S&P 500 Index-Futures Price Jumps and Macroeconomic News

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Abstract

This paper examines the influence of macroeconomic news on price discontinuities in the S&P 500 index futures. Results document a strong association between macro news and price jumps. Over three-fourths of the price jumps between 8:30-8:35 am and over three-fifths of the jumps between 10:00-10:05 am are related to news released at 8:30 am and 10:30 am, respectively. Notably, among several types of news releases considered, Non-farm Payroll and Consumer Confidence are found to be significantly related with price jumps. Our findings also provide insights into the speed of news absorption.

Keywords: Macroeconomic News, Jumps, Index Futures, Price Adjustment Process

JEL Classification Codes: G10, G14

I. Introduction

This paper examines the influence of macroeconomic news announcements on price discontinuities in equity index futures. The study can be placed in the context of a large and rapidly evolving research program examining the distributional properties of speculative returns. This research carries important implications on risk measurement and management, portfolio allocation and rebalancing, and on the pricing of various derivative instruments. While most of the standard literature in finance assumes that prices follow a geometric Brownian motion, this assumption has come under heightened scrutiny as empirical observations increasingly point to the presence of infrequent and large price movements (labeled as "jumps") that violate the Gaussian distribution assumption. Several studies such as Bates (2000), Eraker, Johannes, and Polson (2003), Zhou and Zhu (2011) document the importance of stochastic volatility and systematic jump risk when pricing returns. Maheu and McCurdy (2004) argue that price discontinuities are likely the result of uncertainty resolution associated with the release of new and relevant information, or "news".

Among the various sources of public information available for the resolution of uncertainty, announcements pertaining to macroeconomic news are easily available and closely followed. Hence, they provide insights into the canonical model of efficient markets which posit that security prices reflect all available information. The speed with which news is incorporated into prices and the volatility of returns are important for actively trading investment managers. Assets that are more sensitive to news announcements may need to be more closely monitored and rebalanced more frequently than less sensitive assets. Furthermore, evidence favoring the influential role of macro

announcements on returns would support the notion that any variable that affects the investment opportunity set (Merton, 1973) or consumption level (Breeden, 1979) should be a priced factor in equilibrium.

However, the theoretical relationship between news – both firm-specific and macroeconomic – and equity returns has found only limited, and often contradictory, support among empirical studies. Papers that report a weak relationship between stock market activity and news include Roll (1988), Cutler, Poterba, and Summers (1989), Mitchell and Mulherin (1994), and Berry and Howe (1994). Although, the effect of *real* sector macroeconomic variables has proven to be somewhat elusive, the influence of monetary and price variables are found to be more consistent with theoretical predictions, (Flannery and Protopapadakis, 2002). In general, there seems to be a divergence of scholarly viewpoints on the role of fundamentals in explaining equity returns, leading several researchers to the conclusion that there exists an "embarrassing gap" (Chen, Roll and Ross, 1986) and a "poor showing" (Chan, Karceski and Lakonishok, 1998) in the empirical asset pricing literature.

Given this backdrop the contributions of the paper are threefold. First, by narrowing our investigation to significant price movements, we attempt to better identify the underlying relationship between economic fundamentals and equity prices. Second, we compare the behavior of intraday volatility and trading volume on news days with corresponding jumps versus news days without any corresponding jumps. Finally, in the course of the examination, we provide insights into the speed of market response and price resolution to news releases.

There are two additional features of the study that are important to note. First, the equity index futures product we consider, standard-sized S&P 500 futures, is somewhat unique in its trading feature in that it trades around-the-clock separately on the floor of the Chicago Mercantile Exchange (CME) and the GLOBEX electronic exchange without any overlap in trading hours. The open outcry CME market operates during the daytime hours of 9:30 am to 4:15 pm Eastern Time, while the electronic platform provides after-hours and overnight trading facility. In light of the growing transition from open outcry markets to electronic trading, several studies examine the microstructure behavior of the two trading systems. Results indicate that automated exchanges tend to provide more liquidity, have lower bid-ask spreads, faster execution, and lower transaction costs (see for example, Ates and Wang, 2005; Aitken et al., 2004; Tse and Zabotina 2001). On the other hand, there is some evidence that the liquidity of automated exchanges deteriorates more rapidly than floor traded systems during periods of high volatility (Frino, McInish and Toner, 1998). Therefore, given underlying microstructure differences, an examination of price jumps in the S&P 500 futures index provides an interesting window into how markets process information under alternative trading systems.

Second, we employ a recent jump identification technique developed by Lee and Mykland (2008) that allows us to detect the precise timing of the intraday jump. Identifying the precise timing of the high-frequency price jump is important in order to account for the possibility of major price adjustments that occur within a few minutes after news announcements and provide evidence on the price response function (see Ederington and Lee, 1993, 1995; Balduzzi, Elton and Green, 2001, inter alia).

The paper proceeds as follows. Section II provides a brief literature review. Sections III and IV outline the data and describe the jump detection methodology, respectively. Section V reports empirical evidence linking jumps with news announcements and presents results on the speed of news absorption. Finally, section VI concludes.

II. Related Literature

The central questions we seek to answer are as follows: if economic state variables are not very helpful in explaining equity return movements, can they at least be used to explain dramatic price fluctuations? How do volatility and trading volume adjust in the immediate aftermath of news announcements? Is the adjustment process different for days with news and corresponding jumps versus days with news and no jumps? Furthermore, in the event macro news events are found to be related to price jumps in some predictable manner, what is the speed of price adjustments? In examining the price reaction, several other related questions arise: Are equity index futures prices more sensitive to changes in some economic news items than other news items? What is the nature and direction of the relationship?

The empirical literature provides guidance to some of these questions. Flannery and Protopapadakis (2002) document the impact of inflation on the level and/or volatility of equity market portfolio returns. However, they find that measures of overall economic activity such as Industrial Production and GNP are not significant. Adams, McQueen, and Wood (2004) report that large stocks respond to inflation surprises "within 10-20 minutes or about six trades", and that small stocks response to inflation news is less significant. Fair (2002) identifies 69 events between 1982 and 1999 that were followed

by large price changes in the S&P 500 futures. The author indicates that these events were directly associated with money supply or interest rate announcements, and were indirectly related to monetary policy announcements.

More recently, jump detection methods are used to reexamine the news-returns relationship. Rangel (2011) examines ‘‘normal” and ‘‘surprising” news events and finds that jumps are more frequent on announcement days than on non-announcement days. Evans (2011) also reports that about one-third of the observed price jumps in the equity, bond and currency markets occur on macro news release days. The sizes of the jumps are directly related to the “informational surprise” contained in the announcements and the market incorporates the news within about five minutes. However, elevated return volatility may persist for several more hours and, interestingly, the reactions of the S&P 500 E-Mini futures are “more dramatic” than the reactions of the T-bond and exchange rate futures. Bjursell, Wang and Webb (2010) identify intraday jumps in interest rate futures prices for the period 2001 to 2004 and find that although jumps make up a large proportion of the total variance for days with jumps, a substantial percentage of jumps cannot be associated with specific macroeconomic news announcements. The ‘employment’ report is found to have the most significant impact on interest rates. Their study documents that on days where news items are associated with jumps there is a spike in the volatility and trading volume following the news release. Interestingly, volatility is found to revert back to pre-announcement levels faster following scheduled news releases with jumps than after announcements without jumps.

Lahaye, Laurent and Neely (2011) relate macro news announcements to intraday price jumps in exchange rates, bonds, and stocks. They find that their set of news announcements: (a) explains a larger proportion of bond or equity jumps than currency jumps, and (b) drives a higher percentage of cojumps than jumps. Jiang, Lo, and Verdelhan (2011) use 5-minute price data on Treasury notes and bonds to compare the impact of macroeconomic news announcements with the impact of liquidity shocks and conclude that liquidity shocks in addition to announcement shocks "play an important role" in the price discovery process (also see Lee, 2012).

III. Data Description

The S&P 500 equity index futures (SP) contract is traded on the *Chicago Mercantile Exchange* (CME). Although in most markets there has been a migration away from floor-based trading towards screen-based systems, in the case of S&P 500 index futures the same contract is traded in non-overlapping hours on both platforms. Trading in the CME pit occurs on weekdays between 9:30 am Eastern Time (ET) to 4:15 pm ET while the underlying securities trade on the NYSE and Nasdaq stock exchanges between 9:30 am-4:00 pm (ET), Monday through Friday.[1] Trading on the electronic trading platform (GLOBEX) begins at 4:30 pm and ends at 9:15 am the following day, Monday through Thursday with an hour maintenance shutdown during 5:30 pm to 6:30 pm. The electronic market is closed Friday night and all day Saturday, and is open on Sunday from 6:00 pm to 9:15 am the next day.

[1] Note all times in the study are U.S. Eastern Standard Time.

