The Index Effect: Evidence from the Option Market*

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Abstract

We document a significantly positive response of delta-hedged option positions on companies entering or leaving the S&P 500 index. Our findings (i) hold for both call and put options, (ii) are robust to placebo- and risk-adjustments, and (iii) are stronger for companies that are likely subject to more demand pressure from stock index investors. The inclusion effect is permanent, while the exclusion effect is transitory. We explore various mechanisms to explain these results, including leading theories of benchmarking, investor recognition, noise trading, and dispersion trading. We find that these explanations cannot individually account for all our novel results.

JEL classification: G12, G11, G17

Keywords: Delta-Hedged Options, Event Study, Index Effect, Placebo Group

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I Introduction

A large literature studies the response of volatility instruments to informative events such as earnings announcements (Dubinsky et al., 2018; Gao et al., 2018). While these papers enable us to better understand the response of volatility traders to events that convey new information about the fundamentals of firms, it is quite surprising that we know very little about the impact of non-fundamental news on volatility assets.

This paper analyzes the impact of S&P 500 index recomposition news for volatility traders. These index recompositions constitute major non-fundamental news events for companies.[1] We seek to answer the following questions: do volatility traders respond to index recomposition news? If yes, what is the sign and magnitude of the announcement effect? Is the announcement response permanent or transitory? Are existing explanations of the index effect consistent with the new empirical findings?

Answering these questions is important because, while existing theoretical models agree on the impact of index recomposition news on stock prices, they yield conflicting predictions regarding the impact of these news on volatility. For instance, Cuoco and Kaniel (2011) develop a model to study the impact of delegated portfolio management on asset prices. Under the assumption that portfolio managers are rewarded based on asymmetric performance fees, the authors show that stocks added to the benchmark index witness a decrease in the conditional volatility of their stock returns. In contrast, the institutional benchmarking model of Basak and Pavlova (2013) predicts an increase in the conditional volatility of the returns of stocks added to the benchmark index.

We use a large sample of S&P 500 inclusion and exclusion announcements between 1996 and 2015 to examine the impact of index recomposition news on (i) stock prices and

[1] We view index recomposition events as non-fundamental news events in the sense that, unlike earnings announcements and mergers and acquisitions, for instance, index recompositions do not convey material new information about the fundamentals of the included and excluded firms.

(ii) delta-hedged call option positions. Analyzing the short-term event window, which starts from the day of the announcement to the following trading day, we confirm that the short-term inclusion (exclusion) effects on stock prices are positive (negative). We compare the short-term announcement responses of stocks added to the S&P 500 index, while they were previously (i) outside of the S&P 400 mid-cap index (outsider) and (ii) inside the S&P 400 mid-cap index (insider). On a placebo and risk-adjusted basis, the equity response is, with 2.19 percentage points, significantly stronger for the outsider stocks than for the insider stocks.

Turning to delta-hedged call options, the main focus of our paper, we document several novel findings. First, the delta-hedged call options of companies added to the S&P 500 index display a significantly positive response (1.10 %) over the short event window. This positive announcement response is significantly higher than the unconditional average daily delta-hedged call option return over our sample. We carry out a placebo and risk-adjustment to evaluate the robustness of the announcement effect. We find a placebo and risk-adjusted average return (1.04 %) that is very similar to the average raw short-term announcement effect (1.10 %). Comparing the responses of the delta-hedged call options of insider and outsider firms, we establish that the delta-hedged call options of outsider firms exhibit a short-term response that is, with 0.65 percentage points, significantly stronger than that of the insider stocks.

Second, we compare the responses of the delta-hedged call options to inclusion and exclusion news. Similar to the response of delta-hedged call options to inclusion news, we find a significantly positive, though smaller (0.46 %), placebo and risk-adjusted short-term response to exclusion news. Analyzing the long-horizon event window that spans the period from the day of the announcement to 126 trading days after the effective date, we find a significant placebo and risk-adjusted long-term response to inclusion news

(2.87 %, p-value=0.0 %) and an insignificant long-term effect for exclusion news (−0.34 %, p-value=72.4 %). We thus conclude that the inclusion effect is permanent while the exclusion effect is transitory.

We perform several tests to evaluate the robustness of our results. To begin with, we document similar results for delta-hedged put options. Next, we show that the main findings hold for near at-the-money options and options of short maturity. Following Coval and Shumway (2001), we perturbate our Black and Scholes (1973) delta hedge ratio to analyze the impact of potential measurement errors in the hedge ratio and reach qualitatively similar conclusions. Finally, we show that our results are distinct from the earnings announcement effect of Gao et al. (2018).

To rationalize the joint announcement responses of the equity and delta-hedged call option prices, we separately consider explanations based on investor awareness (Merton, 1987), noise trading (Black, 1986; Ben-David et al., 2018), dispersion trading (Driessen et al., 2009), and benchmarking by institutional investors (Basak and Pavlova, 2013). While most of these theories have been proposed in the literature to explain the response of equity prices to index recomposition news, they might have implications for the joint response of equity and delta-hedged call option prices, which we explore in this paper. The investor awareness explanation does not predict an increase in the conditional volatility of stock returns of firms added to the index. All the remaining theories posit that the response of the conditional volatility of stock returns of included firms is positive while that of excluded firms is negative. In the data, we observe a positive response of the delta-hedged options of both included and excluded firms. Overall, we conclude that the aforementioned explanations are difficult to reconcile with our key findings.

Our work relates to the growing literature that analyzes changes in option-implied volatility in event studies. Kelly et al. (2016) analyze the response of the option-implied volatility to political news. Dubinsky et al. (2018) use option prices to study the uncertainty associated with earnings news. A common theme among these studies is that they focus on events that are expected to materially affect the fundamentals of a company. To the best of our knowledge, we are the first to document the impact of non-fundamental news on delta-hedged option returns.

Our research is linked to the literature that analyzes volatility changes around index recomposition news. Harris (1989) analyzes the impact of S&P 500 index inclusion and exclusion news on the realized volatility of stock returns. Ben-David et al. (2018) and Coles et al. (2020) exploit changes in the composition of equity indices to study the impact of index investing on various quantities, including the realized volatility of stock returns. Different from the aforementioned studies, we focus on the response of delta-hedged option portfolios to index recomposition news. This difference is important because delta-hedged options are forward looking and informative about the market's pricing of the expected future volatility. To the best of our knowledge, we are the first to jointly study the impact of the index recomposition news on the risk premia associated with the first two moments of the return distribution.

Dhillon and Johnson (1991) and Dash and Liu (2008) study the response of outright option positions to index recomposition news. When interpreting their empirical results, it is important to stress that the outright option position is sensitive to (i) the directional movement in the underlying and (ii) the volatility effects. Thus, the authors finding of a negative response of the outright put option on the included firm simply indicates that the directional movement in the underlying dominates the volatility effects. It does not shed light on the existence and importance of the volatility effects, the goal of our paper.

Finally, our paper adds to the large literature that analyzes the impact of index recomposition events on asset prices. Harris and Gurel (1986), Shleifer (1986), Lynch and

Mendenhall (1997), Chen et al. (2004), and Chang et al. (2014) are some important studies in the literature. Generally, these studies document a significantly positive (negative) inclusion (exclusion) effect on stock returns. We update and confirm the findings of this stream of the literature. Our study goes one step further by providing the first analysis of the announcement impact on the pricing of volatility which we study through the lenses of delta-hedged options. By doing so, our paper raises the bar for explanations of the index effect since any satisfactory explanation should jointly explain the responses of equity and delta-hedged option prices.

The remainder of this paper is organized as follows. Section II presents the data and methodology. Section III summarizes the results of our analysis of the impact of index recomposition events on the equity and delta-hedged option returns. Section IV provides various robustness checks. Section V presents and tests several economic mechanisms to jointly explain the responses of equity and delta-hedged options. Finally, Section VI concludes.

II Data and Methodology

A Data

Stock Data We obtain daily data on stock prices, the associated returns, and shares outstanding from the Center for Research in Security Prices (CRSP). We download this information for all stocks traded on the New York Stock Exchange (NYSE), the American Stock Exchange (AMEX), and the National Association of Securities Dealers Automated Quotations (NASDAQ).[2] Standard and Poors (S&P) has a detailed set of eligibility cri-

[2]One may ask: why do we cover a broad range of companies, irrespective of whether they belonged to the S&P 500 index at any point in time? Our decision is motivated by the need to have a large pool of companies from which we can draw firms that will form the placebo group.

teria related to the domicile, exchange listing, organizational structure, and share type of securities added to the S&P 500 index.[3] Accordingly, we only include stocks with CRSP share codes of 10, 11, 12, 18, or 48 in our analysis.

Option Data We match the stock data with the option dataset retrieved from OptionMetrics. The OptionMetrics dataset spans the period starting in January 1996 and ending in December 2015.[4] It includes the daily bid and ask option prices, the option trading volume, the open interest, and the Black and Scholes (1973) option sensitivities.[5] It is worth pointing out that, as a result of the matching of the equity and option datasets, our effective sample period starts in January 1996 and ends in December 2015.

We process the option dataset as follows. First, we discard options with time-to-maturity (i) smaller than 8 calendar days or (ii) greater than 120 calendar days since they are likely illiquid and noisy (Bollerslev et al., 2015).[6] Second, we only retain options with (i) positive bid and ask prices, (ii) positive volume and (iii) a mid-quote price that is at least equal to \$0.125 (Cao and Han, 2013). Third, we only keep options with a moneyness range, defined as the ratio of the strike price over the spot price, between 0.80 and 1.20. By taking this step, we ensure that we are analyzing option contracts that are likely liquid.[7] Fourth, we discard observations that violate the no-arbitrage conditions: $\max(S_{j,t} - PV(K), 0) \leq C_{j,t} \leq S_{j,t}$ and $\max(PV(K) - S_{j,t}, 0) \leq P_{j,t} \leq K$ where $S_{j,t}$ is the ex-dividend stock price of security j at time t. $PV(K)$ is the present value of the strike

[3]For more details about these criteria, we refer the interested reader to the following address: https://us.spindices.com/indices/equity/sp-500.

[4]The beginning of our sample period is driven by the fact that the OptionMetrics dataset starts in January 1996. In a similar vein, our sample ends in 2015, which is the latest observation available to us at the time we started the research project.

[5]Please double check that these deltas are not the Cox, Ross and Rubinstein deltas, which are adjusted for early exercise etc.

[6]As a robustness check, we repeat our analysis while focusing on options of maturity up to 60 days only (see Section IV.B). The results are qualitatively similar.

[7]As an additional analysis, we focus on options with moneyness between 0.90 and 1.10. The economic conclusions are qualitatively similar (see Section IV.B).

price K computed using the term-structure of interest rates available from OptionMetrics. $C_{j,t}$ and $P_{j,t}$ denote the time-t call and put option prices of strike price K written on the stock j, respectively.[8] In order to avoid the bid-ask bounce from daily closing option prices, we use the mid-quote as representative of the option price (Gao et al., 2018).

Index Recomposition Events The S&P 500 index has a fixed number of constituents (500) that are selected at the discretion of the index committee. The committee only considers firms that satisfy some inclusion criteria such as a market capitalization of at least $8.2 billion, positive earnings in the most recent quarter, as well as positive average earnings over the past 4 quarters to name but a few.[9,10] The index committee pays close attention to sector balance in the selection of companies for the index.

We hand-collect information on the changes in the composition of the S&P 500 index, the announcement dates, the effective dates, and the reason for the index changes.[11] We extract this information from the official Standard & Poors (S&P) press releases on PR Newswire. Following Barberis et al. (2005), we exclude all index changes that are related to firm-specific corporate events such as acquisitions, bankruptcies, mergers, or spinoffs. It is worth emphasizing that we only focus on companies that have an associated option market prior to, on, and after the announcement date. To be more specific, for each

[8] Although the option price depends on the strike price K, we have decided to not reflect this in the notation. This decision is motivated by our desire to make the notation as simple as possible.

[9] The complete list of inclusion criteria is available at the following address: https://us.spindices.com/documents/methodologies/methodology-sp-us-indices.pdf. It is worth pointing out that the criteria relate to the inclusion of stocks. They are not criteria for continued membership in the index.

[10] A company's stock may be among the largest firms in terms of market capitalization and meet all the eligibility criteria and still not be immediately included in the S&P 500 index as the decision of the index committee is discretionary. The case of Tesla illustrates this point. In July 2020, the company reported its fourth consecutive quarter of profitability, raising expectations that it will be included in the S&P 500 index in September 2020. Even though the company met all the requirements, it was not added to the S&P 500 index in September 2020. In November 2020, S&P announced that Tesla will be added to the index in December 2020.

