The impact of US macroeconomic news announcements on Chinese commodity futures

Haidong Cai* Shamim Ahmed† Ying Jiang‡ Xiaoquan Liu§

7 January, 2020

Abstract

Using intraday data from 2013 to 2016, we examine the instantaneous response of eight Chinese commodity futures to 19 different types of scheduled US macroeconomic news announcements after the introduction of night trading in China. We provide robust evidence that the surprise components of a number of news announcements exhibit a significant effect on returns, trading volume, and volatility of a majority of Chinese futures contracts, with gold and silver futures being the most sensitive. Moreover, we observe an asymmetric effect between positive and negative surprise components. A further examination of the responses to the US macroeconomic news announcements using US gold and silver futures over the same sample period provides qualitatively similar results with larger magnitudes. This evidence suggests a possible channel through which the impact of macroeconomic news announcements transmits from the US to the Chinese commodity futures market.

JEL Classification: G10, G13, G14.

Keywords: Trading activity; Market quality; Cross-border information transmission.

*Nottingham University Business School China, University of Nottingham Ningbo, Ningbo 315100, China. Email: haidong.cai@nottingham.edu.cn.

†University of Liverpool Management School, University of Liverpool, Liverpool L69 7ZH, United Kingdom. Email: shamim.ahmed@liverpool.ac.uk.

‡Corresponding author. Nottingham University Business School China, University of Nottingham Ningbo, Ningbo 315100, China. Email: ying.jiang@nottingham.edu.cn.

§Nottingham University Business School China, University of Nottingham Ningbo, Ningbo 315100, China. Email: xiaoquan.liu@nottingham.edu.cn.

1 Introduction

In this paper, we explore the instantaneous impact of scheduled US macroeconomic news announcements on returns, trading volume, and volatility of Chinese commodity futures contracts using intraday data. Our paper is motivated by two related strands of the literature. First, it connects to the literature on cross-border information transmission and news spillover. There is ample evidence in the literature that information tends to flow from larger, more liquid, and more efficient markets to those that are smaller, less liquid, and less efficient (see, among others, Fung, Tse, Yau, and Zhao, 2013; Hou and Li, 2016; Wu, Li, and Zhang, 2005, and references therein). Wongswan (2006) documents a large and significant reaction in Asian, European, and Latin American equity markets to US monetary policy surprises at short time horizons. As the US financial markets play a central and predominant role in the information flow across the global financial markets (see, for example, Hauptfleisch, Putnins, and Lucey, 2016; Jiang, Kellard, and Liu, 2019), China represents a good setting for assessing the information transmission from the US market to an emerging market because even though the Chinese commodity futures market is relatively young, it enjoys good market quality and the trading volumes are already leading the global rankings.[1]

Our study is related to a number of recent papers documenting empirical evidence on the informational link between commodity futures markets in the US and China: Fung, Liu, and Yiuman (2010) investigate the US-China metallurgical futures market and show that the market activities of aluminum and copper futures are closely related; Liu and An (2011) document a bi-directional relationship and a stronger effect from the US to Chinese market with respect to price and volatility spillovers for copper and soybeans futures; and the same assets are examined in Han, Liang, and Tang (2013) and Yin and Han (2016). Jiang, Kellard, and Liu (2019) offer comprehensive evidence that closer integration between the US and Chinese precious metal futures markets has led to improved market quality in terms of higher liquidity and lower volatility in the latter market.

The second strand of literature upon which our paper builds is the impact of information in the form of macroeconomic news on financial assets. It has been extensively documented that macroeconomic news exhibits a substantial impact on the prices of stocks (Boyd, Hu, and Jagannathan, 2005), bonds (Nowak, Andritzky, Jobst, and Tamirisa, 2011), foreign exchange rates (Goodhart, Hall, Henry, and Pesaran, 1993; Omrane and Hafner, 2015), and derivatives (Elder, Miao, and Ramchander, 2012; Smales and Yang, 2015). Macroeconomic news mainly

[1] The Futures Industry Association annual survey reports the most traded commodity futures contracts in the world on the basis of the trading volume. For more information, see https://fia.org/articles/fia-releases-annual-trading-statistics-showing-record-etd-volume-2018.