The intraday futures prices for SP are obtained from TickData which provides the transaction price and the time of each trade to the nearest second. The regular SP contracts are not to be confused with the more popular E-mini S&P 500 contracts which are traded exclusively on the GLOBEX electronic platform. In examining the yearly trading volume over the sample period it is evident that, with the exception of the year 2003, the E-mini futures contract dominates the regular S&P 500 contract on a size-adjusted basis. For instance, in 2003 the volume in the regular SP contract was about 136% of the E-mini. In 2011, volume in the regular SP contract represented only about 5% of the volume in the E-mini. However, despite the growth of the E-mini futures, many of the big market players still prefer the standard S&P 500 futures contract due to its relative cost advantage during regular trading hours and its liquidity in the electronic after-hours market (see Dungey, Fakhrutdinova and Goodhart, 2009). Part of our attraction in examining regular S&P 500 futures is that they provide an interesting set of circumstances to compare the price jump response and absorption of news releases between non-overlapping electronic and open outcry markets.

The dataset contains all pit transactions from January 2001 through December 2010 and all GLOBEX transactions beginning July 2003 to yearend 2010. Following standard procedure a continuous time series of transactions is developed using the contract with the greatest number of transactions. We begin with the front-month contract, but roll into the first back-month contract when the daily transactions of the current front month contract are exceeded by the first back-month contract. By following this procedure we avoid the front-month contract stale prices that occur as it approaches expiration. The data is then sampled at the 1, 5, 10 and 15 minutes frequencies.

This study considers several different types of announcements released at 8:30 am and 10:00 am.[2] *Bloomberg* is the source of both the pre-announcement consensus (median) forecast and the realized value for each monthly, pre-scheduled macroeconomic news release. Each news release is "standardized" by dividing the difference between the realized value and the consensus forecast by its standard deviation. This allows us to compare the impact across the different macroeconomic news announcements. That is,

$$SA_{i,t} = \frac{A_{i,t} - E_{i,t}}{\sigma_i}, \quad (1)$$

where $SA_{i,t}$ is the surprise element of the announcement of type i at time t, $A_{i,t}$ is the realized or actual value of an announcement, $E_{i,t}$ is the consensus forecast and σ_i is the sample standard deviation of the surprise component of the type i announcement, $A_{i,t} - E_{i,t}$. The standardization procedure does not affect the statistical significance of the estimated response coefficients and the fit of the regression model discussed below, because σ_i is constant for each announcement.

A brief set of descriptive statistics for the 17 pre-scheduled monthly news releases at 8:30 am and 10:00 am over the period 2001-2010 are shown in Table 1. Since the 8:30 am announcements are released forty-five minutes before the opening of the CME pit market we measure their price impact using GLOBEX transactions. With the exception of Business Inventories each of the remaining 10 economic variables has 90 different news releases. The majority of Business Inventories are released at 10:00 am. The 10:00 am announcements are released thirty minutes after the opening of the CME futures pit

[2] The set of announcements used are essentially the same as those used by Ederington and Lee (1993) and Simpson and Ramchander (2004). Also, it would be pertinent to note that Business Inventories was released alternatively at 8:30 am or 10:00 am.

market and after trading starts in the NYSE and Nasdaq markets. The differences in the mean surprises and the standard deviations confirm that the news variables should be standardized in order to assess the impact of the different types of announcements.

IV. Jump Identification Methodology

The evolution of asset prices in jump-diffusion models is represented as a sum of a continuous sample path process and occasional discontinuous jumps with the following stochastic differential equation form:

$$dp_t = \mu_t dt + \sigma(t) dw_t + \kappa_t dq_t, t \geq 0, \quad (2)$$

where p_t denotes the continuous-time log-price process, the mean process μ_t is continuous and locally bounded, the instantaneous volatility process σ_t is càdlàg, w_t is a standard Brownian motion independent of the drift, and q_t refers to a normalized counting process such that $dq_t = 1$ indicates a jump at time t, and $dq_t = 0$ otherwise, with the κ_t process describing the size of the jump if a jump actually occurs at time t.

The continuous-time expression in equation (2) is convenient for theoretical pricing arguments, but is of limited relevance in empirical studies that rely on discretely sampled prices. In practice, the discrete-time returns implied by equation (2) are defined as:

$$r_t = p_t - p_{t-1}, t = 1,2, \ldots \quad (3)$$

where the unit time interval is usually referred to as a "day." With $M + 1$ observations per day of high-frequency data, the continuously compounded M intra-daily returns for day t are similarly denoted by,

$$r_{t_j} = p_{t_j} - p_{t_{j-1}}, t = 1,2, \ldots, T, \quad (4)$$

where, p_{t_j} denotes the j^{th} intra-day log-price for day t and T is the total number of days in the sample.

Following Andersen and Bollerslev (1998), Andersen et al. (2001) and Barndroff-Nielsen and Shephard (2002), realized volatility for day t is defined as:

$$RV_t = \sum_{j=1}^{M} r_{t_j}^2,\ t = 1, \dots, T. \tag{5}$$

From the theory of quadratic variation, RV_t provides a consistent estimator of the daily increment to the quadratic variation for the underlying log-price process in equation (2). That is, for M $\to \infty$,

$$RV_t \to_p \int_{t-1}^{t} \sigma_s^2 ds + \sum_{s=q_{t-1}}^{q_t} \kappa_s^2, t = 1, \dots, T. \tag{6}$$

Clearly, the realized volatility measure includes the contributions of both integrated volatility (the first term) and total variation stemming from the squared jumps.

On the other hand, the realized bipower variation (BV) introduced by Barndorff-Nielsen and Shephard (2004) is defined as:

$$BV_t \equiv \mu_1^{-2} \sum_{j=2}^{M} \left|r_{t_j}\right| \left|r_{t_{j-1}}\right|, t = 1, \dots, T, \tag{7}$$

where $\mu_1$is the mean of the absolute value of the standard normally distributed random variable and $\mu_1 = \sqrt{2/\pi}$. It has been shown that, even in the presence of jumps, for $M \to \infty$,

$$BV_t \to_p \int_{t-1}^{t} \sigma_s^2 ds, t = 1, \dots, T. \tag{8}$$

Combining equations (6) and (8), we have, for $M \to \infty$,

$$RV_t - BV_t \to \sum_{s=q_{t-1}}^{q_t} \kappa_s^2, t = 1, \dots, T. \tag{9}$$

The difference between RV_t and BV_t provides a consistent estimate of the contribution of the jump component to the total variation. Based on this framework, Lee and Mykland (2008) propose a statistic to identify intraday jumps.[3]

For n observation in a fixed time interval $[0, T]$, the statistic to test at time t_i whether there was a jump from t_{i-1} to t_i is defined as:

$$\mathcal{L}(i) = \frac{r_{t_i}}{\widehat{\sigma_{t_i}}}, \tag{10}$$

where, $\widehat{\sigma_{t_i}}$ is the realized bipower variation and,

$$\widehat{\sigma_{t_i}}^2 = \frac{1}{K-2}\sum_{j=i-k+3}^{i-1} \left|r_{t_j}\right| \left|r_{t_{j-1}}\right|. \tag{11}$$

Based on the further developed properties of the statistic, Lee and Mykland (2008) suggest a rejection region for the null hypothesis of no jump at t_i at a given significance level, α, is:

$$\frac{|\mathcal{L}(i)| - C_n}{S_n} > -log(-log(1-\alpha)), \tag{12}$$

where,

$$C_n = \frac{(2logn)^{1/2}}{c} - \frac{log\pi + \log(logn)}{2c(2logn)^{\frac{1}{2}}}, \tag{13}$$

and

$$S_n = \frac{1}{2c(2logn)^{1/2}}, \tag{14}$$

where n is the number of observations. The selection of the window size K is determined by the sampling frequency. They suggest that the optimal choice for K is the smallest integer such that, $K \geq \sqrt{252 \times nobs}$, where $nobs$ is the number of observations per day.

[3] Anderson et al. (2010) proposed another jump identification procedure to detect intra-day jumps. We also applied that jump identification. The results are found to be very similar.

Therefore, the optimal window sizes for 1-minute, 5-minute, 10-minute, and 15-minute data are: 603, 270, 191 and 156, respectively.

V. Macroeconomic News and Jumps in Equity Index Futures

A. Jumps in Equity Index Futures Prices

In theory the jump identification test can be used at any data frequency. However, Anderson et al. (2007), Dumitru and Urga (2012) and Lee and Mykland (2008) indicate that as the intraday sampling frequency used to detect jumps increases there is a greater likelihood that the jump tests are contaminated by microstructure noise. For instance, employing high frequency data for five stocks Dumitru and Urga (2012) document a marked decrease in the percentage of identified jumps as the sampling frequency decreases. The authors propose using a sample frequency where the percentage of jumps tends to stabilize. Following their procedures, a 5-minute frequency is used in our empirical analysis.