[11] A growing number of studies analyze the recomposition of the Russell 2000 index using a regression discontinuity design. Cao et al. (2019) is an example along these lines. We do not analyze that index because doing so would restrict our focus to fairly small firms, for which the option contracts are likely not liquid enough to carry out a robust analysis.

company included in our analysis, either as treated firm or in the placebo group, we require at least 100 option return observations during the period starting from 10 trading days before the announcement date until 252 trading days after. This filter is necessary because the goal of our paper is to study the impact of index recomposition events on stock and delta-hedged option returns. Overall, our final sample consists of 393 inclusion and 93 exclusion events.[12] Figure A1 of the Online Appendix shows the number of index inclusions and exclusions over time. As can be seen, these events occur quite frequently each year. Indeed, our untabulated analysis reveals that, on average, there are 18 (76) days between two consecutive inclusion (exclusion) events.

B Methodology

Overview S&P publicly announces the changes to the index composition at 05:15 PM Eastern Time. Since the press release occurs after the regular trading hours, the impact of the index recomposition announcements can only be seen on the next trading day. Similar to Patel and Welch (2017), we refer to that day as the announcement date (AD). The public announcement by S&P also specifies the date when the index recomposition takes effect. We call this date the effective date (ED). On average, there are 6 trading days between the AD and ED during our sample period.[13] Figure 1 illustrates our timing

[12]Intuitively, one would expect the samples of inclusion and exclusion events to be of similar size. Yet, our results reveal that the final exclusion sample is much smaller than the inclusion sample. This finding arises from the fact that (i) we discard recomposition events that occur around firm-specific corporate events, including bankruptcy, mergers, takeovers, and exchange delisting and (ii) we require the availability of market data several days after the announcement date. These requirements are more demanding for the exclusion events. The difference between the sample sizes of included and excluded firms is also apparent in existing studies. For instance, Chen et al. (2004) study 760 additions and 235 deletions for the period beginning from July 1962 and ending in December 2000. Barberis et al. (2005) study 455 inclusions and 76 deletion events between September 22, 1976 and December 31, 2000.

[13]Generally, the announcement and effective days are well spread across the week. For inclusion events in our sample, the minimum number of days between the AD and ED is 1 and the maximum is 71 trading days. The standard deviation amounts to 6 trading days. For exclusions, the minimum is 2 and the maximum is 18 trading days. The standard deviation amounts to 2 trading days.

convention. Throughout the paper, we use the expression short event window to denote the window starting at $AD-1$ and ending at AD. We also analyze the event window beginning at $AD-1$ and ending 126 trading days after the effective date, i.e., $ED+126$. Similar to Patel and Welch (2017), we refer to this window as the long-term window.[14]

Delta-hedged Option Returns In order to carry out our analysis, we need to compute the delta-hedged option returns.[15] For each optionable stock and trading day, we create a delta-hedged position in each option. We then calculate the daily profit and loss of the corresponding position (Bakshi and Kapadia, 2003):

$$\Pi_{j,t} = \underbrace{O_{j,t} - O_{j,t-1}}_{\text{Option Gain/Loss}} - \underbrace{\delta_{j,t-1}\left[S_{j,t} - S_{j,t-1}\right]}_{\text{Delta-hedging Gain/Loss}} - \underbrace{r_{f,t-1}\left[O_{j,t-1} - \delta_{j,t-1}S_{j,t-1}\right]}_{\text{Interest Rate Component}} \quad (1)$$

where $\Pi_{j,t}$ is the profit and loss, at time t, of the delta-hedged option written on security j. For our main analyses, we focus on call options.[16] $O_{j,t}$ is the price at time t of the option contract written on security j. $\delta_{j,t-1}$ is the Black and Scholes (1973) delta of the option at time $t-1$.[17] $r_{f,t-1}$ is the 1-day interest rate, expressed on a per day basis, which

[14] If a trader is able to accurately predict the decision of the S&P index committee, our analysis of the short and long event windows is informative about the profitability of the event-driven trading strategy that seeks to exploit the index recomposition events. Since it is difficult to accurately predict the decision of the index committee, this strategy may not be easy to implement. Therefore, we also consider the event window starting at AD, i.e. after the release of the information, and ending at $ED+126$. Generally, we find that it yields conclusions that are similar to those of the long event window.

[15] One may be tempted to study the dynamics of the variance swap rate of constant time-to-maturity around S&P 500 recomposition events. We refrain from pursuing this analysis for several reasons. First, such analysis introduces a number of issues linked to the numerical method used to compute the variance swap rate. Second, such analysis is artificial in that it assumes the existence of options of a fixed time-to-maturity every day and does not take into account the decreasing time-to-maturity of option contracts. Third, the market for variance swaps on single names has dried up since the crisis of 2008 (Hollstein and Wese Simen, 2020). In contrast to the variance swap approach, our focus on delta-hedged options is consistent with the market practice of trading volatility risk through delta-hedged options. As such, our strategy can be easily implemented in the market.

[16] As a robustness check, we repeat our analysis using put instead of call options and obtain qualitatively similar results. See Section IV.A for further details.

[17] One concern may be that the Black and Scholes (1973) delta hedge ratio is not accurate. Section IV.D explores this possibility and shows that the results are robust to measurements errors in the hedge ratio.

we base on the 1-month Treasury Bill from Kenneth French's data library.

Unfortunately, the profit and loss computed using Equation (1) is not well-suited for our empirical analysis because the option price is homogeneous of degree one in the underlying price. An upshot of this is that the profit and loss amounts are not comparable across stocks that have different underlying prices, making it difficult to aggregate the profit and loss amounts across firms. To address this issue, we follow Cao and Han (2013) and compute the return associated with each delta-hedged option position as:[18]

$$R_{Option,j,t} = \frac{\Pi_{j,t}}{|O_{j,t-1} - \delta_{j,t-1} S_{j,t-1}|} \tag{2}$$

$R_{Option,j,t}$ is the return at time t on the delta-hedged option written on security j.[19]

For each trading day and firm in our sample, we use Equation (2) to calculate the daily delta-hedged option returns of all options.[20] Next, we aggregate the returns on all the delta-hedged options positions by weighting them by the U.S. Dollar open interest, defined as the product of the option price and the open interest of the option (Gao et al., 2018).[21] By using this weighting scheme, we aim to assuage the concern that our results may be driven by option contracts that are of limited interest to market participants.[22] We

[18]There are alternative ways to normalize the profit and loss of the delta-hedged option position. For instance, Huang et al. (2019) use the underlying price in the denominator. We also consider this alternative choice and reach qualitatively similar conclusions. These findings are not tabulated for brevity.

[19]This statement needs to be qualified. To be precise, Equation (2) is the formula for the excess return on the delta-hedged option. This can be seen from the fact that the profit and loss formula in Equation (1) already takes into account the cost of funding the position. Throughout this paper, we commit a slight abuse of terminology by referring to this quantity as the delta-hedged option return (Cao and Han, 2013).

[20]By rebalancing the delta-hedged option portfolio at the daily frequency, we ensure that the effect we document in this paper does not merely reflect the directional movement in the underlying stock. Our interest in the daily rebalancing scheme is also consistent with the literature, e.g. Bakshi and Kapadia (2003) and Cao and Han (2013).

[21]It is worth emphasizing that the option positions that underpin the aggregation at the firm level may differ in terms of strike prices and/or maturity dates.

[22]Section IV.C discusses the results based on two alternative weighting schemes, namely the volume-weighting and the equal-weighting schemes. Overall, the weighting scheme has very little bearing on the main results.

repeat these steps every day, thus obtaining the time series of daily delta-hedged option returns aggregated at the company level. In order to obtain long-horizon delta-hedged option returns, we simply compound the daily return series.

Risk-Adjusted Delta-hedged Option Returns We compute the risk-adjusted delta-hedged option returns, defined as the difference between the delta-hedged option returns and the expected delta-hedged option returns. Although intuitive, the computation of the risk-adjusted return is challenging since the expected delta-hedged return is not directly observable. Unfortunately, the existing literature offers little guidance regarding the model for the expected delta-hedged option returns. In light of this, we cast our net wide and use 9 variables drawn from the literature on the cross-section of equity returns and that of option returns to construct our benchmark model. To be more specific, our benchmark model consists of the 6-factor model of Fama and French (2018), which we augment with the 1-day change in the S&P 500 volatility index (VIX), and the aggregate volatility and jump factors of Cremers et al. (2015).[23] The data related to the Fama and French (2018) factors come from Kenneth French's website. We obtain the time series of the VIX from Bloomberg. Finally, we compute the aggregate volatility and jump factors exactly as in Cremers et al. (2015).

Equipped with this empirical model, we can now compute the risk-adjusted delta-

[23]We assess the robustness of our main results to the specification of the benchmark model. In one robustness check, we replace our benchmark model with that of Goyal and Saretto (2009) and obtain qualitatively similar results. We also analyze the sensitivity of our results to the choice of equity factors in the benchmark model. To be specific, we separately replace the Fama and French (2018) factors with (i) the 4-factor model of Carhart (1997), (ii) the Fama and French (2015) 5-factor model, (iii) the factor model of Hou et al. (2015), and (iv) the Stambaugh and Yuan (2016) factors. Overall, the actual choice of the equity factor model makes little empirical difference to our key findings. We do not tabulate these results for brevity.

hedged option returns associated with security j as:

$$AR_{Option,j,t} \quad = \quad R_{Option,j,t} - \sum_{k=1}^{9} \hat{\beta}_{j,k} f_{k,t} \tag{3}$$

where $AR_{Option,j,t}$ is the risk-adjusted return at time t of the delta-hedged option written on firm j. $\hat{\beta}_{j,k}$ is the estimated sensitivity of the delta-hedged return on the options written on firm j with respect to the risk factor k. $f_{k,t}$ is the value at time t of the risk factor k. We estimate the factor sensitivities by pooling together the return data from (i) 202 to 11 days before the announcement date and (ii) from 127 trading days after the effective date to 318 trading days after the effective date.[24]

Control Group Patel and Welch (2017) documented that a group of placebo firms exhibits an economically large positive risk-adjusted return of more than 1.9 % over the long event window. Thus, the positive risk-adjusted long-term return of added stocks reported in the literature does not necessarily shed light on the magnitude of the inclusion effect. Given our interest in ascertaining whether the index effect is permanent or transitory, it is prudent to carry out a placebo-adjustment.

Our approach is similar to that of Patel and Welch (2017). For each stock entering or leaving the S&P 500 index, we randomly select another stock that could have been but was not selected by S&P. For each inclusion (exclusion), we draw a control firm from the list of companies (i) that are outside (inside) the S&P 500 index and (ii) have a market capitalization rank between #200 and #800 on the day before the announcement

[24] Hollstein et al. (2019) show that an estimation window of roughly one year and a half of daily observations performs well for the beta estimation. As a robustness check, we repeat our main analyses based on a shorter estimation window of the parameters. Specifically, we estimate the factor sensitivities based on return data from (i) 111 days to 11 days before the announcement date and (ii) from 127 trading days to 227 trading after the effective day. The related results are slightly stronger than our baseline findings.

of the index recomposition.[25] We then compute the raw and risk-adjusted delta-hedged option return associated with the drawn firm. We repeat this experiment 1,000 times, thus obtaining the placebo distribution of the raw and risk-adjusted delta-hedged option returns.

C Summary Statistics

It is useful to look at the key descriptive statistics contained in Table 1. All returns are expressed in percentage points per day. For each day, we compute the summary statistics based on the cross-section of companies ranked between #200 and #800 by market capitalization. We then average these results in the time-series. In order to shed light on whether there are systematic differences between the constituent and non-constituent stocks, we divide the firms into two groups. The first is made up of constituent firms, i.e., the firms that belonged to the S&P 500 index at that point in time, while the second contains the non-constituent firms.

Starting with stock excess returns, we find an overall daily average of 0.082 %. For constituent stocks, the average return (0.036 %) is markedly lower than that of non-constituent stocks (0.114 %). Turning to the delta-hedged option returns, we observe negative average values for both constituent and non-constituent stocks. This finding is in line with the work of Bakshi and Kapadia (2003) and Cao and Han (2013) to name but a few. The cross-sectional distribution of the option returns displays positive skewness and high kurtosis, indicating that it is non-normal.