conveys two important types of information: real economic activity and future inflation. Positive changes in real economic activity are likely to increase the demand for commodities and lead to higher prices. Meanwhile, growth in real activity brings a higher interest rate, which indirectly reduces prices. In the case of inflation, a higher inflation rate is expected to increase the demand for commodities due to the role of commodities in hedging inflation, and simultaneously, the rising inflation rate pushes up interest rates resulting in a negative effect on commodity prices (Hess, Huang, and Niessen, 2008). Hence, it is natural to expect that the information contained in US macroeconomic news announcements affects the pricing and trading activities of commodities and their derivative (see Elder, Miao, and Ramchander, 2012). Given the strong evidence of dynamic information transmission between the Chinese and US commodity futures markets discussed previously, we hypothesize that the US macroeconomic news announcements also exert significant impact on the Chinese commodity futures market.

Therefore, by examining the real-time impact of US macroeconomic news announcements on the Chinese commodity futures, our paper extends the literature on news spillover between economically linked markets. We contribute to the extant literature in two ways. First, it is the first study to examine the instantaneous impact of US macroeconomic announcements on Chinese commodity futures. Due to the introduction of night trading by the Shanghai Futures Exchange for gold and silver futures on 5th July, 2013, the Shanghai Futures Exchange offers overlapping trading hours with the active morning trading period for the precious metal futures in the US. This policy was subsequently adopted by the Dalian and Zhengzhou Commodity Futures Exchanges, and by now 32 products can be traded during the night. Night trading allows us to evaluate the simultaneous response of the Chinese futures market when scheduled US macroeconomic news arrives overnight. This type of study was not possible prior to July 2013, when trading in China was available only during the day, and there is no intraday analysis on this issue to the best of our knowledge. Our second contribution is that we include almost all commodity futures with night trading sessions and with a high level of liquidity in a comprehensive study. Erb and Harvey (2006) document a low degree of correlation between different commodity futures products. Thus, it is meaningful to explore the response of different commodity futures, and this examination offers relevant empirical evidence should futures exchanges in China or elsewhere consider introducing night trading.

Empirically, we use five-minute data on prices, volume, and realized volatilities for futures written on gold, silver, aluminum, copper, cotton, palm oil, soybean, and sugar. We consider 19 different types of US macroeconomic news releases for the period between 2013 and 2016 in our analysis, with a host of interesting results. First, we show that a number of macroeconomic

announcements play a substantial role in influencing returns, trading volume, and volatility of Chinese commodity futures, including surprises in nonfarm payrolls, unemployment rate, and advanced retail sales. Among the futures products in consideration, gold and silver futures are the most sensitive to news announcements. This leads to a natural question: What is the channel through which US macroeconomic news announcements impact Chinese commodity futures? To answer this, we compare responses of the US gold and silver futures, for which we have intraday data, to the same set of news announcements over the same sample period. We show that the influence of macroeconomic news on the US precious metal futures is in the same direction and of a larger magnitude. This suggests that the information linkage of the two markets could be a possible channel for the US macroeconomic news announcements to influence the Chinese commodity futures market. These results underscore the evidence in the literature that these two commodity futures markets are informationally linked.

Second and interestingly, we document a strong asymmetric effect of positive and negative surprise components of news on Chinese commodity futures. The asymmetric effect is reflected in two ways. First, when both are significant, the impact of positive surprises is statistically different from that of negative surprises. Moreover, the positive surprises present stronger magnitude on the returns, volume, and volatility of futures contracts, especially for gold and silver contracts. This may seem contrary to evidence in the literature on equity markets. We rationalize this as evidence that some commodities could be used as substitutes to financial assets in investment. For example, gold and, to a lesser extent, silver are considered safe-haven assets for investors and allow them to hedge against financial risk (Baur and Lucey, 2010; Baur and McDermott, 2010; Dempster and Artigas, 2010). A *good* piece of economic news indicates an improved macroeconomic environment, which tends to induce investors to shift their wealth away from the precious metal market. Hence, it is *bad* news for gold and silver futures with a stronger impact, whereas *bad* macroeconomic news could be *good* for precious metal futures (Smales and Yang, 2015). Our results are in line with the literature that *bad* news for precious metal futures (or other commodity futures) shows a stronger impact on the commodity futures market. Moreover, the positive and negative macroeconomic news surprises affect returns in different directions. Even though we observe that significant positive and negative surprises quite often exhibit the same, usually a negative sign, as in the case of change in nonfarm payrolls and new home sales for silver returns, economically these negative signs exhibit asymmetric consequences, as they push up (down) futures returns with negative (positive) shock components. The other asymmetric effect we observe is that the futures contracts are responsive to *either* positive *or* negative surprises of a number of macroeconomic news announcements.