Table 2 presents summary statistics of 5-minute returns for both pit and electronic trades (GLOBEX). Using data from pit trades, a 5-minute discrete interval sampling process results in about 200,000 return observations. The average 5-minute return is slightly negative, and the standard deviation is substantially higher at 0.13%. The distribution is slightly positively skewed at 0.274. The high kurtosis indicates that the return distribution is not normal. The results reveal that GLOBEX trading returns are relatively less volatile but exhibit higher skewness and kurtosis.

Table 3 documents descriptive properties of jump returns that are significant at the 1% threshold at the 5-minute frequency. Several interesting results are evident for the pit trading statistics. First, the number of days with at least one significant jump occurs during 20% of the trading days. Second, there are 727 jumps for SP which accounts for about 0.36% of the total number of observations. Third, there are more negative jumps than positive jumps. Finally, the mean absolute jump values are 0.46% which is nearly five times higher than the mean of the absolute returns (0.8%).

The GLOBEX results show a higher jump propensity. There is evidence of at least one jump in about 70% of the trading days. The average numbers of jumps per jump day is 2.29. Interestingly, the jump sizes in GLOBEX are substantially smaller in magnitude than those in pit trading. The jump size in the pit is 0.46% versus 0.20% in the electronic market. Although jump sizes are relatively much smaller in GLOBEX, they are still significantly higher than the "normal" means of the absolute returns. In addition, the return levels in the pit market are on average larger than GLOBEX returns which may explain why the pit market exhibits higher price jumps. If transaction prices in the two trading platforms are pooled together most of the price jumps in GLOBEX tend to get washed away due to their relatively smaller sizes.[4]

B. Role of Macro News Releases

Having identified intraday jumps, we next match the 8:35 am and 10:05 am jumps (defined as jump returns for the interval 8:30 am-8:35 am and 10:00 am-10:05 am, respectively) with news released at 8:30 am and 10:00 am. Figure 1 presents the jump

[4] These results are available from the authors upon request.

distribution. It is clear that there are a far greater numbers of jumps at 8:35 am than at any other time during the trading day, and there are also more jumps at 10:05 am than most other time in the trading day except market openings. There are 362 significant jump events at 8:35 am; and additional 99 jumps at 10:35 am.[5] These preliminary findings suggest that some of these jumps may be associated with macroeconomic news released at those times. Table 4 provides additional results on this relationship.

Table 4 shows that about 60% of the 10:05 am jumps can be matched with the release of at least one 10:00 am macroeconomic news announcement. Notably, Consumer Confidence has the largest impact on jumps – about 18% of these releases can be matched with jumps of SP returns. In terms of importance, ISM and Construction Spending are also prominently associated with jumps in the index futures. The table also documents a substantial number of jumps at 8:35 am. About 78% of these jumps occur in the 5-minute interval after the release of at least one pre-scheduled 8:30 am news release. Changes in Nonfarm Payroll (which is part of the Employment Report), CPI, GDP and Personal Consumption are among the most influential macro news announcements. Out of the 90 total news releases of Changes in Nonfarm Payroll at 8:30 am, there are 69 (77%) announcements that are followed by jumps in SP. The corresponding statistic for CPI is 57%. All of the 8:30 am jumps (except Trade Balance) are more highly associated with news releases than are the 10:30 am jumps. Trade Balance seems to be the least influential on jump returns.

[5] We also observe a relatively large number of significant jumps at 9:35 am, 4:35 pm, and 6:05 pm. These jumps correspond to the immediate 5-minute time interval after the stock exchange opens, opening of electronic trades on Globex, and the reopening of Globex after the regular maintenance shutdown.

Table 5 documents the top twenty 10:05 am and 8:35 am jumps based on the absolute values of the returns in the index futures series and the corresponding macroeconomic announcements. Among the top twenty jumps, 16 occur immediately after the release of at least one macroeconomic announcement. Among the top ten jumps, five jumps can be tagged with the release of Consumer Confidence, and three closely follow the releases of ISM. The directional relationship is also highlighted by the fact that most negative jumps follow worse-than-expected economic news and positive jumps follow better-than-expected news. 17 out of the top twenty jumps at 8:35 am are primarily connected to one (or in some cases two) macroeconomic news announcements. Furthermore, the results confirm the importance of the nonfarm payroll statistics. A total of 11 among the top twenty 8:35 am jumps correspond with the Changes in Nonfarm Payroll.

Overall, results from Table 5 indicate a positive association between news and index return jumps and highlight several news announcements that seem to be influential. This exploratory work is more formally investigated through regression analysis.

C. Marginal Impact of Macro News on Jump Returns

The marginal impact of each time-stamped news surprise on the 8:35 am and 10:05 am jumps are examined by fitting a multivariate regression model of the following form:

$$jp_{t_{j+1}} = c + \sum_{i=1}^{n} c_i^{+} SA_{i,t_j}^{+} + \sum_{i=1}^{n} c_i^{-} SA_{i,t_j}^{-} + \varepsilon_{t_{j+1}}. \quad (14)$$

The variable $jp_{t_{j+1}}$ refers to the 8:35 am or 10:05 am jump returns and SA_{i,t_j}^{+}, and SA_{i,t_j}^{-} are the positive and negative standardized surprises of the i^{th} macro news announcement. The regression model fits jumps following the release of at least one announcement.

Table 6 provides results sorted by positive and negative news. Positive surprises in these variables are taken to represent stronger-than-expected economic growth, and negative values are indicative of weaker-than-expected economic growth. We first discuss the results for 10:00 am news releases. First, examining the set of positive surprises, we find that the majority of the coefficients have a positive sign, with Consumer Confidence, Factory Orders and Construction Spending and ISM having statistically significant impacts. For example, a one standard deviation positive surprise of ISM results in a 0.34% price jump on average during the five minute interval immediately after the news release. Second, in the case of negative surprises, all coefficients that are statistically significant are found to carry a positive sign. In interpreting the c_i^- coefficients, it should be noted that a positive sign suggests that worse-than-expected economic news leads to negative jump returns. Notably, Consumer Confidence announcements have significant impacts. Overall the results provide clear and compelling evidence that good (bad) economic news is followed by positive (negative) jumps. Finally, support for the model's goodness-of-fit is provided by relatively large adjusted-R^2 values of 52%.

Examining the 8:35 am jumps, we find that a majority of the surprises are positively related with jumps. Among the 22 different parameters estimated 17 are positive. Notably, Changes in Nonfarm Payroll is the only announcement for which the parameters of both positive and negative surprises are significantly positive. The primacy of the 'Employment Situation' report is a well-documented phenomenon in asset markets (Andersen and Bollerslev (1998) refer to this announcement as the "king" of all announcements). Furthermore, the parameter of negative GDP surprises is positive and

significant at the 5% level of significance. The results also highlight the presence of a lackluster association between several news releases – e.g., Durable Goods Orders, Housing Starts – and price jumps. Finally, an examination of the magnitude of the coefficient values for positive and negative surprises does not support the presence of a strong asymmetric behavior in the price response. In general, the magnitudes of the estimates are not statistically different from each other.

D. Intraday Adjustment Process of Return, Volatility and Volume To News

This section examines the intraday adjustment process of return, volatility and trading volume to macroeconomic news. The announcements are conditioned on whether or not there is a jump in the return process at the time of the news event. Similar to Bjursell, Wang and Webb (2010) we use the following regression model,

$$V_{t_i} = c_0 + \sum_{i=1, i\neq j}^{n} c_i D_i + \varepsilon_{t_i}, \tag{15}$$

where, V_{t_i} alternatively denotes intraday return, volatility (measured by absolute returns) or volume for the i^{th} five-minute interval on day t, and D_i is a dummy variable that takes a value of 1 for the i^{th} intraday interval and 0 otherwise. These regressions are conducted separately for GLOBEX and pit market transactions. In the case of GLOBEX the interval 8:20-8:25 am is omitted from the corresponding regressions. For pit market transactions the omitted interval is 9:50-9:55 am. In this regression framework, c_0 provides an intraday benchmark estimate of the mean volatility or volume for the omitted (j^{th}) time interval. Our empirical analysis is constrained to the extent that trading volume data is available only for GLOBEX.

The regression model is run on three samples, days with both news and jumps (Model I); days with news that are unaccompanied by jumps (Model II); and days without news and no jumps (Model III). In order to capture the influence of positive versus negative jumps, Model I is further distinguished by days with news and *positive* jumps, and days with news and *negative* jumps. Tables 7 and 8 provide results from the various regression models.

Table 7 reports the intraday return, volatility and volume adjustment processes from 8:30 am announcements using GLOBEX transactions. In general the return regression results show that on days with news and jumps, the mean of returns in the 8:30-8:35 am interval (0.03%) is significantly different from the benchmark interval (-0.006%). When the jumps are separated into positive and negative jumps, the results are much clearer. On days with news and positive and negative jumps, the mean returns are 0.291% with T-statistic of 23.14 and -0.293% with T-statistic of -21.62%, respectively. However, those are the only significant coefficients for Model I. The coefficients in the following 5-minute intervals are not significant. The results indicate that the impacts of news on returns are spikes and vanish very quickly.