As is standard in the literature, we view long positions in delta-hedged options as instruments to trade volatility. In order to better understand the link between delta-hedged

[25] One may think of an alternative matching algorithm. Such approach could involve making a list of variables that are thought to accurately predict the decision of S&P. We refrain from this approach because the selection of the index committee is discretionary (see Section II.A). Thus, this approach would lead to noisy matches. See as well the discussion in Patel and Welch (2017).

option returns and volatility trading, it is useful to analyze a simple Taylor approximation of the daily profit and loss of delta-hedged options:

$$\Pi_{j,t} = \underbrace{\frac{1}{2}\Gamma_{j,t-1}S^2_{j,t-1}\left(\frac{S_{j,t}-S_{j,t-1}}{S_{j,t-1}}\right)^2 + \nu_{j,t-1}(\sigma_{j,t}-\sigma_{j,t-1}) + \theta_{j,t-1}\Delta t + \rho_{j,t-1}(r^a_{f,t}-r^a_{f,t-1}) + \epsilon_{j,t}}_{O_{j,t}-O_{j,t-1}-\delta_{j,t-1}[S_{j,t}-S_{j,t-1}]} - r_{f,t-1}\left[O_{j,t-1}-\delta_{j,t-1}S_{j,t-1}\right] \quad (4)$$

where $\Gamma_{j,t-1}$ is the Black and Scholes (1973) gamma at time $t-1$, i.e., the second-order sensitivity of the option price written on firm j to the underlying price at time $t-1$. $\nu_{j,t-1}$ denotes the Black and Scholes (1973) vega at time $t-1$, defined as the sensitivity of the option price to changes in the implied volatility. $\theta_{j,t-1}$ is the sensitivity of the price of the option written on firm j to the change in time to maturity at time $t-1$. $\rho_{j,t-1}$ is the time $t-1$ sensitivity of the option price to the change in the riskless rate. $r^a_{f,t}$ and $r^a_{f,t-1}$ denote the annualized risk-free rate of the same maturity as the option at times t and $t-1$, respectively. The residual $\epsilon_{j,t}$ captures other terms, including the higher-order components.

Combining Equations (2) and (4), we can show that:

$$R_{Option,j,t} = \frac{1}{2}\frac{\Gamma_{j,t-1}S^2_{j,t-1}}{|O_{j,t-1}-\delta_{j,t-1}S_{j,t-1}|}\left(\frac{S_{j,t}-S_{j,t-1}}{S_{j,t-1}}\right)^2 + \frac{\nu_{j,t-1}}{|O_{j,t-1}-\delta_{j,t-1}S_{j,t-1}|}(\sigma_{j,t}-\sigma_{j,t-1}) + \frac{\theta_{j,t-1}\Delta t + \rho_{j,t-1}(r^a_{f,t}-r^a_{f,t-1}) + \epsilon_{j,t} - r_{f,t-1}\left[O_{j,t-1}-\delta_{j,t-1}S_{j,t-1}\right]}{|O_{j,t-1}-\delta_{j,t-1}S_{j,t-1}|} \quad (5)$$

Equation (5) enables us to understand the drivers of the daily delta-hedged option returns.[26] The first term to the right-hand side of the equality sign highlights the impact

[26]It is important to emphasize that the decomposition is exact for the daily return. It does not naturally extend to the long-horizon returns. This problem arises because the long-horizon return is obtained by compounding daily returns.

of the realized variance of the underlying.[27] If the underlying moves by large amounts as is the case in the presence of jumps, then this channel will lead to a higher delta-hedged option return. The second term of the summation depends on the revision in the implied volatility. If the implied volatility increases, then we will observe a higher delta-hedged option return. The third component of the summation captures the time-decay, the interest rate contribution, and all other effects, respectively.

Several points are worth discussing. First, the formula shows that the response of delta-hedged options does not merely reflect the directional movement of the underlying. This is to be expected since we focus specifically on delta-hedged call options, rather than outright call options. Second, the delta-hedged call option positions benefit from option traders revising upwards their estimate of the implied volatility. In an untabulated analysis, we empirically find that the implied volatility channel accounts for 94.09 % (102.67 %) of the unconditional average delta-hedged option return of firms added to (excluded from) the S&P 500 index over our sample period.[28] Economically, this finding confirms that the delta-hedged options are mostly informative about the pricing of the expected volatility.

III The Impact of S&P 500 Index Recompositions on...

This section presents our main empirical findings regarding the impact of S&P 500 index recomposition news on asset prices. We begin by analyzing the response of the individual stock prices. In so doing, we revisit and update the findings of the extant literature

[27]Our use of the expression "realized variance" is an abuse of terminology. The literature on high-frequency financial econometrics typically uses the term "realized" variance to indicate the variance computed based on intraday data. If we were to delta-hedge the option positions at the intraday (rather than daily) frequency, our use of the expression would be entirely consistent with this literature.

[28]In order to calculate this statistic, we proceed as follows. For each firm, we compute the ratio of the value of the channel of interest (see Equation (5)) on a given day over the daily delta-hedged option return of the same day. Next, we average these results in the time-series dimension to obtain our estimate at the firm level. Finally, we compute the equal-weighted average of the estimates across firms.

that mostly focuses on the response of equities to S&P 500 index recomposition news. We then study the response of delta-hedged options to index recomposition news, the main research goal of our paper. We average the raw and placebo-adjusted announcement responses across all stocks. The statistical inference for the average raw returns is based on the asymptotic distribution, while that of the placebo-adjusted findings is couched on the placebo distribution.[29] Throughout this paper, we use the 5 % significance level.

A Stock Prices

Inclusions Panel A of Table 2 documents the response of equity prices to the announcements of index inclusions. Starting with the raw average return, we observe a significantly positive effect of 3.96 % and 5.71 % over the short- and long-term windows, respectively.[30,31] Analyzing the placebo- and risk-adjusted returns, we find significantly positive average returns of 4.03 % and 4.96 % for the short- and long-term event windows, respectively. The short run positive announcement response is consistent with the existing literature, e.g., Harris and Gurel (1986) and Shleifer (1986). Furthermore, the significant result obtained over the long event window echoes the finding of Chen et al. (2004) of a permanent inclusion effect for individual equities.

[29]By using the placebo distribution, we aim to deal with the non-normal features of the return distribution. As a further robustness check, we implement the winsorization scheme of Patel and Welch (2017). Specifically, we winsorize the (i) excess and (ii) risk-adjusted returns of each stock at $5\% \times \sqrt{T}$ and $-4.74\% \times \sqrt{T}$, where T denotes the length of the event window in trading days. The empirical results are qualitatively similar to our benchmark findings. We do not tabulate these findings for brevity.

[30]Interestingly, the short-term raw announcement return (3.96 %) is similar to the placebo-adjusted average response (3.99 %). This similarity indicates that, for the 1-day horizon, the control group exhibits very little drift. However, at the long-horizon, we notice a large difference between the two sets of estimates (5.71 % vs. 2.85 %), indicating that the control group displays a sizable drift over the long horizon (see also Patel and Welch (2017)).

[31]It is worth noting that the inclusion effect is smaller during our sample period compared to earlier studies. This finding is consistent with the recent observation of Patel and Welch (2017) who document a declining inclusion effect.

Exclusions Panel B of Table 2 reports the results associated with the exclusion events. Contrary to the inclusion events, the placebo- and risk-adjusted returns point to a short-term negative announcement response to exclusion events ($-3.82\,\%$). This finding is congruent with the existing literature, e.g., Patel and Welch (2017). We can see that the short-term response to the exclusion news is similar, in magnitude, to that of the inclusion news ($4.03\,\%$). Turning to the long event window, we do not find a significant placebo- and risk-adjusted average return. This observation leads us to the conclusion that the exclusion announcements have a transitory effect on stock prices.

Overall, our empirical findings are consistent with the research of Chen et al. (2004), who document an asymmetry between the long-term inclusion and exclusion effects on stocks.

B Delta-Hedged Option Prices

Inclusions We now turn our attention to the response of delta-hedged call option positions to the announcements of index inclusions. Panel A of Table 3 summarizes the results. We observe a positive and significant average response ($1.10\,\%$) over the short event window.[32,33] This result is interesting for a number of reasons. To begin with, the average short-term announcement return of the delta-hedged call options of companies added to the index is positive, whereas their unconditional average daily return is negative ($-0.006\,\%$).[34] Moreover, the inclusion effect observed over the short event window is at least an order of magnitude larger than the unconditional average. This finding further confirms that index inclusion news significantly moves the market price of the delta-hedged call option positions.

Turning to the placebo- and risk-adjusted excess returns, we find a positive and significant inclusion effect of 1.04 % and 2.87 % over the short and long event windows,

[32] Analyzing a short event window, Dhillon and Johnson (1991) and Dash and Liu (2008) report that option prices rise by 26.22 % and 83.87 %, respectively. Clearly, our estimate of the short-term inclusion effect is an order of magnitude smaller than theirs. To understand the difference in the empirical results, it is important to note that the authors analyze the impact of index recomposition news on outright option positions, whereas we focus on delta-hedged option positions. Given their focus, they compute the option return as follows:

$$R_{Dash\&Liu,j,t} = \frac{O_{j,t} - O_{j,t-1}}{O_{j,t-1}} \quad (6)$$

Since their object of interest (see Equation (6)) is different from ours (see Equation (2)), the two sets of results are not directly comparable. To verify this, we compute option returns as in Dash and Liu (2008) and repeat our main analysis. Table A1 of the Online Appendix summarizes the findings. We find a short-term announcement effect of 48.34 %, which is an order of magnitude larger than the result based on delta-hedged option returns (1.10 %).

[33] One may wonder whether the strong equity price reaction around the news announcement date materially affects our understanding of the drivers of the delta-hedged option return. Specifically, if the underlying price jumps around the announcement time, then the contribution of the implied volatility channel to the delta-hedged option return might decline, while that of the realized variance channel might increase. To shed light on this, we implement the decomposition suggested by Equation (5). Our untabulated analysis reveals that, on average, the revision in the implied volatility channel still accounts for 88.21 % of the short-term announcement effect. The upshot of this analysis is that most of the delta-hedged option response arises from revisions in the implied volatility.

[34] In order to calculate this unconditional average, we take the complete time-series of delta-hedged option returns associated with all companies added to the S&P 500 index. We calculate the U.S. Dollar open interest weighted average daily delta-hedged option return first at the company level and then take the mean of the resulting estimates across all companies added to the index during that period. These findings are not tabulated for brevity.

respectively.[35,36] Economically, our results suggest that a good explanation of the inclusion effect needs to rationalize the positive announcement effects on (i) the underlying equity and (ii) the delta-hedged call option position. We shall return to this point in Section V. Furthermore, the positive response of delta-hedged options points to an increase in the implied volatility of stock returns. This finding is difficult to reconcile with the prediction of the model of Cuoco and Kaniel (2011) under asymmetric performance fees discussed in the introduction.

Exclusions Panel B of Table 3 focuses on the response of delta-hedged call options to the news of index exclusion. We observe a significantly positive response (0.44 %) over the short event window.[37] Our untabulated analysis suggests that the unconditional average delta-hedged call return of firms in our exclusion sample is $-0.05\,\%$. Keeping this in mind, it is clear that the short-term announcement response to the exclusion news is both economically and statistically significant.

It is also worth noting that the short-term announcement response of the delta-hedged call option is positive whereas that of the underlying asset is negative. This result may be explained by the leverage effect (Black, 1976), namely the empirical observation that

[35] As a further analysis, we consider another event window that starts from AD and ends at $ED{+}126$. We find a placebo- and risk-adjusted return of 1.82 %. This untabulated result is interesting because it suggests that part of the inclusion effect on delta-hedged call options might be exploitable in practice. We leave a thorough analysis of the formulation and implementation of such trading strategy to future research.

[36] Similar to our findings for the stock prices, we find little to distinguish between the average raw (1.10 %) and placebo-adjusted (1.08 %) responses over the short event window. This result may explain why the prior literature, e.g., Dash and Liu (2008), does not carry out any placebo adjustment when analyzing short event windows.

[37] Similar to the inclusion events, there is very little difference between the raw and placebo-adjusted mean returns over the short window, indicating that the delta-hedged call options written on firms belonging to the control group show little movement around the exclusion announcements. However, the results related to the long event window point to a negative wedge of $-1.10\,\%$ between the two groups of firms.

equity returns become more volatile as the underlying price decreases.[38]

Comparing the results for the inclusion and exclusion effects, we can see that the placebo and risk-adjusted short-term response of delta-hedged call options associated with exclusion news (0.46 %) is less than half that of inclusion events (1.04 %). Turning to the long event window, we observe a significant inclusion effect (2.87 %) and an insignificant exclusion effect (−0.34 %). The finding of a transitory exclusion effect is in sharp contrast with the permanent inclusion effect. This conclusion extends that of Chen et al. (2004), who document a similar asymmetry for individual equities, to delta-hedged call option positions.

IV Are the Findings Robust to ...

In this section, we evaluate the robustness of our findings to the various methodological choices discussed in Section II. In particular, we repeat our analysis of the response of delta-hedged option prices using put options only. We then study the robustness of our results with respect to at-the-money options. Relatedly, we evaluate the sensitivity of the results to the maturity of the options. Additionally, we consider different methods to aggregate the option returns at the firm level. Next, we assess the potential impact of measurement errors in the hedge ratio. Finally, we analyze the possibility that our main results may be affected by the concurrent release of earnings news.

