index serves as a proxy for the return on the market portfolio. AD is the announcement day, and ED is the effective day.

Table 8. Changes in liquidity for stocks added to or deleted from the DJIA index in 1990-2015.

Measure	Parameter	Pre–Event	Post–Event	Change	*t* test (*p*-value)	Sign test (*p*-value)	Wilcoxon signed-rank test (*p*-value)
Panel A. Additions							
Dollar trading volume (N = 24)	Mean	19.4345	19.6776	0.2431	4.04*** (0.00)	6.00** (0.02)	113.00*** (0.00)
	Median	19.4688	19.5513	0.1853			
Relative bid–ask spread (N = 21)	Mean	0.0024	0.0023	–0.0001	–0.46 (0.65)	–1.50 (0.66)	–6.50 (0.83)
	Median	0.0007	0.0006	–0.0000			
Illiquidity ratio (N = 24)	Mean	0.0002	0.0001	–0.0001	–2.16** (0.04)	–8.00*** (0.00)	–114.00*** (0.00)
	Median	0.0000	0.0000	–0.0000			
Panel B. Deletions							
Dollar trading volume (N = 20)	Mean	18.2506	18.2522	0.0016	0.02 (0.98)	–1.00 (0.82)	5.00 (0.87)
	Median	18.3650	18.2653	–0.1196			
Relative bid–ask spread (N = 18)	Mean	0.0057	0.0054	–0.0003	–0.51 (0.62)	–2.00 (0.48)	–13.50 (0.58)
	Median	0.0021	0.0019	–0.0002			
Illiquidity ratio (N = 20)	Mean	0.0022	0.0019	–0.0003	–1.04 (0.31)	1.00 (0.82)	6.00 (0.84)
	Median	0.0001	0.0001	0.0000			

Dollar trading volume is the average of the natural logarithm of daily trading volume in dollars. Relative bid-ask spread is the average of the difference between the daily closing ask and bid prices divided by the mid-point of closing ask and bid prices. Illiquidity ratio is the average of the daily ratio of absolute stock return to its daily trading volume in dollars. Pre-Event values of each liquidity proxy are computed over a 180-day period that ends at AD–31, where AD is the announcement day. Post-Event values are computed over a 180-day period that starts at ED+61, where ED is the effective day.

***,**, and * indicate statistical significance at the 0.1%, 1%, and 5% level, respectively, using a two-tail test.

Table 9. Changes in analysts following and analysts forecast error for stocks added to or deleted from the DJIA index in 1990-2015.

Measure	Parameter	Pre-Event	Post-Event	Change	*t* test (*p*-value)	Sign test (*p*-value)	Wilcoxon signed-rank test (*p*-value)
Panel A. Additions (N = 24)							
Number of analysts	Mean	21.30	22.05	0.75	0.89 (0.39)	1.50 (0.68)	28.50 (0.40)
	Median	20.00	21.38	0.38			
Forecast error	Mean	0.15	0.15	–0.00	–0.02 (0.99)	–2.00 (0.54)	–30.00 (0.40)
	Median	0.07	0.07	–0.01			
Panel B. Deletions (N = 20)							
Number of analysts	Mean	14.64	13.80	–0.84	–1.08 (0.29)	0.00 (1.00)	–18.00 (0.52)
	Median	13.38	14.75	–0.25			
Forecast error	Mean	0.30	0.43	0.13	0.86 (0.40)	1.00 (0.82)	3.00 (0.93)
	Median	0.15	0.22	0.01			

The number of analysts is defined as the number of analysts' forecasts comprised in the consensus forecast of earnings per share (EPS). The forecast error is computed as the absolute difference between the consensus median forecast EPS and the actual EPS divided by the actual EPS. The Pre-Event (Post-Event) values are calculated over a period of four fiscal quarters before (after) the fiscal quarter of the effective day.

Table 10. Changes in the number of shareholders and Merton's shadow cost for stocks added to or deleted from the DJIA index in 1990-2015.