In order to obtain a more granular perspective on the impact of 8:30 am news on the return, volatility and volume adjustment process, Figure 2 plots the time series of the means of return, volatility and volume at 1-minute intervals. The return plot shows that on days with positive or negative jumps and news, there are big spikes in the time interval between 8:30 am-8:31 am. The mean returns for the other intervals are very close

to zero. The results suggest that news takes less than one minute to be fully absorbed into prices.

The volatility regression results show that on days with news and jumps (see Model I) there is a dramatic increase in volatility in the 8:30-8:35 am interval. For example, the mean of volatility in the benchmark (or omitted) interval is 0.041%. By comparison, the regression coefficient for the 8:30-8:35 am interval is about 5 times larger, 0.254% with a t-statistic of 31.19. In other words, the mean of volatility at 8:30-8:35 am is about 0.296%, which is calculated as the sum of the coefficient of the intercept and the coefficient at the 8:30-8:35 am interval (i.e., 0.041% + 0.254% = 0.296%). In contrast, for days with news with no jumps (see Model II) the average volatility for the 8:30-8:35 am interval is relatively much smaller at 0.060%, and is only slightly higher than the benchmark interval at 0.41%. Not surprisingly, for the "no news-no jump" sample (Model III) the mean of volatility during the 8:30-8:35 interval, and in fact all subsequent intervals, are found to be very close to the mean for the benchmark 8:20-8:25 am interval. On days with news and associated jumps, the largest volatility spikes are observed at the 8:30-8:35 am interval, followed by days with news but no jumps during the same time interval. The coefficients are significant only for the three five-minute intervals right after 8:30am. That is, the persistence of the impacts of news on the futures volatility is about 15 minutes. The results in columns "POS" and "NEG" show that both positive and negative jumps elicit a similar volatility response. The average increases (i.e., the regression coefficients) at the 8:30-8:35 am interval on positive and negative jump days are 0.25% and 0.26%. Figure 2 indicates that the volatility responses on news related jump and non-jump days persist for several periods, with the most dramatic impact registered on the

immediate 1-minute interval after the 8:30 am announcement. Finally, and not surprisingly, our results show that the response of volatility is hardly perceptible on days with no news and no jumps.

Table 7 also presents the volume adjustment process to 8:30 am news announcements using GLOBEX transactions. In general, the results suggest a contemporaneous and positive relationship between volatility and volume; however, the elevation in volume (particularly, on news days with positive jumps) seems to persist longer than the corresponding volatility response. For example, on news related jump days (see Model I), the mean of SP volume in the immediate 5-minute interval after 8:30 am news releases is found to be nearly 467 contracts larger than the corresponding volume in the 8:20 am-8:25 am benchmark interval. By comparison, for days with news but no related jumps (Model II) the average increase in volume is only 131 contracts. These results are corroborated in the second graph in Figure 2 which plots the mean of volumes at 1-minute intervals. The graphs shows large volume spikes on days with both news and jumps at the time of the announcement followed by a smooth reversal process to pre-announcement levels.

Table 8 uses pit market transactions to report intraday, 5-minute, return and volatility response behavior in response to 10:00 am news announcements.[6] The 1-minute means of return and volatility are presented in Figure 3. The results show that the return response is similar to GLOBEX. For days with jumps, there are return spikes in the first 1-minute

[6] Since volume data is not available for pit transaction, we apply the price adjustment model on two alternative liquidity measures introduced by Roll (1984) and Bao, Pan and Wang (2009). There is evidence, albeit weak, that for days with news and corresponding jumps liquidity increases (or illiquidity decreases) in equity futures. These results are available from the authors upon request.

and the means revert to normal (close to zero). These results along with the 1-minute plots in Figure 3 indicate that there is a distinct surge in volatility in the immediate post-announcement interval. The increase in volatility is relatively more pronounced than those associated with 8:30 am announcements. Furthermore, in contrast to GLOBEX, there is some indication that the mean of volatility on days with news and jumps subsides to pre-announcement levels faster than on days with news but no corresponding jumps, with negative jumps lasting a bit longer than positive jumps on news days.

VI. Concluding Remarks

The study examines the relationship between macroeconomic news and intraday price jumps in the S&P 500 equity futures index. Several important results are evident. First, we document a strong correspondence between the two sets of morning economic news releases and jumps in S&P 500 index futures prices. Over 60% of the jumps between 10:00-10:05 am and over 75% of the jumps between 8:30-8:35 am are related to one or more news items released at 10:00 am and 8:30 am, respectively. Second, we find that macroeconomic news share a pro-cyclical relationship with equity futures jumps. Specifically, positive jumps are preceded by better-than-expected economic news and, correspondingly, negative jumps are preceded by negative surprises. Third, among the 8:30 am and 10:00 am announcements, Non-farm Payroll and Consumer Confidence respectively are the most significantly related with jumps. The influential role of positive surprises in GDP, PPI, and Factory Orders, and negative surprises in CPI and Advanced Retail Sales are also noted. Fourth, there is a sharp surge in both volatility and volume in the immediate post-announcement period on days with scheduled news and

corresponding jumps. For instance, for the 8:30 am (10:00 am) announcements the mean of the absolute returns for each equity index product during the immediate 5-minute post-announcement interval is about 5 times (3.5 times) higher on news days with related jumps compared to news days without jumps. In the case of the pit market, the post-announcement volatility adjustment process is faster on days with news and jumps than on days with news but no jumps. Finally, we document a rapid adjustment of returns, volatility and volume to macro news events.

References

Adams, G., McQueen, G. & Wood, R. (2004). The effects of inflation news on high frequency stock returns. Journal of Business, 77, 547-574.

Aitken, M.J., Frino, A., Hill, A.M., & Jarnecic, E. (2004). The impact of electronic trading on bid-ask spreads: Evidence from futures markets in Hong Kong, London, and Sydney. Journal of Futures Markets, 24, 675-696.

Andersen, T.G., & Bollerslev, T. (1998). Deutsche mark-dollar volatility: Intraday activity patterns, macroeconomic announcements, and longer run dependencies. Journal of Finance, 53, 219-265.

Andersen, T.G., Bollerslev, T., Diebold, F.X. & Ebens, H. (2001). The distribution of realized stock return volatility. Journal of Financial Economics, 61, 43-76.

Andersen, T.G., Bollerslev, T., & Dobrev, D., (2007). No-arbitrage semi-martingale restrictions for continuous-time volatility models subject to leverage effects, jumps and i.i.d. Noise: theory and testable distributional implications. Journal of Econometrics, 138, 125-180.

Andersen, T.G., Bollerslev, T., Frederiksen, P., & Nielsen, M.Ø. (2010). Continuous-time models, realized volatilities, and testable distributional implications for daily stock returns. Journal of Applied Econometrics, 25, 233-261.

Ates, A., and Wang, G. (2005). Information transmission in electronic versus open-outcry trading systems: an analysis of U.S. equity index futures markets. Journal of Futures Markets, 25, 679-715.

Bao, J., Pan, J., & Wang, J. (2011). The illiquidity of corporate bonds, Journal of Finance, 66, 911-946.

Barndorff-Nielsen, O.E., & Shephard, N. (2002). Econometric analysis of realized volatility and its use in estimating stochastic volatility models. Journal of Royal Statistical Society, 64, 253-280.

Barndorff-Nielsen, O.E., & Shephard, N. (2004). Power and bipower variation with stochastic volatility and jumps. Journal of Financial Econometrics, 2, 1-37.

Bates, D.S. (2000). Post-'87 crash fears in S&P 500 futures option market. Journal of Econometrics, 94, 181-238.

Balduzzi, P., Elton, E.J. & Green, T.C. (2001). Economic news and bond prices: Evidence from the U.S. treasury market. Journal of Financial and Quantitative Analysis, 36, 523-543.

Berry, T.D., & Howe, K.M. (1994). Public information arrival. Journal of Finance, 49, 1331-1346.

Bjursell, C.J., Wang, G.H.K., & Webb, R. (2010). Jumps and trading activity in interest rate futures markets: the response to macroeconomic announcements. Available at SSRN: http://ssrn.com/abstract=1570824

Breeden, D.T. (1979). An intertemporal asset pricing model with stochastic consumption and investment opportunities. Journal of Financial Economics, 7, 265-296.

Chan, K.C., Karceski, J. & Lakonishok, J. (1998). The risk and return from factors. Journal of Financial and Quantitative Analysis, 33, 159-188.

Chen, N., Roll, R. & Ross, S. (1986). Economic forces and the stock market. Journal of Business, 59, 383-403.