[38] It is worth highlighting that the leverage explanation of Black (1976) is just one potential mechanism. An alternative explanation is that higher expected volatility should be accompanied by high expected returns. As a result of the high expected returns, prices must fall, thus giving rise to the negative correlation between equity returns and expected volatility. For more details, we refer the interested reader to Ait-Sahalia et al. (2013) and the references therein.

A The Option Type?

Up to this point, our main analysis has focused on delta-hedged call options. To the extent that our results reflect volatility effects, our findings should also hold for delta-hedged put options.

Table 4 summarizes the response of delta-hedged put options to index recomposition news. Panel A of that table focuses on inclusion news. It documents a significant placebo- and risk-adjusted reaction of the delta-hedged put options of 0.62 % and 1.60 % for the short- and long-term event windows, respectively. These estimates are qualitatively similar, although slightly lower, to those of the call option contracts. It is worth mentioning that our finding of a significantly positive response of delta-hedged put option prices to inclusion news is not necessarily inconsistent with the significantly negative response of put option prices documented by Dhillon and Johnson (1991) and Dash and Liu (2008).[39] To understand why, it is useful to recall that the put option prices decrease with the underlying price and increase with volatility. Thus, their finding should be viewed as indicating that the underlying channel dominates the volatility effects. It does not necessarily imply that the volatility effects are non-existent. Turning to exclusion events, the placebo- and risk-adjusted average return (see Panel B of Table 4) points to a significant short-term reaction (0.48 %) that is not discernible over the long event window.

Taken as a whole, these results are qualitatively consistent with those based on delta-hedged call options. The inclusion effect is significantly positive and permanent, whereas the exclusion effect is smaller and transitory.

[39] As a robustness check, we use the same definition of returns as Dash and Liu (2008) (see Equation (6)) to compute the put option returns. Panel A of Table A2 of the Online Appendix documents a significantly negative response of −23.25 % and −67.32 % for the short- and long-term event windows, respectively. Our short-term result is qualitatively consistent with that of Dash and Liu (2008) who document a positive response (34.75 %) of the short put position.

B The Illiquidity of Options?

Our analysis involves options that cover a wide moneyness range. However, options that are near the at-the-money range are more liquid than other options (Carr and Wu, 2020). This observation motivates us to focus on call options that are near the at-the-money range, i.e., with moneyness range between 0.90 and 1.10. Panel A of Table 5 shows that the placebo- and risk-adjusted delta-hedged returns display a significantly positive inclusion effect at both the short (1.07 %) and long (2.81 %) horizons, respectively. Panel B of Table 5 confirms that the impact of exclusion news on delta-hedged option positions is transitory. Taken together, these results are aligned with our benchmark findings.

Up to this point, we have focused on options of time to maturity up to 120 days. One may be concerned that the prices of options of longer maturity are noisier than those of short-term options. It is thus interesting to repeat our analysis for short-term options, defined as options with time to maturity shorter than 60 days. Table 5 confirms that the inclusion effect is significantly positive and permanent, whereas the exclusion effect is weaker and transitory. This set of results is consistent with our benchmark results.

C The Method of Aggregation?

So far, we have used weights based on the U.S. Dollar open interest to aggregate the delta-hedged option returns at the firm level. As previously discussed, the motivation for this weighting scheme is to give more prominence to options that attract more open interest. It is, however, interesting to analyze the extent to which the results are sensitive to the method of aggregation.

Accordingly, we repeat our main analysis after separately implementing (i) a volume-weighting scheme, which gives more prominence to options that attract more trading volume and (ii) an equal-weighting scheme, which treats all option contracts in the same manner. If the obtained results are very different from our benchmark findings, then we can infer that the weighting scheme significantly affects our main results.

Panel A of Table 5 documents an average placebo- and risk-adjusted inclusion effect based on the volume-weighting scheme equal to 1.21 % and 2.15 % over the short and long windows, respectively. Turning to the equal-weighting scheme, we obtain 1.42 % and 2.82 % over the short and long event windows, respectively. Overall, these numbers are comparable to the benchmark estimates of 1.04 % and 2.87 % over the short and long event windows (see Table 3), respectively. Turning to exclusion events, Panel B of Table 5 confirms that the results are qualitatively similar to our benchmark findings. We thus conclude that the method of aggregation does not materially influence our main findings.

D Measurement Errors in the Hedge Ratio?

Our empirical analysis requires the estimation of the hedge ratio to create the delta-hedged option positions. Unfortunately, the "true" hedge ratio is not directly observable but instead needs to be estimated using a specific option pricing model. Since different models can lead to different estimates, it is likely that the hedge ratio used for our main analysis is computed with errors arising from model misspecification. If the "true" hedge ratio differs from the Black and Scholes (1973) hedge ratio, our analysis will be affected by measurement errors.

There are several approaches to analyzing the sensitivity of the results to the estimation of the delta hedge ratio. One possibility is to formulate and estimate an empirical model for the delta. That is, we can assume that the delta of an option depends on several characteristics. We then empirically estimate the sensitivity of delta to the various characteristics and use the parameter estimates to compute the model-implied hedge ratio. Huang et al. (2019) follow this approach and document that the resulting hedge ratio is quite noisy. A seemingly better alternative approach used in the literature, e.g. Coval and Shumway (2001) and Huang et al. (2019) consists in pertubating the Black and Scholes (1973) hedge ratio. More specifically, we assume that the "true" hedge ratio is equal to 90 % or 110 % of the Black and Scholes (1973) delta and repeat the analysis using these new hedge ratios.[40,41] Table 5 presents the results for the delta-hedged call options based on the new hedge ratios. Starting with inclusion events in Panel A, we can see that the announcement effect is still discernible over both the short and long event windows. Turning to the exclusion events, we observe that the index exclusion news has a transitory effect on delta-hedged call option (see Panel B of Table 5). Overall, these results are aligned with our main findings.

E Concurrent Earnings News?

Our finding of a significant positive short-term announcement response of the delta-hedged option market to index recomposition news is reminiscent of the work of Gao et al. (2018) who document that, while the straddle returns of individual stocks are negative on average, there is a significantly positive average straddle return around earnings announcements. Naturally, one may wonder if the index inclusion news coincide with the earnings announcements of the treated firms. If this were the case, the effect we document around index recomposition news would be the same as that of Gao et al. (2018).

To shed light on this hypothesis, we remove from the treated and control groups all stocks for which either the earnings announcement date or the day after correspond to

[40] Huang et al. (2019) assume values of 95 % and 105 %. We use a wider range, 90 % to 110 %, in order to carry out a more conservative analysis.

[41] It is worth pointing out that, given our formula for the delta-hedged option return (see Equation (2)), the impact of measurement errors in the hedge ratio on these returns is non-linear. This is because the hedge ratio affects both the numerator and the denominator.

an index recomposition announcement day.[42] The last row of Panel A of Table 5 repeats our analysis of inclusion events. We observe a statistically significant placebo- and risk-adjusted delta-hedged call return of 1.03 % and 2.92 % over the short- and long-term event windows, respectively. These results are very similar to the significant benchmark estimates of 1.04 % and 2.87 % observed over the short and long windows, respectively.[43] We also repeat a similar analysis for the announcements of index exclusions. Panel B of Table 5 documents a significant response over the short event window (0.48 %) that is no longer discernible over the long event window. Taken together, these results are qualitatively similar to our benchmark findings. We thus conclude that the effect we document is distinct from the earnings announcement findings of Gao et al. (2018).

V Potential Explanations

We now assess the ability of several mechanisms to jointly explain the responses of the stock and delta-hedged option prices. In particular, we present and evaluate explanations based on (i) investor recognition, (ii) noise trading, (iii) dispersion trading, and (iv) benchmarking by institutional investors.

A Investor Recognition

Merton (1987) develops a theoretical model to study asset prices in an informationally incomplete market. In that model, the investor is only aware of a subset of the securities available in the economy. Because the investor includes a security in her portfolio only if she is aware of it, she holds an incompletely diversified portfolio. In equilibrium, the

[42] In the data, we find that there are 13 (5) inclusion (exclusion) events where the announcement day or the day after the announcement day corresponds to an earnings news date or the following day.

[43] We have also repeated the analysis for stocks. Table A3 of the Online Appendix presents placebo- and risk-adjusted results that are similar to those of Table 2.

stocks with low investor recognition offer high returns to compensate the stock holder for the limited risk-sharing. As the recognition increases, the equilibrium required rate of return of that stock falls and its price rises. Chen et al. (2004) argue that index inclusions increases the awareness of investors. The authors also point out that, to the extent that the investor does not become "unaware" of a stock following news of its exclusion from the index, exclusion announcements should not affect equity prices over the long event window.

Motivated by this argument, we analyze the impact of S&P 500 index recomposition news on firms with different levels of analyst coverage. Since the argument of Chen et al. (2004) is that inclusion to an index raises investor's awareness, we would expect the inclusion effect to be weaker for companies with higher analyst coverage before the announcement. This is because the high analyst coverage would have already raised the awareness of investors to the stock. We obtain data on the number of analysts covering each stock from the Institutional Brokers Estimate System (IBES) database. For the S&P 500 recomposition announcements, we sort the treated stocks into two categories below and above the median, namely high and low, based on the number of analysts covering them prior to the announcement date. We then compute and report the placebo- and risk-adjusted results for each of these two categories. Starting with Panel A of Table 6, which focuses on short-term inclusion events, we can see that there is no significant difference between the equity response of the two groups. Panel A of Table 7, which focuses on the long-term effect of inclusion news, documents that the response of stocks is significant (7.70 %, p-value=0.3 %) for companies that already had a high number of analysts. In contrast, we observe an insignificant (3.12%, p-value=15.2 %) effect for stocks that have low analyst coverage. This result is diametrically opposed to the prediction of an explanation based on investor recognition.

Overall, the cross-sectional test reveals that the response of equities is difficult to reconcile with an explanation based on investor recognition. Moreover, in the original model of Merton (1987), the increased awareness of investors towards a stock does not increase the volatility of its returns. Consequently, the model cannot shed light on the response of delta-hedged options to index recomposition news (see Panel A of Tables 3 and 4).

B Noise Trading

Index-related products, such as index futures and exchange traded funds, are highly liquid products. In turn, the ease of trading these products attracts noise traders who have a high-frequency and non-fundamental demand (Black, 1986). Since the index product is linked to the constituent stocks by the absence of arbitrage, the high-frequency trading of noise traders in the index product essentially impounds non-fundamental volatility into the stock prices of index constituents. Although this noise trading argument does not speak to the issue of the directional response of equity prices to index recomposition news, it has some potential to explain our volatility results.[44] Consistent with this mechanism, Ben-David et al. (2018) find that an increase in ETF ownership is associated with more volatile

[44]It is important to point out that the noise trader that we consider here is primarily interested in trading the index product, rather than the underlying index constituents. Obviously, one can think of a framework where noise trading risk affects the price of individual equities. For instance, De Long et al. (1990) develop a theoretical model to study the impact of noise trader risk on individual asset prices. In the model, the arbitrageur is deterred from betting against the noise trader as she may be forced to close the arbitrage trade before the asset price converges to its fundamental price. We do not believe that noise trader risk can help explain our results. If the stock price reaction of included firms were the result of noise trading risk, we would expect an opposite effect for the stocks of excluded firms. This prediction is inconsistent with the transitory exclusion effect documented in the literature and our own empirical evidence (see Panel B of Table 2).

stock returns.[45] If option traders account for this increased volatility, we expect to see a positive and permanent placebo- and risk-adjusted response of the delta-hedged options of included firms. Moreover, this response should be stronger during periods of high noise trading activity. Turning to exclusions, the noise trading explanation counterfactually predicts a permanently negative response of the delta-hedged options of excluded firms (see Panel B of Tables 3 and 4). Additionally, the magnitude of the negative response should be high during periods of high noise trading activity.

The preceding discussion motivates two cross-sectional tests of the noise trading explanation that focus on the long event window. To understand our interest in the long event window, it is useful to recall that, in the case of index inclusions, the no-arbitrage link between the index product and the index constituents hinges on the stock being in the index, i.e., it holds only after the effective date. If one considers the short rather than the long event window, the transmission mechanism of the noise trader shock from the index product to the soon-to-be stock becomes somewhat tenuous.[46]

The first test builds on the Baker and Wurgler (2006) measure of investor sentiment. Assuming that noise traders are more active during periods of high sentiment, we expect the inclusion effect to be stronger for delta-hedged options during times of high sentiment compared to low sentiment. We orthogonalize the sentiment measure with respect to business cycle variables following Sibley et al. (2016). Next, we compute the average of the orthogonalized measure over the event window. We then sort all recomposition events into two groups, high and low, based on the size of the orthogonalized sentiment measure.