Panel A. Additions

Measure	Parameter	Pre-Event	Post-Event	Change	*t* test (*p*-value)	Sign test (*p*-value)	Wilcoxon signed-rank test (*p*-value)
Number of shareholders (N = 23)	Mean	192,802	203,937	11,135	1.04 (0.31)	–1.5 (0.68)	8 (0.81)
	Median	92,068	112,001	–343			
Shadow cost ($\times 10^{-9}$) (N = 12)	Mean	11.40	11.60	0.27	0.25 (0.81)	–1 (0.77)	–3 (0.85)
	Median	3.98	5.34	–0.56			
Panel B. Deletions							
Number of shareholders (N = 18)	Mean	306,798	277,719	–29,079	–1.32 (0.20)	–7*** (0.00)	–70.5*** (0.00)
	Median	102,450	96,359	–5,552			
Shadow cost ($\times 10^{-9}$) (N = 9)	Mean	1.78	2.06	0.28	0.46 (0.66)	–1.5 (0.51)	–2.5 (0.82)
	Median	1.97	1.52	–0.01			

The Pre-Event number of shareholders is obtained in a quarter as close as possible prior to the announcement day. The Post-Event number of shareholders is obtained at least nine months after the effective day. Merton's shadow cost is computed as:

$$Shadow\ Cost = \frac{Residual\ Standard\ Deviation}{DJIA\ Market\ Cap} \times \frac{Firm\ Size}{Number\ of\ Shareholders}$$

The Pre-Event (Post-Event) Residual Standard Deviation is calculated as the standard deviation of the difference between the firm's return and the DJIA total return in the 252–trading day period before (after) the announcement (effective) day. Firm Size (the market value of equity) and the DJIA Market Cap are measured on the announcement day.

Table 11. Regressions on announcement day abnormal returns in 1990–2015.

	(1)	(2)	(3)
Constant	0.00 (0.71)	0.00 (0.59)	0.00 (0.54)
Δ Dollar trading volume	0.02* (0.09)		
Δ Relative bid–ask spread		–3.73* (0.09)	
Δ Illiquidity ratio			–8.47** (0.04)
Δ Number of institutional shareholders	0.00 (0.92)	0.00 (0.36)	0.00 (0.20)
Δ Percentage of shares held by institutions	0.01 (0.93)	–0.02 (0.90)	–0.02 (0.91)
Δ Number of analysts	0.00 (0.63)	0.00 (0.45)	0.00 (0.71)
Δ Forecast error	–0.02** (0.04)	–0.01 (0.33)	–0.01 (0.22)
Δ Number of shareholders	0.00 (0.92)	0.00 (0.29)	0.00 (0.45)
Addition dummy x *A1*	22.62 (0.30)	25.92 (0.25)	28.14 (0.19)
(1 – Addition dummy) x *A1*	–2.79 (0.52)	–4.74 (0.30)	–5.71 (0.18)
Market Value	0.00 (0.98)	0.00 (0.62)	0.00 (0.62)
N	41	36	41
Adj R^2	11.9%	13.9%	16.0%

The dependent variable is the abnormal return on the announcement day estimated by using the Fama-French three factor model and a 180-trading day post-event estimation period that runs from ED+61 to ED+240. The CRSP value-weighted index serves as a proxy for the return on the market portfolio. ED is the effective day. Dollar trading volume, Relative bid-ask spread, and Illiquidity ratio are defined in Table 8. *A1* is the variance of the error term from a regression of the stock's excess return on the market's excess return over the 180 trading estimation period from AD–210 to AD–31. Addition dummy is equal to 1 if a stock is a member of the additions group and zero otherwise. Market Value is the stock's market value on AD–30. Two tailed p-values are shown in brackets below estimated coefficients.
***,**, and * indicate statistical significance at the 0.1%, 1%, and 5% level, respectively, using a two-tail test.