Cutler, D., Poterba, J. & Summer, L. (1989). What moves stock prices? Journal of Portfolio Management, 15, 4-12.

Dumitru, A., & Urga, G. (2012). Identifying jumps in financial assets: A Comparison between nonparametric jump tests, *Journal of Business and Economic Statistics*, forthcoming.

Dungi, M., Fakhrutdinova, L. & Goodhart, L. (2009). After hours trading in equity futures markets, Journal of Futures Markets, 29, 114-136.

Ederington, L.H., & Lee, J.H. (1993). How markets process information: News releases and volatility. Journal of Finance, 48, 1161-1191.

Ederington, L.H., & Lee, J.H. (1995). The short-run dynamics of the price adjustment to new information. Journal of Financial and Quantitative Analysis, 30, 117-134.

Eraker, B., Johannes, M. & Polson, N. (2003). The impact of jumps in volatility and returns. Journal of Finance, 58, 1269-1300.

Evans, K.P. (2011). Intraday jumps and U.S. macroeconomic news announcements. Journal of Banking & Finance, 35, 2511-2527.

Fair, R.C. (2002). Events that shook the market. Journal of Business, 4, 713-731.

Flannery, M. J., & Protopapadakis, A.A. (2002). Macroeconomic factors do influence aggregate stock returns. The Review of Financial Studies, 15, 751-782.

Frino, A., McInish, T, & Toner, M. (1998). The liquidity of automated exchanges: New evidence from German bond futures. Journal of International Financial Markets, Institutions and Money, 54, 1901-1915.

Jiang, G.J., Lo, I. & Verdelhan, A. (2011). Information shocks, liquidity shocks, jumps, and price discovery: Evidence from the U.S. Treasury market. Journal of Financial and Quantitative Analysis, 46, 527-551.

Lahaye, J., Laurent, S. & Neely, C.J. (2011). Jumps, cojumps and macroannouncements. Journal of Applied Econometrics, 26, 893-921.

Lee, S.S. (2012). Jumps and information flow in financial markets. Review of Financial Studies, 25, 439-479.

Lee, S.S., & Mykland, P.A. (2008). Jumps in financial markets: A new nonparametric test and jump dynamics. Review of Financial Studies, 21, 2535-2563.

Maheu, J.M., & McCurdy, T.H. (2004). News arrival, jump dynamics, and volatility components for individual stock returns. Journal of Finance, 59, 755-793.

Merton, R.C. (1973). An intertemporal capital asset pricing model. Econometrica, 41, 867-887.

Mitchell, M, & Mulherin, J.H. (1994). The impact of public information on the stock market. Journal of Finance, 49, 923-950.

Rangel, J.G. (2011). Macroeconomic news, announcements, and stock market jump intensity dynamics. Journal of Banking & Finance, 35, 1263–1276.

Roll, R. (1988). R^2. Journal of Finance, 43, 541-566.

Simpson, M.W., & Ramchander, S. (2004). An examination of the impact of macroeconomic news on the spot and futures treasuries markets. Journal of Futures Markets, 24, 453-478.

Tse, Y., & Zabotina, T. (200. Transaction costs and market quality: Open-outcry versus electronic trading. Journal of Futures Markets, 21, 713-735.

Zhou, H., & Zhu, Q. (2011). Jump risk and cross section of stock returns: Evidence from China's stock market. Journal of Economics and Finance, 35, 309-331.

Table 1. Statistics of Macroeconomic News Announcements over the Period 2001-2010

News	Obs.	Mean	Std. Dev.
8:30 News Announcements:			
Advanced Retail Sales (ARS)	90	0.0000	0.0057
Business Inventories (BI)	17	-0.0002	0.0024
Changes in Nonfarm Payrolls (CNP)	90	-16.1444	76.9932
Consumer Price Index (CPI)	90	0.0000	0.0015
Durable Goods Orders (DGO)	90	-0.0024	0.0238
Gross Domestic Product (GDP)	90	-0.0003	0.0048
Housing Starts (HS)	90	4.4222	91.3879
Personal Consumption (PC)	90	-0.0001	0.0036
Personal Income (PI)	90	0.0005	0.0032
Producer Price Index (PPI)	90	0.0006	0.0053
Trade Balance Goods and Services (TBGS)	90	0.1444	3.4473
10:00 News Announcements:			
Business Inventories (BI[1])	74	-0.0001	0.0022
Consumer Confidence (CC)	118	-0.2831	5.3733
Construction Spending (CS)	120	0.0011	0.0080
Factory Orders (FO)	119	0.0002	0.0071
ISM-Manufacturing (ISM)	120	0.2067	2.1174
Leading Economic Indicators (LEI)	119	0.0001	0.0018
New Home Sales (NHS)	120	5.6000	69.4272

Notes: 1. Before 2003, Business Inventories was released at 8:30 am. During 2003-2005, it was released at 8:30 am for some months and 10:00 am for other months. Specific, 3 announcements in 2003, 6 announcements in 2004 and 5 announcements in 2005 were made at 10:00 am and the others at 8:30 am. It has been released at 10:00 am since 2006.

2. The mean and standard deviation are the statistics of daily data of those announcement days.

Table 2. Summary Statistics of 5-Minute Returns

This table reports the summary statistics of the 5-minute returns for pit and globex transactions. Sample periods for the pit and globex transactions are from January 2001 through December 2010 and from July 2003 through December 2010, respectively.

Statistics	Returns (%)	
	Pit	Globex
Mean	-0.0004	-0.0001
Std. Deviation	0.1253	0.0546
Min	-2.7304	-1.4250
Max	3.6989	4.2652
Skewness	0.2744	1.9449
Kurtosis	25.21	199.72
Count	203523	291731
Days	2553	1903

Table 3. Descriptive Properties of Significant Return Jumps Sampled at 5-minute Frequency

	Pit	Globex
Observations	203523	291731
E(|abs(return)|)	0.08	0.03
Days	2553	1903
Jump Days	520	1327
P(Jumpday) (%)	20	70
E(#Jump|Jump Day)	1.40	2.29
Jumps	727	3041
P(jump) (%)	0.36	1.04
E(|jumpsize||jump)	0.46	0.20
Std(|jumpsize||jump) (%)	0.35	0.19
Positive Jumps	306	1473
P(jump>0) (%)	0.15	0.50
E(jumpsize|jump>0)	0.48	0.20
Std(jumpsize|jump>0) (%)	0.40	0.22
Negative Jumps	421	1568
P(jump<0) (%)	0.21	0.54
E(jumpsize|jump<0)	-0.44	-0.20
Std(jumpsize|jump<0) (%)	0.32	0.16
% of Negative Jumps	57.91	51.56

Table 4. Jump Returns Matched with Macroeconomic News Releases

10:05 am Jumps and 10:00 am Macroeconomic News Releases			*8:35 am Jumps and 8:30 am Macroeconomic News Releases*		
News	**Obs.**	**%**	**News**	**Obs.**	**%**
BI	3	4.05	ARS	38	42.22
CC	21	17.80	BI	6	35.29
CS	17	14.17	CNP	69	76.67
FO	7	5.88	CPI	51	56.67
ISM	20	16.67	DGO	25	27.78
LEI	3	2.52	GDP	43	47.78
NHS	7	5.83	HS	27	30.00
			PC	43	47.78
			PI	22	24.44
			PPI	35	38.89
			TBGS	12	13.33
Total jumps	99			362	
Jump match news	60	60.61		284	78.45

Note: Symbols and their meanings: Business Inventories (BI); Consumer Confidence (CC); Construction Spending (CS); Factory Orders (FO); ISM-Manufacturing (ISM); Leading Economic Indicators (LEI); New Home Sales (NHS); Advanced Retail Sales (ARS); Changes in Nonfarm Payrolls (CNP); Consumer Price Index (CPI); Durable Goods Orders (DGO); Gross Domestic Product (GDP); Housing Starts (HS); Personal Consumption (PC); Personal Income (PI); Producer Price Index (PPI); Trade Balance Goods and Services (TBGS).