[45] Harris (1989) compares the volatility of the returns of stocks included in the S&P 500 index to that of a placebo group of firms. Analyzing the period after 1985, the author finds that stocks added to the index witness a significant increase in the short-term volatility of their returns of 14 basis points. Interestingly, there is no significant difference between the short-term volatility estimates of the included and placebo firms before 1983. Taken together, these results leave open the possibility that the higher short-term volatility of included firms in the post 1983 sample may be linked to the introduction of index products such as the S&P 500 index futures and option contracts.

[46] Nonetheless, we present the results linked to the short-term window in Table 6.

We repeat our analysis separately for each of these two groups. Panel A of Table 7 shows that there is no significant difference in the response of delta-hedged call options observed during periods of high and low investor sentiment. This finding is difficult to reconcile with an explanation based on the impact of noise trading in the index products. Turning to exclusion events, the spread between the high and low groups yields a result that has a sign opposite to that predicted by the noise trading explanation.

The second test is motivated by the work of Baltussen et al. (2019) who show that the rise of indexing has lowered the autocorrelation of the returns of index stocks. We turn this argument on its head. If a stock has witnessed a meaningful decline in its autocorrelation since joining the index, it likely is the result of noise trading in the index product that gets transmitted to the stock via arbitrage trading. In this case, we expect to see a stronger inclusion effect for the delta-hedged options linked to companies with a larger fall in the autocorrelation of their stock returns. We compute the multi-period autocorrelation (MAC) of order 5 as in Baltussen et al. (2019) for each treated stock:[47]

$$MAC(5) = r_t(4r_{t-1} + 3r_{t-2} + 2r_{t-3} + 1r_{t-4})/5\sigma^2 \tag{7}$$

where $MAC(5)$ is the multi-period autocorrelation of order 5. r_t, r_{t-1}, r_{t-2}, r_{t-3}, and r_{t-4} denote the stock return at times t, $t-1$, $t-2$, $t-3$, and $t-4$, respectively. σ^2 is the unconditional variance of the returns.

We estimate the change in the autocorrelation dynamics (ΔMAC) as the difference between (i) the MAC computed over the 126-trading-day period starting immediately after ED and (ii) the MAC related to the 126-trading-day period that ends on $AD - 1$. We sort all the inclusion event windows into two groups, namely high and low, based on

[47] As a robustness check, we use the simple $AR(1)$ autocorrelation estimate and obtain qualitatively similar results. These findings are not tabulated for brevity.

the median ΔMAC. We analyze the index effect for each of these two groups. Panel A of Table 7, which focuses on inclusions, shows a significantly positive effect (4.05 %, p-value=0.0 %) for the delta-hedged call options of companies in the low ΔMAC and a positive (1.60 %) but insignificant response for the group with the high ΔMAC. However, the difference between the two groups is not statistically significant. Turning to exclusion events, we do not detect any significant response for any of the two groups (Panel B of Table 7). Again, this finding is difficult to reconcile with the noise trading hypothesis.

C Dispersion Trading

Several studies document a sizable correlation risk premium in the S&P 500 index option market (Driessen et al., 2009; Hollstein and Wese Simen, 2020). In order to capture this premium, the dispersion trader takes a short position in the index options and long positions in the options of all the index stocks. If a large amount of money is passively invested in this dispersion strategy, then the inclusion of a stock in the S&P 500 index will trigger an excess demand for its options from dispersion traders. In turn, this excess demand will raise the price of options written on the included firm(s) and lead to a positive announcement response of their delta-hedged options. The empirical evidence of Panel A of Tables 3 and 4 lends support to this argument.

There are, however, several reasons to be skeptical of this explanation. To begin with, the dispersion trading argument is silent on the announcement response of the underlying stock. Thus, it can at best serve as a partial explanation for the reaction of delta-hedged options. Additionally, this explanation predicts that the delta-hedged options of firms are expensive as long as they remain in the index. If a company is excluded from the index, we should observe a negative and permanent exclusion effect since its options would no longer be affected by the excess demand of dispersion traders. This prediction is not borne out by the data. Panel B of Tables 3 and 4 documents a positive and transitory exclusion effect on delta-hedged options. Furthermore, conversations with market participants reveal that, in practice, the dispersion trading strategy typically does not involve positions in the options on all the S&P 500 constituent stocks. This is because of the high costs associated with trading the derivatives on all 500 constituent stocks. Instead, practitioners only trade the options of a subset of large and very liquid firms.[48] Consequently, it is unlikely that dispersion traders take positions in the derivatives of the newly included and excluded stocks. To verify this, we analyze the abnormal volume and open interest of the call options of excluded firms.[49] On a placebo-adjusted basis, we do not find evidence of a significant average abnormal volume and open interest. We do not tabulate these findings for brevity.[50]

D Benchmarking and Institutional Investors

Basak and Pavlova (2013) develop a theory to understand the response of stocks to index recomposition news. The theoretical model features an institutional investor alongside a retail investor. The institutional investor is evaluated relative to a benchmark

[48] For instance, the CBOE S&P 500 implied correlation index does not use the option contracts on all 500 constituent stocks. Instead, the index is based on the 50 largest stocks in the S&P 500 index. For further details on the construction of this index, we refer the reader to: `https://www.cboe.com/micro/impliedcorrelation/impliedcorrelationindicator.pdf`. For practical examples of dispersion strategies, see `https://www.newconstructs.com/wp-content/uploads/2010/10/JP-Morgan-and-Correlation`.

[49] Our model for the abnormal volume (open interest) is similar to that of Augustin et al. (2019). The main independent variables are the median call option trading volume (open interest) taken across the call options of all S&P 500 constituent firms, the S&P 500 implied volatility index, the return on the S&P 500 index, and the stock return of the company being analyzed. We also include the 1-period lag of the aforementioned independent variables as well as that of the dependent variable of our model. We use the same windows as for the risk-adjustment to estimate the loadings.

[50] As an additional analysis, we also analyze the abnormal open interest and trading volume of the call options of firms added to the S&P 500 index. On a placebo-adjusted basis, we observe a significantly positive and permanent abnormal open interest and trading volume. The significantly positive abnormal option trading volume is congruent with the research of Dash and Liu (2008). While this finding may lend credence to the explanation based on dispersion traders, the absence of a negative exclusion effect on trading activity casts doubt on the plausibility of this mechanism.

index and, thus, has an incentive to do well when the benchmark index performs well. In order to hedge against the fluctuations in the benchmark index, the institutional investor demands additional holdings of index stocks. This hedging incentive creates an excess demand for the index stocks (Brennan, 1993), thus raising the stock price of added firms. This positive inclusion effect is consistent with the findings of the literature, e.g. Harris and Gurel (1986), Shleifer (1986), Patel and Welch (2017), and our own evidence (see Panel A of Table 2).

The theoretical model has an implication for the conditional volatility of index stock returns. Specifically, the model posits that the conditional volatility of index stock returns is higher in the economy with the institutional investor. This is the result of market clearing. Given that stocks are in limited supply and institutional investors generate an excess demand for index stocks, the higher conditional volatility of index stock returns makes these stocks less attractive to retail investors who will cede part of their holdings to institutional investors.[51] To the extent that derivatives traders account for this volatility effect in their pricing on the announcement-day, we should observe a positive response of the delta-hedged options of added stocks over the short window. The empirical evidence of Panel A of Tables 3 and 4 is congruent with this implication. Turning to exclusion news, the model predicts a decline in the volatility of the returns of excluded stocks. Essentially, this lower volatility incentivises retail investors to acquire the stocks sold by institutional investors. Alas, this prediction is not supported by the data (see Panels B of Tables 3 and 4). Instead, our finding of a positive return to the volatility strategy may be consistent with the leverage effect.

Notwithstanding this limitation, we find it interesting to further explore the implica-

[51] The authors emphasize that the predictions *"concern only the announcement date"* and that they *"cannot make finer predictions which separate announcement-date returns and inclusion-date returns"* (Basak and Pavlova, 2013, p. 1752). Accordingly, our empirical tests mostly focus on the short event window.

tions of the model of Basak and Pavlova (2013). In particular, the model also predicts that the index effect increases with benchmarked institutional investors. This motivates us to carry out a simple cross-sectional test. We compare the addition effect for stocks included in the S&P 500 index that were previously (i) inside the S&P 400 mid-cap index and (ii) outside of the S&P 400 mid-cap index.[52,53] When a stock transitions from the S&P 400 mid-cap index to the S&P 500 index, it is subject to buying pressure from institutional investors benchmarked against the S&P 500 index. However, that buying pressure is partly offset by the selling pressure of institutional investors benchmarked against the S&P 400 mid-cap index. The net result is that the effect of benchmarking is likely weaker for a stock that transitions from the S&P 400 mid-cap index to the S&P 500 index compared to a stock that joins the S&P 500 index from outside the S&P 400 mid-cap index.

If the mechanism of Basak and Pavlova (2013) holds in the data, we should observe a short-term positive inclusion effect for both the stock and the delta-hedged options. Moreover, the effect should be stronger for stocks that were not previously in the S&P 400 mid-cap index. Consistent with the model, Panel A of Table 6 documents a positive inclusion effect for both groups of companies. Furthermore, it reveals that the short-term inclusion response is 2.19 percentage points (p-value = 0.0 %) stronger for added stocks that were outside the S&P 400 mid-cap index compared to those that were in the S&P 400 mid-cap index. Repeating this analysis for delta-hedged call options, we find a

[52]Overall, 215 of the 393 added stocks come from the S&P 400 mid-cap index. Conversely, 43 out of the 93 stocks excluded from the S&P 500 index in our sample go to the S&P 400 mid-cap index.

[53]The ownership of index investors is determined by the product of the weight of the company in the new index and the amount of money passively tracking that index. When a stock moves from the S&P 400 mid-cap index to the S&P 500 index, its weight in the new index is quite likely to drop. However, the drop in the index weight can be largely counteracted by the fact that the amount of money benchmarked against the S&P 500 index is significantly larger than that tracking the S&P 400 mid-cap index. Saglam et al. (2019) empirically show that the combined ownership of ETF and index funds generally increases as a stock transitions from the S&P 400 mid-cap index to the S&P 500 index. Interestingly, their detailed analysis also reveals that the ownership of ETFs decreases when a stock moves from the S&P 400 mid-cap index to the S&P 500 index.

qualitatively similar result, though of a smaller magnitude (0.65 percentage points, p-value = 0.0 %). The short-term reaction to exclusion news is 4.36 percentage points (p-value = 0.0 %) stronger for stocks that are excluded from the S&P 500 index to outside of the S&P 400 mid-cap index compared to those that ended up in the S&P 400 mid-cap index. Turning to the delta-hedged call options, we can see a positive response to exclusion news, which is at odds with the negative response predicted by the model.

VI Conclusion

We analyze the impact of S&P 500 index recomposition news on both equity and delta-hedged option returns. Consistent with the earlier literature, we document a significantly positive (negative) inclusion (exclusion) short-term announcement response of equity prices.

Our novel finding is that the delta-hedged options of included and excluded firms exhibit a significantly positive announcement response. This result holds for both call and put options and is robust to placebo- and risk-adjustments. Analyzing a long event window, we establish that the inclusion effect is permanent, whereas the exclusion effect is temporary. We explore potential explanations for the documented announcement effects and find that, existing theories of the index effect cannot individually explain the joint responses of equity and delta-hedged option prices.

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Figure 1: Event Study: Timeline

This figure illustrates the timeline used in the paper. AD indicates the announcement date. Essentially, this is the first trading day after the announcement, which is made after the regular trading hours of day $AD - 1$. ED is the effective date, i.e., the date when the recomposition event actually takes effect. Time differences are expressed in trading days. For example, $ED + 126$ denotes the date 126 trading days after the ED.