Table 5. Top 20 Jumps and Corresponding Macroeconomic Announcements

	10:05 am Jumps and 10:00 am News				*8:35 am Jumps and 8:30 am News*			
Rank	Date	Return	News	Standard Surprise	Date	Return	News	Standard Surprise
1	10/29/2002	-1.11	CC	-1.97	10/16/2008	1.42	CPI	-0.68
2	1/2/2003	0.98	ISM	2.22	6/4/2010	-1.12	CNP	-1.36
3	8/1/2002	-0.94	ISM	-2.13	3/11/2008	1.09	TBGS	0.38
4	9/1/2010	0.86	ISM	1.65	1/4/2008	-1.00	CNP	-0.68
5	7/11/2002	0.85			6/5/2009	0.92	CNP	2.27
6	8/27/2002	-0.84	CC	-0.65	4/4/2008	-0.90	CNP	-0.39
7	7/29/2003	-0.79	CC	-1.56	8/19/2010	-0.87		
8	5/26/2009	0.78	CC	2.29	10/30/2008	0.87	GDP	0.42
							PC	-1.97
9	9/24/2002	0.75	CC	0.22	3/14/2008	0.85	CPI	-2.03
10	1/17/2008	-0.75			5/2/2008	0.85	CNP	0.71
11	8/19/2010	-0.74	LI	0.00	2/1/2008	-0.84	CNP	-1.13
12	2/7/2008	0.74			9/5/2008	-0.79	CNP	-0.12
13	9/5/2002	-0.72	FO	0.00	6/6/2008	-0.78	CNP	0.14
14	11/2/2009	0.72	CS	1.24	3/7/2008	-0.78	CNP	-1.08
			ISM	1.28				
15	11/12/2001	0.68			12/5/2008	-0.78	CNP	-2.57
16	9/4/2001	0.66	ISM	1.84	1/9/2009	0.77	CNP	0.01
17	7/1/2010	-0.64	CS	0.75	11/25/2008	0.76	GDP	0.00
			ISM	-1.32			PC	-1.40
18	6/29/2010	-0.62	CC	-1.79	2/5/2009	-0.75		
19	6/1/2010	0.62	CS	3.36	8/17/2007	0.74		
			ISM	0.33				
20	6/23/2010	-0.62	NHS	-1.58	1/31/2008	-0.73	PI	0.31

Note: Symbols and their meanings: Business Inventories (BI); Consumer Confidence (CC); Construction Spending (CS); Factory Orders (FO); ISM-Manufacturing (ISM); Leading Economic Indicators (LEI); New Home Sales (NHS); Advanced Retail Sales (ARS); Changes in Nonfarm Payrolls (CNP); Consumer Price Index (CPI); Durable Goods Orders (DGO); Gross Domestic Product (GDP); Housing Starts (HS); Personal Consumption (PC); Personal Income (PI); Producer Price Index (PPI); Trade Balance Goods and Services (TBGS).

Table 6. Marginal Impact of Macroeconomic News on Jumps

This table reports panel regression results of the following form: $jp_{t_j} = c + \sum_{i=1}^{n} c_i^{+} SA_{i,t_j}^{+} + \sum_{i=1}^{n} c_i^{-} SA_{i,t_j}^{-} + \varepsilon_{t_j}$. Specifically, jumps that match at least one news announcement are regressed against the standardized surprises of news announcements ofive minute before the occurrence of the jump.

10:05 am Jumps and 10:00 am News				*8:30 am Jumps and 8:30 am News*			
News	Estimate	t-stat	p-value	News	Estimate	t-stat	p-value
BI^{+}	0.00	.	.	ARS^{+}	0.06	0.97	0.33
CC^{+}	0.35^{***}	3.37	0.00	BI^{+}	0.12	0.76	0.45
CS^{+}	0.22^{**}	2.09	0.04	CNP^{+}	0.35^{***}	5.22	0.00
FO^{+}	0.45^{**}	2.39	0.02	CPI^{+}	-0.10^{*}	-1.72	0.09
LEI^{+}	0.19	1.14	0.26	DGO^{+}	0.06	0.66	0.51
ISM^{+}	0.34^{***}	3.76	0.00	GDP^{+}	0.09	1.39	0.17
NHS^{+}	0.12	0.63	0.53	HS^{+}	0.08	0.79	0.43
				PC^{+}	0.08	0.83	0.40
				PI^{+}	0.02	0.33	0.74
				PPI^{+}	-0.11^{*}	-1.69	0.09
				$TBGS^{+}$	0.37	1.17	0.24
BI^{-}	-0.24	-0.92	0.36	ARS^{-}	0.17^{***}	2.68	0.01
CC^{-}	0.30^{***}	3.11	0.00	BI^{-}	-0.05	-0.40	0.69
CS^{-}	0.10	0.94	0.35	CNP^{-}	0.27^{***}	5.21	0.00
FO^{-}	0.07	0.32	0.75	CPI^{-}	-0.13^{**}	-2.06	0.04
LEI^{-}	0.27	0.80	0.43	DGO^{-}	0.15	1.60	0.11
ISM^{-}	0.18	1.19	0.24	GDP^{-}	0.18^{**}	2.25	0.03
NHS^{-}	0.20	1.40	0.17	HS^{-}	0.09	0.91	0.36
				PC^{-}	0.00	0.05	0.96
				PI^{-}	-0.02	-0.13	0.90
				PPI^{-}	0.03	0.27	0.79
				$TBGS^{-}$	0.06	0.34	0.73
Obs		60				284	
Adj-R^2(%)		51.52				22.43	
F-Value		5.82^{***}				4.72^{***}	
P-value		0.00				0.00	

Note: 1. Superscripts "***", "**", and "*" represent statistical significance at the 1%, 5% and 10% level, respectively

2. Symbols and their meanings: Business Inventories (BI); Consumer Confidence (CC); Construction Spending (CS); Factory Orders (FO); ISM-Manufacturing (ISM); Leading Economic Indicators (LEI); New Home Sales (NHS); Advanced Retail Sales (ARS); Changes in Nonfarm Payrolls (CNP); Consumer Price Index (CPI); Durable Goods Orders (DGO); Gross Domestic Product (GDP); Housing Starts (HS); Personal Consumption (PC); Personal Income (PI); Producer Price Index (PPI); Trade Balance Goods and Services (TBGS).

Table 7: Returns, Volatility and Volume Adjustment Processes in the GLOBEX Market

This table reports the results of the regression model: $V_{t_i} = c_0 + \sum_{i=1, i\neq j}^{n} c_i D_i + \varepsilon_{t_i}$, where, the five minute return, volatility (measured by the absolute returns), and volume are regressed against interval dummies on different sub-samples, respectively. Specifically, Models I to III are on days with news and 8:35 jumps, days with news and no 8:35 jumps and days with no news and no 8:35 jumps.

	Returns					Volatility					Volume				
	Model I			Model II	Model III	Model I			Model II	Model III	Model I			Model II	Model III
	All	POS	NEG			All	POS	NEG			All	POS	NEG		
Intercept	-0.006	-0.002	-0.010	0.000	0.004*	0.041***	0.040***	0.043***	0.043***	0.041***	94.285***	89.465***	100.244***	72.254***	69.668***
	(-0.70)	(-0.26)	(-1.06)	(0.06)	(1.96)	(7.16)	(4.98)	(5.21)	(12.73)	(22.62)	(8.71)	(5.99)	(6.40)	(13.49)	(18.70)
8:15 - 8:20	0.018	0.018	0.017	-0.004	-0.010**	-0.002	0.002	-0.008	-0.002	0.001	-9.928	-12.522	-6.649	-2.161	5.822
	(1.52)	(1.46)	(1.25)	(-0.69)	(-3.34)	(-0.28)	(0.19)	(-0.66)	(-0.37)	(0.37)	(-0.65)	(-0.59)	(-0.30)	(-0.28)	(1.11)
8:25 - 8:30	0.011	0.000	0.024*	0.005	-0.006*	0.021***	0.017	0.027**	0.005	-0.005*	16.718	10.758	24.087	8.363	-6.401
	(0.95)	(0.02)	(1.80)	(0.93)	(-1.85)	(2.63)	(1.47)	(2.34)	(1.09)	(-1.81)	(1.09)	(0.51)	(1.09)	(1.10)	(-1.22)
8:30 - 8:35	0.030***	0.291***	-0.293**	-0.009	0.001	0.254***	0.249***	0.260***	0.017***	-0.002	466.595***	488.752***	439.205***	131.070***	10.733**
	(2.59)	(23.14)	(-21.62)	(-1.54)	(0.20)	(31.19)	(22.00)	(22.30)	(3.56)	(-0.65)	(30.47)	(23.14)	(19.81)	(17.31)	(2.04)
8:35 - 8:40	0.000	0.005	-0.005	-0.003	-0.005	0.033***	0.030***	0.037***	0.016***	-0.004	182.454***	199.229***	161.717***	40.331***	-6.322
	(0.04)	(0.37)	(-0.34)	(-0.44)	(-1.57)	(4.08)	(2.68)	(3.15)	(3.41)	(-1.42)	(11.92)	(9.43)	(7.30)	(5.33)	(-1.20)
8:40 - 8:45	0.013	0.006	0.021	0.002	-0.005*	0.026***	0.019*	0.034***	0.008*	-0.005*	102.183***	115.726***	85.441***	21.112***	-7.997
	(1.07)	(0.44)	(1.56)	(0.35)	(-1.68)	(3.15)	(1.70)	(2.88)	(1.74)	(-1.89)	(6.67)	(5.48)	(3.85)	(2.79)	(-1.52)
8:45 - 8:50	0.008	0.007	0.010	-0.000	-0.006*	0.011	0.014	0.009	0.006	-0.005*	63.989***	81.318***	42.567*	11.134	-6.911
	(0.71)	(0.55)	(0.74)	(-0.08)	(-1.89)	(1.39)	(1.20)	(0.73)	(1.16)	(-1.82)	(4.18)	(3.85)	(1.92)	(1.47)	(-1.31)
8:50 - 8:55	0.010	0.016	0.001	-0.001	-0.006**	0.018**	0.011	0.026**	0.000	-0.005**	33.884**	45.777**	19.113	13.098*	-6.449
	(0.82)	(1.28)	(0.10)	(-0.18)	(-2.09)	(2.20)	(0.99)	(2.26)	(0.05)	(-2.04)	(2.21)	(2.17)	(0.86)	(1.73)	(-1.23)
8:55 - 9:00	-0.002	-0.004	0.001	-0.007	-0.003	0.006	0.003	0.009	-0.000	-0.006**	18.874	23.388	13.291	2.767	-4.538
	(-0.13)	(-0.31)	(0.10)	(-1.22)	(-1.05)	(0.72)	(0.27)	(0.81)	(-0.06)	(-2.45)	(1.23)	(1.11)	(0.60)	(0.37)	(-0.86)
9:00 - 9:05	0.004	0.002	0.006	0.005	-0.007**	0.007	0.006	0.008	0.007	-0.001	23.757	31.920	13.693	8.679	6.252
	(0.34)	(0.18)	(0.45)	(0.83)	(-2.14)	(0.83)	(0.49)	(0.70)	(1.49)	(-0.36)	(1.55)	(1.51)	(0.62)	(1.15)	(1.19)
9:05 - 9:10	0.004	-0.001	0.009	0.003	-0.008**	0.005	0.010	0.000	-0.001	-0.006**	19.644	25.000	13.012	5.451	-1.836
	(0.30)	(-0.09)	(0.68)	(0.50)	(-2.66)	(0.67)	(0.87)	(0.01)	(-0.22)	(-2.45)	(1.28)	(1.18)	(0.58)	(0.72)	(-0.35)
9:10 - 9:15	0.008	-0.000	0.017	-0.003	-0.005*	0.004	0.006	0.001	-0.000	-0.007**	9.306	15.401	1.772	16.881**	-0.941
	(0.65)	(-0.04)	(1.29)	(-0.57)	(-1.68)	(0.43)	(0.53)	(0.04)	(-0.03)	(-2.53)	(0.61)	(0.73)	(0.08)	(2.23)	(-0.18)
Adj-R^2	0.00	0.33	0.38	0.00	0.00	0.33	0.30	0.36	0.01	0.00	0.33	0.34	0.32	0.09	0.00
F Stat	1.15	87.13	83.87	1.17	1.99	150.97	75.05	77.90	3.75	2.04	152.55	87.98	64.86	46.10	2.75

Note: Superscripts "***", "**", and "*" represent statistical significance at the 1%, 5% and 10% level, respectively.

Table 8: Returns and Volatility Adjustment Processes in the Pit Market

This table reports the results of the regression model: $V_{t_i} = c_0 + \sum_{i=1, i\neq j}^{n} c_i D_i + \varepsilon_{t_i}$, where, the five minute return and volatility (measured by the absolute returns) are regressed against interval dummies on different sub-samples. Specifically, Models I to III are on days with news and 10:05 jumps, days with news and no 10:05 jumps and days with no news and no 10:05 jumps.

	Returns					Volatility				
	Model I			Model	Model	Model I			Model	Model
	All	POS	NEG	II	III	All	POS	NEG	II	III
Intercept	-0.006	0.027	-0.028	-0.007	-0.005	0.083***	0.096***	0.074***	0.096***	0.106***
	(-0.23)	(0.84)	(-1.13)	(-1.19)	(-1.59)	(5.67)	(3.89)	(4.14)	(22.70)	(42.03)
9:45 - 9:50	-0.006	-0.018	0.002	0.011	0.001	0.009	-0.010	0.022	0.009	-0.001
	(-0.17)	(-0.40)	(0.04)	(1.36)	(0.20)	(0.44)	(-0.29)	(0.86)	(1.46)	(-0.36)
9:55 - 10:00	0.037	-0.006	0.066*	0.027***	-0.001	0.007	-0.022	0.027	-0.005	-0.006
	(1.00)	(-0.13)	(1.88)	(3.21)	(-0.25)	(0.36)	(-0.64)	(1.08)	(-0.90)	(-1.63)
10:00 - 10:05	-0.111**	0.428***	-0.471**	0.017**	0.007	0.398***	0.359***	0.425***	0.042***	0.011***
	(-3.00)	(9.59)	(-13.53)	(2.00)	(1.54)	(19.28)	(10.27)	(16.78)	(7.11)	(2.99)
10:05 - 10:10	-0.014	-0.018	-0.010	-0.008	0.006	0.047**	0.020	0.064**	0.020***	-0.004
	(-0.36)	(-0.41)	(-0.30)	(-1.02)	(1.25)	(2.25)	(0.58)	(2.53)	(3.33)	(-1.12)
10:10 - 10:15	0.010	-0.021	0.031	0.008	0.003	0.024	-0.000	0.040	0.011*	-0.008**
	(0.28)	(-0.47)	(0.89)	(0.99)	(0.57)	(1.17)	(-0.00)	(1.60)	(1.92)	(-2.30)
10:15 - 10:20	0.025	0.050	0.008	-0.003	0.006	0.034*	0.066*	0.013	0.004	-0.009**
	(0.67)	(1.12)	(0.23)	(-0.36)	(1.20)	(1.66)	(1.88)	(0.53)	(0.67)	(-2.48)
10:20 - 10:25	-0.037	-0.090**	-0.001	0.007	0.010**	0.050**	0.043	0.055**	-0.008	-0.018**
	(-0.99)	(-2.02)	(-0.02)	(0.90)	(2.16)	(2.42)	(1.23)	(2.16)	(-1.33)	(-4.97)
10:25 - 10:30	0.008	-0.031	0.033	0.007	0.005	0.023	0.015	0.029	-0.010*	-0.016**
	(0.20)	(-0.69)	(0.95)	(0.84)	(0.96)	(1.13)	(0.44)	(1.13)	(-1.66)	(-4.43)
10:30 - 10:35	-0.018	-0.037	-0.006	0.011	0.003	0.017	-0.021	0.042	-0.000	-0.015**
	(-0.49)	(-0.82)	(-0.17)	(1.35)	(0.66)	(0.80)	(-0.60)	(1.64)	(-0.05)	(-4.21)
10:35 - 10:40	-0.023	-0.074*	0.011	0.003	0.006	0.028	-0.005	0.050**	-0.012**	-0.022**
	(-0.62)	(-1.66)	(0.31)	(0.31)	(1.34)	(1.37)	(-0.14)	(1.99)	(-2.02)	(-6.10)
10:40 - 10:45	-0.012	-0.070	0.027	0.007	0.003	-0.005	-0.018	0.004	-0.009	-0.016**
	(-0.31)	(-1.57)	(0.79)	(0.83)	(0.70)	(-0.23)	(-0.51)	(0.16)	(-1.51)	(-4.39)
Adj-R^2	0.02	0.41	0.45	0.00	-0.00	0.46	0.40	0.51	0.02	0.01
F Stat	2.04	18.85	33.19	2.43	0.95	56.87	18.15	41.45	13.74	13.25

Note: Superscripts "***", "**", and "*" represent statistical significance at the 1%, 5% and 10% level, respectively.

Figure 1. The Number of Jumps Distribution at 5-minute Interval (Frequency)