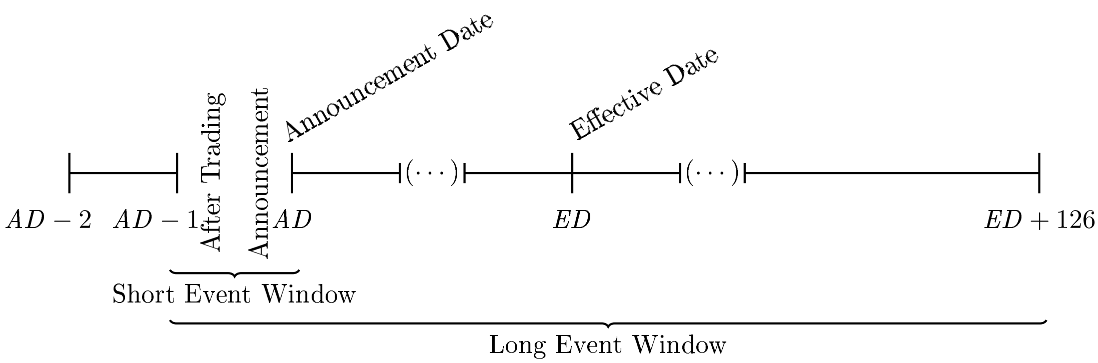

Table 1: Summary Statistics

This table presents the summary statistics of daily stock, delta-hedged call, and delta-hedged put returns. At each point in time, we compute the summary statistics using the returns related to the stocks ranked between #200 and #800 by market capitalization. We then compute and present the time-series average of these summary statistics. We do this separately for the stocks and for the delta-hedged calls and puts. Avg reports the average of the *[name in row]* returns. All returns are expressed in percentage points per day. Med, $Skew$, $Kurt$, $Q_{0.10}$, and $Q_{0.90}$ report the median, skewness, kurtosis, as well as the 10% and 90% quantiles, respectively. The subscripts C and nC indicate that the calculation relate to S&P 500 index constituent and non-constituent stocks, respectively.

	Avg	Avg_C	Avg_{nC}	Med_C	Med_{nC}	Std	Std_C	Std_{nC}	$Skew$	$Kurt$	$Q_{0.10}$	$Q_{0.90}$
Stocks	0.082	0.036	0.114	−0.006	0.027	2.196	1.953	2.303	0.697	20.53	−2.116	2.325
Calls	−0.009	−0.006	−0.012	−0.042	−0.051	0.860	0.716	0.920	2.185	59.49	−0.659	0.643
Puts	−0.019	−0.021	−0.018	−0.055	−0.067	0.779	0.628	0.847	2.703	62.25	−0.586	0.547

Table 2: Announcement Effect: Stocks

This table summarizes the response of stocks to index recomposition news. Panels A and B summarize the results associated with inclusion and exclusion news, respectively. AD and ED denote the announcement and effective dates, respectively. We present the results for different event windows with the length of the window expressed in trading days. For each panel, we analyze the (i) raw and (ii) placebo-adjusted returns. The placebos for the inclusion events are based on stocks not currently included in the S&P 500 index. For exclusion events, the placebo stocks are drawn from the constituents of the S&P 500 index. $\overline{R}$ denotes the average excess return. $\overline{AR}$ is the average risk-adjusted excess return. In order to carry out the risk-adjustment, we use a model that includes the 6 factors of Fama and French (2018), the daily innovation to the VIX, and the aggregate volatility and jump factors of Cremers et al. (2015). In parentheses, we report the p-values based on the Newey and West (1987) standard errors with 4 lags for the raw results or the placebo distribution for the placebo-adjusted results. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. Inclusions

	$AD-2$ to $AD-1$	$AD-1$ to AD	$AD-1$ to ED	$AD-1$ to $ED+10$	$AD-1$ to $ED+21$	$AD-1$ to $ED+63$	$AD-1$ to $ED+126$
				Raw			
$\overline{R}$	0.0011	0.0396***	0.0529***	0.0406***	0.0379***	0.0449***	0.0571***
	(0.595)	(0.000)	(0.000)	(0.000)	(0.000)	(0.007)	(0.010)
$\overline{AR}$	0.0029	0.0408***	0.0508***	0.0406***	0.0296***	0.0406***	0.0692***
	(0.106)	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.004)
				Placebo-Adjusted			
$\overline{R}$	0.0006	0.0399***	0.0489***	0.0386***	0.0299***	0.0283***	0.0285**
	(0.742)	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.049)
$\overline{AR}$	0.0008	0.0403***	0.0494***	0.0391***	0.0298***	0.0371***	0.0496***
	(0.624)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)

Panel B: Exclusions

	$AD-2$ to $AD-1$	$AD-1$ to AD	$AD-1$ to ED	$AD-1$ to $ED+10$	$AD-1$ to $ED+21$	$AD-1$ to $ED+63$	$AD-1$ to $ED+126$
				Raw			
$\overline{R}$	−0.0149	−0.0391***	−0.0745***	−0.0166	0.0250	0.1160*	0.1541
	(0.164)	(0.000)	(0.000)	(0.458)	(0.412)	(0.059)	(0.125)
$\overline{AR}$	−0.0123	−0.0379***	−0.0702***	−0.0160	0.0011	0.0182	0.0009
	(0.194)	(0.000)	(0.000)	(0.564)	(0.968)	(0.600)	(0.984)
				Placebo-Adjusted			
$\overline{R}$	−0.0137***	−0.0388***	−0.0693***	−0.0182***	0.0118	0.0797***	0.0767***
	(0.000)	(0.000)	(0.000)	(0.006)	(0.177)	(0.000)	(0.000)
$\overline{AR}$	−0.0128***	−0.0382***	−0.0693***	−0.0156**	0.0025	0.0193	−0.0017
	(0.000)	(0.000)	(0.000)	(0.017)	(0.799)	(0.177)	(0.932)

Table 3: Announcement Effect: Delta-Hedged Call Options

This table summarizes the response of delta-hedged call options to index recomposition news. Panels A and B summarize the results associated with inclusion and exclusion news, respectively. AD and ED denote the announcement and effective dates, respectively. We present the results for different event windows with the length of the window expressed in trading days. For each panel, we analyze the (i) raw and (ii) placebo-adjusted returns. The placebos for the inclusion events are based on stocks not currently included in the S&P 500 index. For exclusion events, the placebo stocks are drawn from the constituents of the S&P 500 index. $\overline{R}$ denotes the average excess return. $\overline{AR}$ is the average risk-adjusted excess return. In order to carry out the risk-adjustment, we use a model that includes the 6 factors of Fama and French (2018), the daily innovation to the VIX, and the aggregate volatility and jump factors of Cremers et al. (2015). In parentheses, we report the p-values based on the Newey and West (1987) standard errors with 4 lags for the raw results or the placebo distribution for the placebo-adjusted results. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. Inclusions

	$AD-2$ to $AD-1$	$AD-1$ to AD	$AD-1$ to ED	$AD-1$ to $ED+10$	$AD-1$ to $ED+21$	$AD-1$ to $ED+63$	$AD-1$ to $ED+126$
				Raw			
$\overline{R}$	−0.0014*	0.0110***	0.0084***	0.0092***	0.0084**	0.0105*	0.0246***
	(0.059)	(0.000)	(0.000)	(0.000)	(0.011)	(0.052)	(0.009)
$\overline{AR}$	−0.0011	0.0105***	0.0094***	0.0109***	0.0120***	0.0218***	0.0437***
	(0.103)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
				Placebo-Adjusted			
$\overline{R}$	−0.0012*	0.0108***	0.0080***	0.0066***	0.0055**	0.0099**	0.0242***
	(0.081)	(0.000)	(0.000)	(0.003)	(0.046)	(0.029)	(0.000)
$\overline{AR}$	−0.0011	0.0104***	0.0073***	0.0062***	0.0057*	0.0123**	0.0287***
	(0.121)	(0.000)	(0.000)	(0.006)	(0.051)	(0.010)	(0.000)

Panel B: Exclusions

	$AD-2$ to $AD-1$	$AD-1$ to AD	$AD-1$ to ED	$AD-1$ to $ED+10$	$AD-1$ to $ED+21$	$AD-1$ to $ED+63$	$AD-1$ to $ED+126$
				Raw			
$\overline{R}$	0.0004	0.0044**	0.0018	−0.0011	0.0000	−0.0038	−0.0233
	(0.837)	(0.021)	(0.698)	(0.834)	(0.995)	(0.770)	(0.348)
$\overline{AR}$	0.0001	0.0050***	0.0044	0.0032	0.0061	0.0046	−0.0037
	(0.959)	(0.009)	(0.257)	(0.474)	(0.332)	(0.660)	(0.868)
				Placebo-Adjusted			
$\overline{R}$	−0.0004	0.0043***	0.0022	−0.0028	−0.0004	−0.0032	−0.0110
	(0.718)	(0.000)	(0.273)	(0.441)	(0.927)	(0.620)	(0.222)
$\overline{AR}$	−0.0007	0.0046***	0.0032	−0.0013	0.0025	−0.0012	−0.0034
	(0.548)	(0.000)	(0.130)	(0.726)	(0.591)	(0.861)	(0.724)

Table 4: Announcement Effect: Delta-Hedged Put Options

This table summarizes the response of delta-hedged put options to index recomposition news. Panels A and B summarize the results associated with inclusion and exclusion news, respectively. AD and ED denote the announcement and effective dates, respectively. We present the results for different event windows with the length of the window expressed in trading days. For each panel, we analyze the (i) raw and (ii) placebo-adjusted returns. The placebos for the inclusion events are based on stocks not currently included in the S&P 500 index. For exclusion events, the placebo stocks are drawn from the constituents of the S&P 500 index. $\overline{R}$ denotes the average excess return. $\overline{AR}$ is the average risk-adjusted excess return. In order to carry out the risk-adjustment, we use a model that includes the 6 factors of Fama and French (2018), the daily innovation to the VIX, and the aggregate volatility and jump factors of Cremers et al. (2015). In parentheses, we report the p-values based on the Newey and West (1987) standard errors with 4 lags for the raw results or the placebo distribution for the placebo-adjusted results. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. Inclusions

	$AD-2$ to $AD-1$	$AD-1$ to AD	$AD-1$ to ED	$AD-1$ to $ED+10$	$AD-1$ to $ED+21$	$AD-1$ to $ED+63$	$AD-1$ to $ED+126$
				Raw			
$\overline{R}$	0.0007	0.0068***	0.0066***	0.0032	0.0009	0.0016	0.0019
	(0.404)	(0.000)	(0.000)	(0.133)	(0.763)	(0.770)	(0.836)
$\overline{AR}$	0.0010	0.0065***	0.0073***	0.0047**	0.0036	0.0098*	0.0170*
	(0.202)	(0.000)	(0.000)	(0.030)	(0.217)	(0.097)	(0.094)
				Placebo-Adjusted			
$\overline{R}$	0.0012**	0.0065***	0.0071***	0.0028	0.0013	0.0074*	0.0143**
	(0.045)	(0.000)	(0.001)	(0.138)	(0.589)	(0.093)	(0.026)
$\overline{AR}$	0.0011*	0.0062***	0.0070***	0.0026	0.0012	0.0080*	0.0160**
	(0.070)	(0.000)	(0.001)	(0.183)	(0.639)	(0.092)	(0.021)

Panel B: Exclusions

	$AD-2$ to $AD-1$	$AD-1$ to AD	$AD-1$ to ED	$AD-1$ to $ED+10$	$AD-1$ to $ED+21$	$AD-1$ to $ED+63$	$AD-1$ to $ED+126$
				Raw			
$\overline{R}$	0.0001	0.0049***	0.0043	0.0021	−0.0032	−0.0168	−0.0342*
	(0.955)	(0.009)	(0.340)	(0.624)	(0.531)	(0.124)	(0.083)
$\overline{AR}$	−0.0002	0.0048***	0.0057	0.0037	−0.0030	−0.0139	−0.0278
	(0.926)	(0.008)	(0.184)	(0.349)	(0.532)	(0.198)	(0.148)
				Placebo-Adjusted			
$\overline{R}$	0.0004	0.0050***	0.0063***	0.0042	0.0025	−0.0010	0.0001
	(0.605)	(0.001)	(0.009)	(0.126)	(0.443)	(0.839)	(0.993)
$\overline{AR}$	−0.0001	0.0048***	0.0065***	0.0042	0.0007	−0.0026	−0.0009
	(0.956)	(0.001)	(0.009)	(0.136)	(0.840)	(0.606)	(0.902)

Table 5: Robustness: Placebo- and Risk-Adjusted Delta-Hedged Option Returns

This table presents various robustness checks regarding the placebo- and risk-adjusted responses of delta-hedged call options to S&P 500 index recomposition news. Panels A and B summarize the results associated with inclusion and exclusion news, respectively. AD and ED denote the announcement and effective dates, respectively. We present the results for different event windows with the length of the window expressed in trading days. The placebos for the inclusion events are based on stocks not currently included in the S&P 500 index. For exclusion events, the placebo stocks are drawn from the constituents of the S&P 500 index. $\overline{AR}$ is the average risk-adjusted excess return. In order to carry out the risk-adjustment, we use a model that includes the 6 factors of Fama and French (2018), the daily innovation to the VIX, and the aggregate volatility and jump factors of Cremers et al. (2015). In parentheses, we report the p-values relative to the placebo distribution. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. Inclusions