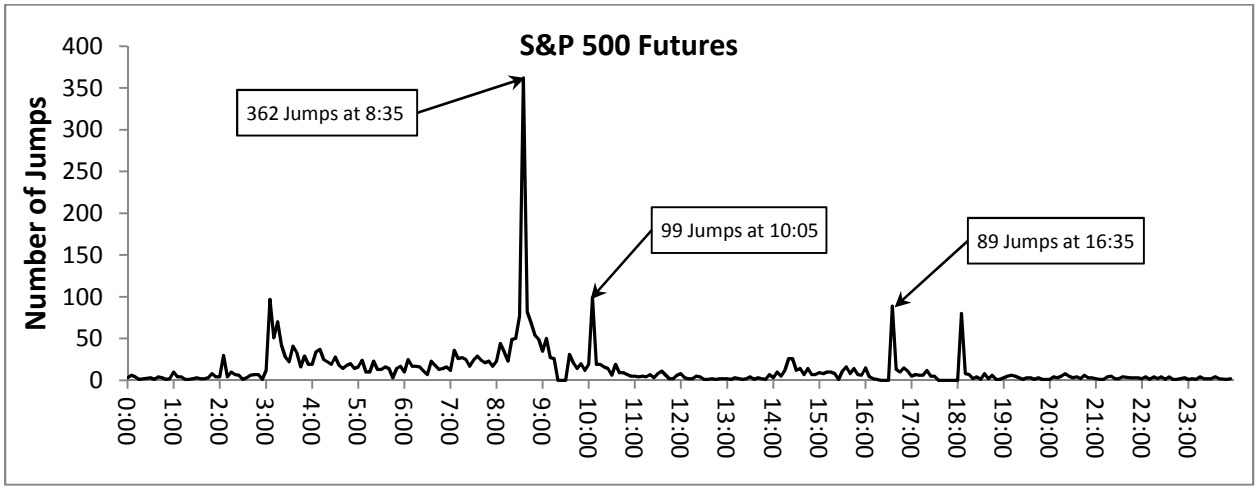
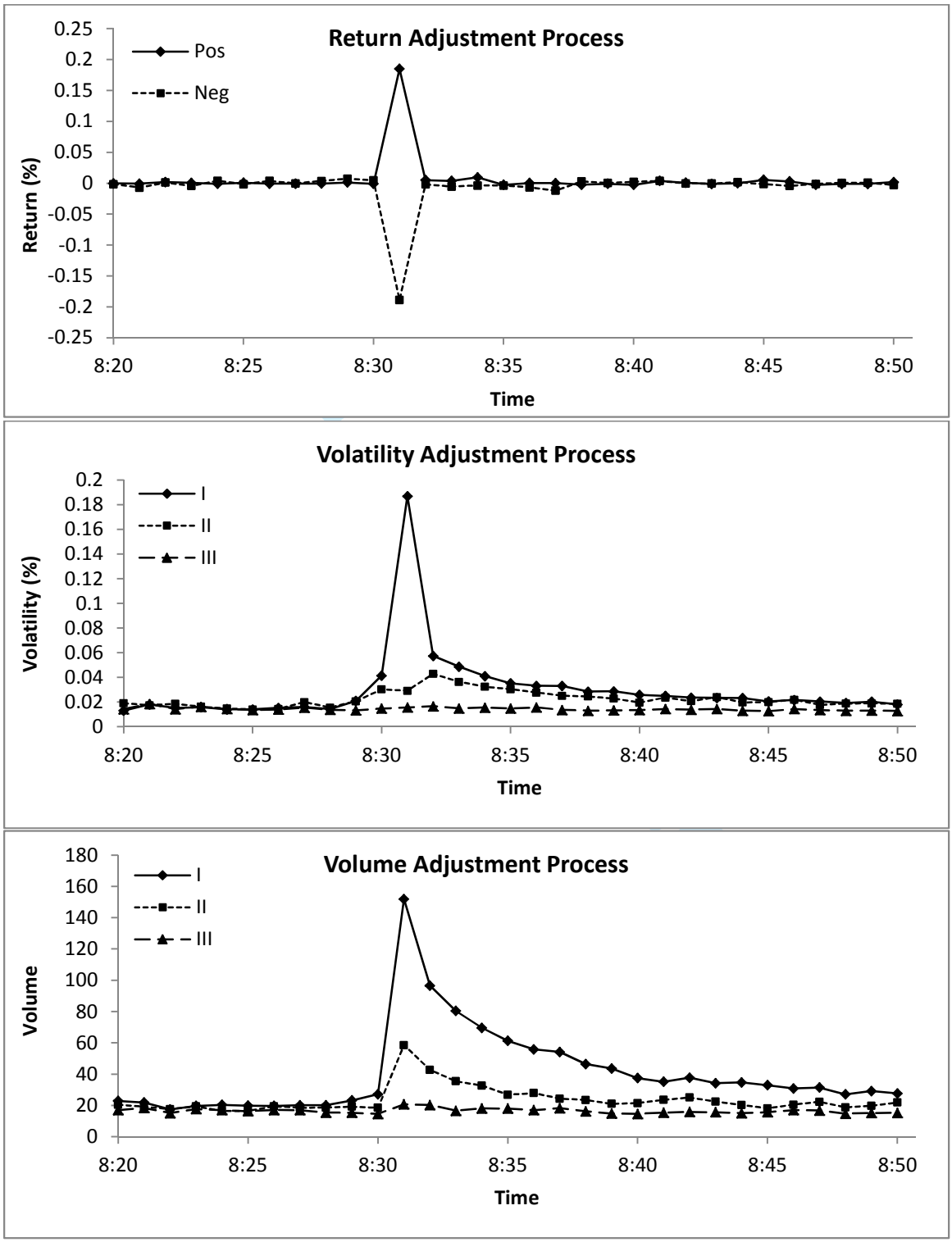
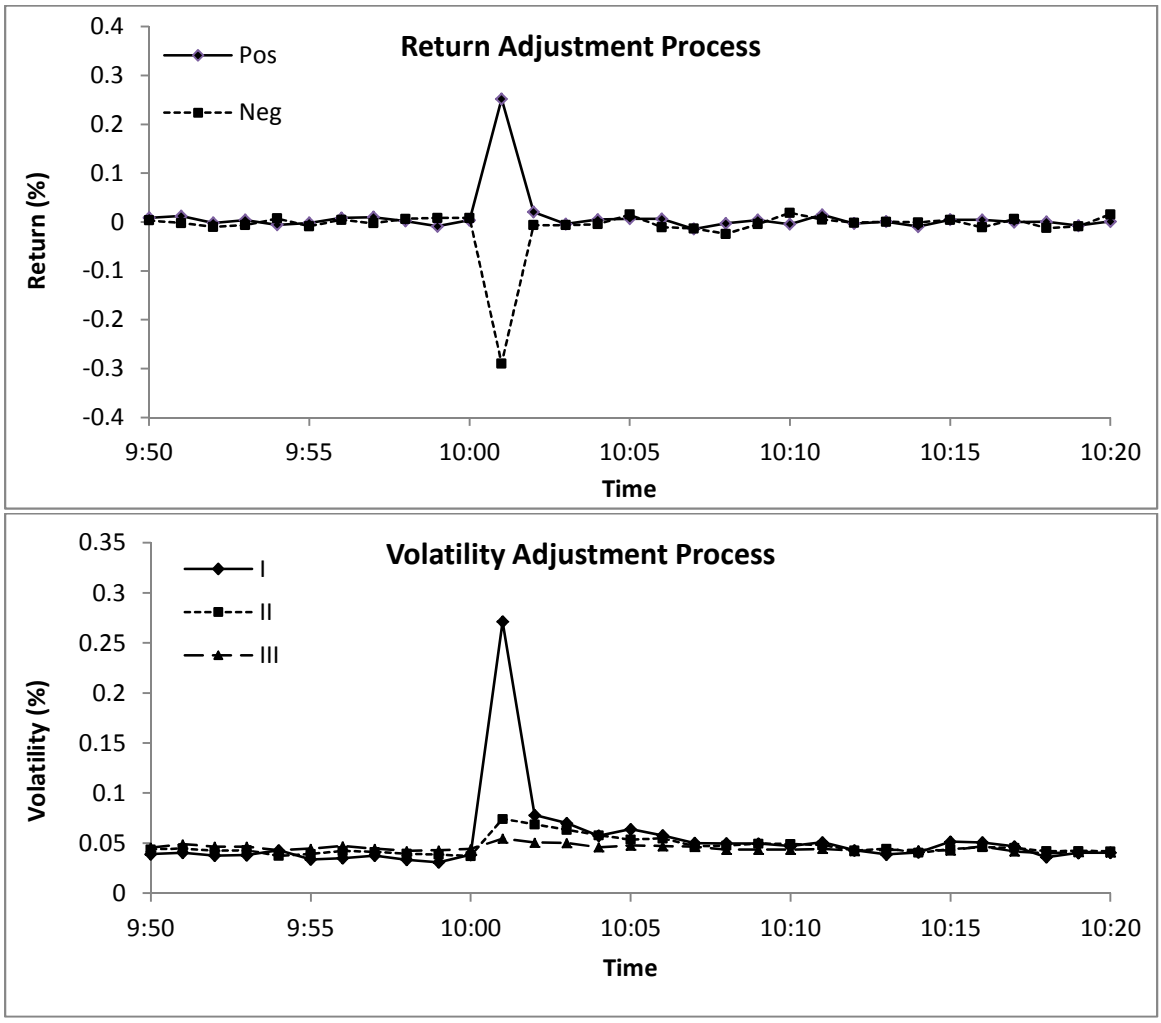


Figure 2: One-minute Intraday Return, Volatility and Volume Adjustment Process in the Globex Market



Note: "Pos" for days with positive jump and news; "Neg" for days with negative jumps and news; I is for days with news and jumps; II is for days with news but no jumps; III is for days with no news and no jumps.

Figure 3: One-minute Intraday Return and Volatility Adjustment Process in the Pit Market



Note: "Pos" for days with positive jump and news; "Neg" for days with negative jumps and news; I is for days with news and jumps; II is for days with news but no jumps; III is for days with no news and no jumps.