	$AD-2$ to $AD-1$	$AD-1$ to AD	$AD-1$ to ED	$AD-1$ to $ED+10$	$AD-1$ to $ED+21$	$AD-1$ to $ED+63$	$AD-1$ to $ED+126$
				At-the-Money Calls			
$\overline{AR}$	−0.0009	0.0107***	0.0073***	0.0062***	0.0062**	0.0151***	0.0281***
	(0.206)	(0.000)	(0.000)	(0.001)	(0.019)	(0.000)	(0.000)
				Short-Term Options			
$\overline{AR}$	−0.0008	0.0132***	0.0086***	0.0080***	0.0077**	0.0145***	0.0260***
	(0.256)	(0.000)	(0.000)	(0.001)	(0.010)	(0.003)	(0.002)
				Volume-Weighting			
$\overline{AR}$	−0.0006	0.0121***	0.0083***	0.0043	0.0050	0.0113*	0.0215**
	(0.530)	(0.000)	(0.001)	(0.157)	(0.210)	(0.089)	(0.038)
				Equal-Weighting			
$\overline{AR}$	−0.0010	0.0142***	0.0100***	0.0092***	0.0085***	0.0150***	0.0282***
	(0.179)	(0.000)	(0.000)	(0.000)	(0.002)	(0.003)	(0.001)
				Perturbation: Delta × 0.9			
$\overline{AR}$	−0.0012	0.0168***	0.0147***	0.0118***	0.0103***	0.0181***	0.0412***
	(0.145)	(0.000)	(0.000)	(0.000)	(0.004)	(0.002)	(0.000)
				Perturbation: Delta × 1.1			
$\overline{AR}$	−0.0010*	0.0053***	0.0016	0.0016	0.0021	0.0078*	0.0201***
	(0.091)	(0.000)	(0.266)	(0.415)	(0.413)	(0.069)	(0.001)
				Excluding Earnings Announcements			
$\overline{AR}$	−0.0005	0.0103***	0.0075***	0.0062***	0.0057**	0.0120**	0.0292***
	(0.460)	(0.000)	(0.000)	(0.004)	(0.045)	(0.020)	(0.000)

Table 5: Robustness: Placebo- and Risk-Adjusted Delta-Hedged Option Returns (continued)

Panel B: Exclusions

	$AD-2$ to $AD-1$	$AD-1$ to AD	$AD-1$ to ED	$AD-1$ to $ED+10$	$AD-1$ to $ED+21$	$AD-1$ to $ED+63$	$AD-1$ to $ED+126$
				At-The-Money Calls			
$\overline{AR}$	-0.0013	0.0041^{***}	0.0054^{***}	0.0021	0.0092^{**}	0.0091	0.0127
	(0.164)	(0.000)	(0.005)	(0.507)	(0.029)	(0.165)	(0.173)
				Short-Term Options			
$\overline{AR}$	-0.0017	0.0031^{***}	0.0017	-0.0027	-0.0002	-0.0089	-0.0060
	(0.177)	(0.007)	(0.401)	(0.480)	(0.962)	(0.229)	(0.550)
				Volume-Weighting			
$\overline{AR}$	-0.0009	0.0044^{***}	0.0025	-0.0041	0.0012	0.0001	0.0231
	(0.552)	(0.000)	(0.360)	(0.380)	(0.838)	(0.984)	(0.106)
				Equal-Weighting			
$\overline{AR}$	-0.0013	0.0052^{***}	0.0045^{**}	0.0005	0.0051	0.0004	-0.0008
	(0.261)	(0.000)	(0.029)	(0.856)	(0.237)	(0.964)	(0.948)
				Perturbation: Delta × 0.9			
$\overline{AR}$	-0.0012	0.0015	-0.0032	-0.0066^{*}	-0.0002	-0.0022	-0.0084
	(0.357)	(0.127)	(0.136)	(0.097)	(0.980)	(0.781)	(0.440)
				Perturbation: Delta × 1.1			
$\overline{AR}$	-0.0002	0.0070^{***}	0.0083^{***}	0.0030	0.0048	-0.0002	0.0005
	(0.812)	(0.000)	(0.000)	(0.364)	(0.246)	(0.981)	(0.959)
				Excluding Earnings Announcements			
$\overline{AR}$	-0.0007	0.0048^{***}	0.0040^{*}	-0.0012	0.0033	-0.0018	-0.0026
	(0.543)	(0.000)	(0.056)	(0.751)	(0.475)	(0.771)	(0.751)

Table 6: Testing Potential Explanations: Short-Term Evidence

This table summarizes the results of tests of the investor's recognition, noise traders, and benchmarking hypotheses. Panels A and B summarize the results associated with inclusion and exclusion news, respectively. We report placebo- and risk-adjusted results. The returns relate to the short-term event window, i.e., from $AD - 1$ to AD. The placebos for the inclusion events are based on stocks not currently included in the S&P 500 index. For exclusion events, the placebo stocks are drawn from the constituents of the S&P 500 index. $\overline{AR}$ is the average risk-adjusted excess return. In order to carry out the risk-adjustment, we use a model that includes the 6 factors of Fama and French (2018), the daily innovation to the VIX, and the aggregate volatility and jump factors of Cremers et al. (2015). The first set of results relates to sorts based on the number of analysts following each stock. The second set of results compares the index effect during periods of high and low investor sentiment. The third set of results focuses on the impact of the change in autocorrelation. Finally, the last set of findings relate to stocks promoted from or relegated to the S&P 400 mid-cap index. In parentheses, we report the p-values based on the placebo distribution. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. Inclusions

Analyst Coverage						
	Low		High		High − Low	
Equity $\overline{AR}$	0.0418***	(0.000)	0.0391***	(0.000)	−0.0027	(0.305)
Delta-Hedged Call $\overline{AR}$	0.0132***	(0.000)	0.0072***	(0.000)	−0.0061***	(0.000)
Sentiment						
	Low		High		High − Low	
Equity $\overline{AR}$	0.0438***	(0.000)	0.0367***	(0.000)	−0.0071***	(0.003)
Delta-Hedged Call $\overline{AR}$	0.0104***	(0.000)	0.0104***	(0.000)	−0.0000	(0.968)
Δ Autocorrelation						
	Low		High		High − Low	
Equity $\overline{AR}$	0.0412***	(0.000)	0.0400***	(0.000)	−0.0012	(0.642)
Delta-Hedged Call $\overline{AR}$	0.0113***	(0.000)	0.0096***	(0.000)	−0.0017	(0.118)
Inter-Index Transfer						
	No		Yes		Yes − No	
Equity $\overline{AR}$	0.0523***	(0.000)	0.0303***	(0.000)	−0.0219***	(0.000)
Delta-Hedged Call $\overline{AR}$	0.0140***	(0.000)	0.0074***	(0.000)	−0.0065***	(0.000)

Table 6: Testing Potential Explanations: Short-Term Evidence (continued)

Panel B: Exclusions

	Analyst Coverage					
	Low		High		High − Low	
Equity $\overline{AR}$	−0.0472***	(0.000)	−0.0292***	(0.000)	0.0180***	(0.000)
Delta-Hedged Call $\overline{AR}$	0.0069***	(0.000)	0.0022**	(0.048)	−0.0048**	(0.018)
	Sentiment					
	Low		High		High − Low	
Equity $\overline{AR}$	−0.0377***	(0.000)	−0.0388***	(0.000)	−0.0011	(0.743)
Delta-Hedged Call $\overline{AR}$	0.0034**	(0.019)	0.0059***	(0.000)	0.0024	(0.153)
	Δ Autocorrelation					
	Low		High		High − Low	
Equity $\overline{AR}$	−0.0301***	(0.000)	−0.0477***	(0.000)	−0.0176***	(0.000)
Delta-Hedged Call $\overline{AR}$	0.0023*	(0.083)	0.0067***	(0.001)	0.0044**	(0.029)
	Inter-Index Transfer					
	No		Yes		Yes − No	
Equity $\overline{AR}$	−0.0551***	(0.000)	−0.0115***	(0.000)	0.0436***	(0.000)
Delta-Hedged Call $\overline{AR}$	0.0076***	(0.000)	0.0013	(0.106)	−0.0063***	(0.001)

Table 7: Testing Potential Explanations: Long-Term Evidence

This table summarizes the results of tests of the investor's recognition, noise traders, and benchmarking hypotheses. Panels A and B summarize the results associated with inclusion and exclusion news, respectively. We report placebo- and risk-adjusted results. The returns relate to the long-term event window, i.e., from $AD - 1$ to $ED + 126$. The placebos for the inclusion events are based on stocks not currently included in the S&P 500 index. For exclusion events, the placebo stocks are drawn from the constituents of the S&P 500 index. $\overline{AR}$ is the average risk-adjusted excess return. In order to carry out the risk-adjustment, we use a model that includes the 6 factors of Fama and French (2018), the daily innovation to the VIX, and the aggregate volatility and jump factors of Cremers et al. (2015). The first set of results relates to sorts based on the number of analysts following each stock. The second set of results compares the index effect during periods of high and low investor sentiment. The third set of results focuses on the impact of the change in autocorrelation. Finally, the last set of findings relate to stocks promoted from or relegated to the S&P 400 mid-cap index. In parentheses, we report the p-values based on the placebo distribution. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. Inclusions

	Analyst Coverage					
	Low		High		High − Low	
Equity $\overline{AR}$	0.0312	(0.152)	0.0770***	(0.003)	0.0459	(0.179)
Delta-Hedged Call $\overline{AR}$	0.0221**	(0.031)	0.0379***	(0.002)	0.0159	(0.286)
	Sentiment					
	Low		High		High − Low	
Equity $\overline{AR}$	0.0160	(0.404)	0.0836***	(0.002)	0.0677**	(0.033)
Delta-Hedged Call $\overline{AR}$	0.0250**	(0.016)	0.0325***	(0.004)	0.0076	(0.617)
	Δ Autocorrelation					
	Low		High		High − Low	
Equity $\overline{AR}$	0.0583**	(0.013)	0.0434**	(0.048)	−0.0149	(0.645)
Delta-Hedged Call $\overline{AR}$	0.0405***	(0.000)	0.0160	(0.144)	−0.0245	(0.103)
	Inter-Index Transfer					
	No		Yes		Yes − No	
Equity $\overline{AR}$	0.0553**	(0.020)	0.0450**	(0.036)	−0.0103	(0.747)
Delta-Hedged Call $\overline{AR}$	0.0406***	(0.000)	0.0188*	(0.065)	−0.0217	(0.137)

Table 7: Testing Potential Explanations: Long-Term Evidence (continued)

Panel B: Exclusions

	Analyst Coverage					
	Low		High		High − Low	
Equity $\overline{AR}$	−0.0423	(0.136)	0.0396	(0.109)	0.0818**	(0.029)
Delta-Hedged Call $\overline{AR}$	−0.0144	(0.292)	0.0085	(0.461)	0.0229	(0.214)
	Sentiment					
	Low		High		High − Low	
Equity $\overline{AR}$	0.0918***	(0.000)	−0.0966***	(0.002)	−0.1884***	(0.000)
Delta-Hedged Call $\overline{AR}$	−0.0239	(0.115)	0.0190*	(0.090)	0.0429**	(0.027)
	Δ Autocorrelation					
	Low		High		High − Low	
Equity $\overline{AR}$	0.0079	(0.774)	−0.0312	(0.268)	−0.0391	(0.325)
Delta-Hedged Call $\overline{AR}$	−0.0275*	(0.067)	0.0152	(0.274)	0.0427**	(0.035)
	Inter-Index Transfer					
	No		Yes		Yes − No	
Equity $\overline{AR}$	0.0381	(0.179)	−0.0645**	(0.012)	−0.1026***	(0.008)
Delta-Hedged Call $\overline{AR}$	−0.0351**	(0.024)	0.0312***	(0.005)	0.0663***	(0.002)

The Index Effect: Evidence from the Option Market

Online Appendix

JEL classification: G12, G11, G17

Keywords: Delta-Hedged Options, Event Study, Index Effect, Placebo Group

Figure A1: Inclusions and Exclusions Over Time

This figure presents the number of inclusions (dashed red) and exclusions (solid black) per month in our final sample. The shaded areas indicate business cycle contractions as identified by the NBER.

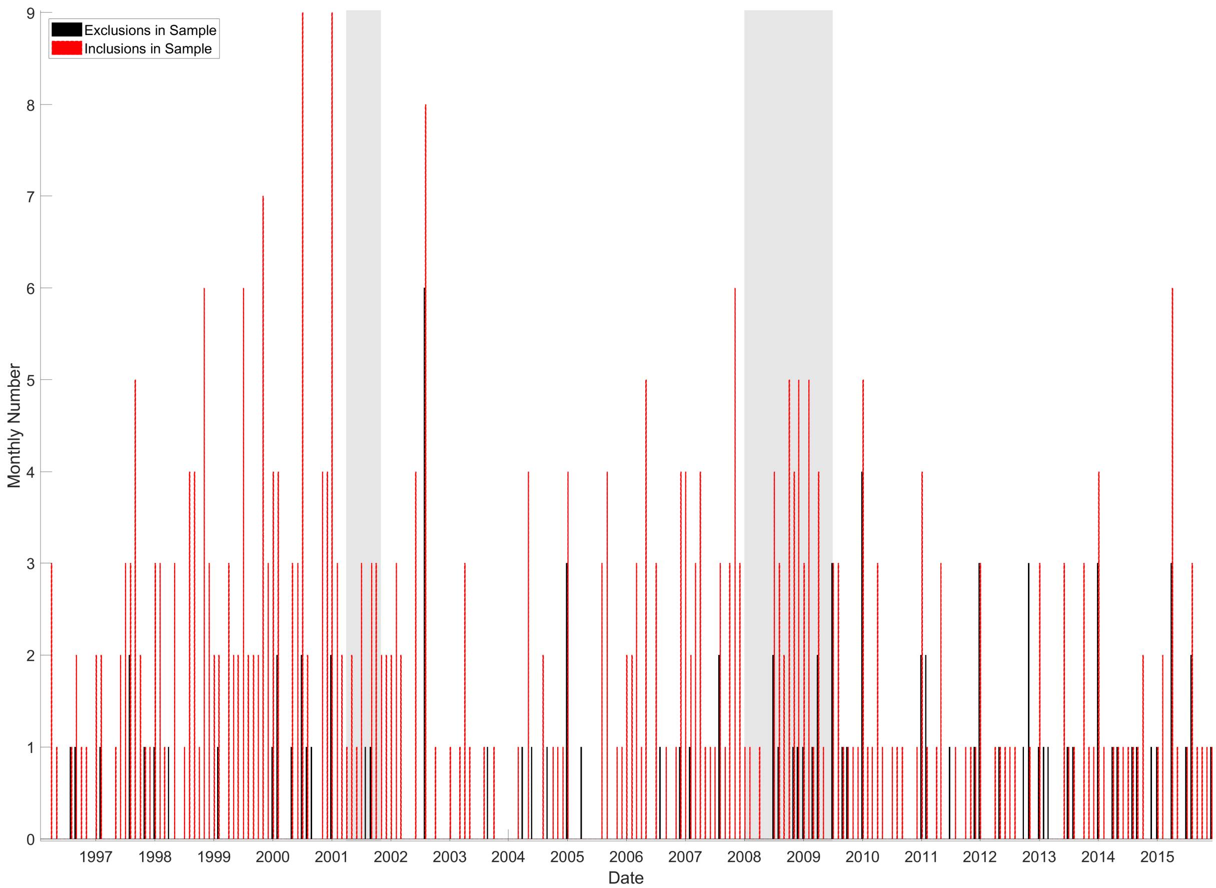

Table A1: Announcement Effect: Call Options (Dash and Liu, 2008)

This table summarizes the response of outright call options to index recomposition news. Panels A and B summarize the results associated with inclusion and exclusion news, respectively. AD and ED denote the announcement and effective dates, respectively. We present the results for different event windows with the length of the window expressed in trading days. We calculate the daily option returns as in Dash and Liu (2008). $\overline{R}$ denotes the average excess return. $\overline{AR}$ is the average risk-adjusted return. In order to carry out the risk-adjustment, we use a model that includes the 6 factors of Fama and French (2018), the daily innovation to the VIX, and the aggregate volatility and jump factors of Cremers et al. (2015). In parentheses, we report the p-values based on the Newey and West (1987) standard errors with 4 lags for the raw results or the placebo distribution for the placebo-adjusted results. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. Inclusions

	$AD-2$ to $AD-1$	$AD-1$ to AD	$AD-1$ to ED	$AD-1$ to $ED+10$	$AD-1$ to $ED+21$	$AD-1$ to $ED+63$	$AD-1$ to $ED+126$
				Raw			
$\overline{R}$	−0.0064	0.4834***	0.6169***	0.5270***	0.3657***	0.2662**	0.7219
	(0.674)	(0.000)	(0.000)	(0.000)	(0.004)	(0.048)	(0.228)
$\overline{AR}$	0.0126	0.4834***	0.6372***	0.4452***	0.3790***	0.6153**	2.0309**
	(0.357)	(0.000)	(0.000)	(0.000)	(0.001)	(0.022)	(0.034)
				Placebo-Adjusted			
$\overline{R}$	−0.0078	0.4808***	0.5657***	0.4802***	0.2754***	0.0094	0.3173
	(0.622)	(0.000)	(0.000)	(0.005)	(0.005)	(0.955)	(0.340)
$\overline{AR}$	−0.0074	0.4736***	0.5888***	0.3532***	0.2753***	0.3348	0.4089
	(0.642)	(0.000)	(0.000)	(0.005)	(0.006)	(0.105)	(0.943)

Panel B: Exclusions

	$AD-2$ to $AD-1$	$AD-1$ to AD	$AD-1$ to ED	$AD-1$ to $ED+10$	$AD-1$ to $ED+21$	$AD-1$ to $ED+63$	$AD-1$ to $ED+126$
				Raw			
$\overline{R}$	−0.0448	−0.1483***	−0.2667***	−0.1271	0.1345	0.7426*	0.1895
	(0.161)	(0.000)	(0.000)	(0.255)	(0.432)	(0.084)	(0.598)
$\overline{AR}$	−0.0079	−0.1414***	−0.2598***	−0.1920**	−0.0127	0.7063	−0.0111
	(0.807)	(0.000)	(0.000)	(0.027)	(0.924)	(0.176)	(0.972)
				Placebo-Adjusted			
$\overline{R}$	−0.0191	−0.1509***	−0.2700***	−0.2121**	0.0233	0.3403	−0.7830
	(0.465)	(0.000)	(0.000)	(0.037)	(0.834)	(0.227)	(0.252)
$\overline{AR}$	−0.0159	−0.1527***	−0.2904***	−0.2619*	−0.0435	0.5106*	−0.2841
	(0.552)	(0.000)	(0.000)	(0.056)	(0.674)	(0.053)	(0.577)

Table A2: Announcement Effect: Put Options (Dash and Liu, 2008)

This table summarizes the response of outright put options to index recomposition news. Panels A and B summarize the results associated with inclusion and exclusion news, respectively. AD and ED denote the announcement and effective dates, respectively. We present the results for different event windows with the length of the window expressed in trading days. We calculate the daily option returns as in Dash and Liu (2008). $\overline{R}$ denotes the average excess return. $\overline{AR}$ is the average risk-adjusted return. In order to carry out the risk-adjustment, we use a model that includes the 6 factors of Fama and French (2018), the daily innovation to the VIX, and the aggregate volatility and jump factors of Cremers et al. (2015). In parentheses, we report the p-values based on the Newey and West (1987) standard errors with 4 lags for the raw results or the placebo distribution for the placebo-adjusted results. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. Inclusions

	$AD-2$ to $AD-1$	$AD-1$ to AD	$AD-1$ to ED	$AD-1$ to $ED+10$	$AD-1$ to $ED+21$	$AD-1$ to $ED+63$	$AD-1$ to $ED+126$
				Raw			
$\overline{R}$	0.0053	−0.2325***	−0.2953***	−0.2644***	−0.3180***	−0.3291***	−0.6732***
	(0.747)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\overline{AR}$	−0.0082	−0.2396***	−0.2817***	−0.2834***	−0.2306***	−0.1958***	−0.3697***
	(0.530)	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)	(0.002)
				Placebo-Adjusted			
$\overline{R}$	−0.0011	−0.2388***	−0.2722***	−0.2350***	−0.2469***	−0.3213	−0.9937*
	(0.928)	(0.000)	(0.000)	(0.002)	(0.009)	(0.107)	(0.056)
$\overline{AR}$	−0.0022	−0.2394***	−0.2641***	−0.2643***	−0.2152**	−0.1926	−0.4847
	(0.862)	(0.000)	(0.000)	(0.000)	(0.015)	(0.219)	(0.142)

Panel B: Exclusions

	$AD-2$ to $AD-1$	$AD-1$ to AD	$AD-1$ to ED	$AD-1$ to $ED+10$	$AD-1$ to $ED+21$	$AD-1$ to $ED+63$	$AD-1$ to $ED+126$
				Raw			
$\overline{R}$	0.0646*	0.2423***	0.7131*	0.3768	0.1247	0.1587	−0.1079
	(0.073)	(0.001)	(0.084)	(0.107)	(0.546)	(0.749)	(0.798)
$\overline{AR}$	0.0289	0.2358***	0.4819**	0.3384**	0.2383	0.0720	−0.0962
	(0.340)	(0.000)	(0.012)	(0.044)	(0.266)	(0.804)	(0.637)
				Placebo-Adjusted			
$\overline{R}$	0.0408	0.2409***	0.6462***	0.4294***	0.3295***	0.4572**	0.1421
	(0.120)	(0.000)	(0.000)	(0.001)	(0.005)	(0.047)	(0.855)
$\overline{AR}$	0.0305	0.2427***	0.5047***	0.3459***	0.2817**	0.1306	−0.0797
	(0.211)	(0.000)	(0.000)	(0.002)	(0.013)	(0.491)	(0.908)

Table A3: Announcement Effect (Without Earnings Announcements): Stocks

This table summarizes the response of stocks to index recomposition news. We discard all companies for which either the earnings announcement date or the day after correspond to an index recomposition announcement day. Panels A and B summarize the results associated with inclusion and exclusion news, respectively. AD and ED denote the announcement and effective dates, respectively. We present the results for different event windows with the length of the window expressed in trading days. For each panel, we first analyze the raw returns. Then, we focus on the placebo-adjusted results. The placebos for the inclusion events are based on stocks not currently included in the S&P 500 index. For exclusion events, the placebo stocks are drawn from the constituents of the S&P 500 index. $\overline{R}$ denotes the average excess return. $\overline{AR}$ is the average risk-adjusted return. In order to carry out the risk-adjustment, we use a model that includes the 6 factors of Fama and French (2018), the daily innovation to the VIX, and the aggregate volatility and jump factors of Cremers et al. (2015). In parentheses, we report the p-values based on the Newey and West (1987) standard errors with 4 lags for the raw results or the placebo distribution for the placebo-adjusted results. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A. Inclusions

	$AD-2$ to $AD-1$	$AD-1$ to AD	$AD-1$ to ED	$AD-1$ to $ED+10$	$AD-1$ to $ED+21$	$AD-1$ to $ED+63$	$AD-1$ to $ED+126$
				Raw			
$\overline{R}$	0.0009	0.0406***	0.0542***	0.0417***	0.0387***	0.0435**	0.0589***
	(0.665)	(0.000)	(0.000)	(0.000)	(0.000)	(0.011)	(0.009)
$\overline{AR}$	0.0025	0.0417***	0.0518***	0.0420***	0.0309***	0.0409***	0.0718***
	(0.149)	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.003)
				Placebo-Adjusted			
$\overline{R}$	0.0005	0.0410***	0.0502***	0.0395***	0.0306***	0.0265**	0.0299*
	(0.794)	(0.000)	(0.000)	(0.000)	(0.000)	(0.024)	(0.054)
$\overline{AR}$	0.0006	0.0413***	0.0505***	0.0405***	0.0313***	0.0377***	0.0533***
	(0.727)	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.003)

Panel B: Exclusions

	$AD-2$ to $AD-1$	$AD-1$ to AD	$AD-1$ to ED	$AD-1$ to $ED+10$	$AD-1$ to $ED+21$	$AD-1$ to $ED+63$	$AD-1$ to $ED+126$
				Raw			
$\overline{R}$	−0.0142	−0.0397***	−0.0751***	−0.0159	0.0263	0.1130*	0.1584
	(0.200)	(0.000)	(0.000)	(0.487)	(0.398)	(0.075)	(0.128)
$\overline{AR}$	−0.0119	−0.0383***	−0.0707***	−0.0155	0.0027	0.0162	0.0025
	(0.223)	(0.000)	(0.000)	(0.590)	(0.921)	(0.652)	(0.956)
				Placebo-Adjusted			
$\overline{R}$	−0.0131***	−0.0391***	−0.0686***	−0.0162**	0.0138	0.0794***	0.0823***
	(0.001)	(0.000)	(0.000)	(0.017)	(0.116)	(0.000)	(0.000)
$\overline{AR}$	−0.0126***	−0.0385***	−0.0693***	−0.0138**	0.0054	0.0187	0.0018
	(0.000)	(0.000)	(0.000)	(0.041)	(0.512)	(0.196)	(0.923)