The result underscores that both *good* or *bad* news about the economic conditions in the US matters for the Chinese commodity futures market.

Third, the US macroeconomic news announcements push up trading volume and volatility of Chinese commodity futures. This is the case for both positive and negative surprise components. It means that regardless of whether the US economic growth is stronger or weaker than expected, the macroeconomic news releases will drive trading volume and volatility increase in the Chinese commodity futures market.

Our paper offers several important economic implications. The reaction of volatility and price changes of Chinese commodity futures to US macroeconomic news is a crucial consideration for producers and consumers when constructing hedging strategies and optimizing their portfolios. Both international and domestic investors can make decisions to adjust their portfolio allocation in response to US macroeconomic conditions, especially as manifestoed in the change in nonfarm payrolls and unemployment rate explored in this paper. Hence, our paper provides valuable evidence on the impact of US macroeconomic news announcements for policymakers in China. Finally, our paper is relevant to policymakers in other, especially emerging, markets, when they consider extending their trading hours.

The remainder of the paper is organized as follows. Section 2 describes the data used in the empirical analyses and provides summary statistics. Section 3 briefly outlines the statistical methods utilized to examine the impact of macroeconomic news announcements on commodity futures. Section 4 summarizes the empirical results. Finally, Section 5 concludes.

2 Data

2.1 Commodity futures

Our data include eight Chinese commodity futures which have night trading sessions. They are futures contracts written on two precious metals (gold and silver), two industrial metals (aluminum and copper), and four agricultural commodities (cotton, palm oil, soybean, and sugar). We select these eight products for two reasons. First, they are the most liquid, in terms of monthly trading volume, among 32 commodity futures that currently trade with night sessions. Second, they are among the earliest contracts to implement the night trading policy. Specifically, the trading of gold and silver futures start in July 2013, aluminum and copper futures start in January 2014, and the four agricultural futures start in January 2015. Hence, these are the beginning of the sample period for these products. The sample period ends in

June 2016 for all commodity futures in consideration.[2]

We obtain futures transaction prices and volumes for all commodity futures sampled at five-minute intervals from the China Stock Market & Accounting Research database. We choose the most liquid contracts to construct continuous time series. For gold and silver futures, the most liquid contracts used in this paper are those expire in June and December. The contracts for soybean, palm oil, sugar, and cotton expiring in January, May, and September exhibit the highest liquidity. For aluminum and copper futures, the contracts with three months to maturity are used, and they are shown to be the most liquid across all maturity months (see Jiang, Ahmed, and Liu, 2017). Those liquid contracts roll over to the next expiry month when the trading volume of the current contract is less than that of the next one.

Table 1 reports summary statistics of logarithmic returns of commodity futures during night trading sessions. There are several takeaways from the results. First, most commodity futures have positive daily mean returns, though the returns are economically small. The only exception is aluminum, which yields a negative daily mean return of -0.01%. Second, aluminum and silver, respectively, have the lowest and the highest daily standard deviations at approximately 0.49% and 0.92%. The daily standard deviations of other commodity futures return series range between 0.64% and 0.76%. Third, the distributions of the return series for gold, silver, aluminum, copper, and cotton show positive skewness, while those for palm oil, soybean, and sugar exhibit negative skewness. Fourth, the distribution of each futures return series exhibits excess kurtosis. Finally, the Jarque-Bera test strongly rejects the null hypothesis of normality for all return series; all p-values round to zero.

To perform empirical analyses, we adopt a five-minute return and a 15-minute realized volatility measure.[3,4] Both measures make use of five-minute observations on closing futures prices in Chinese Yuan. Specifically, the return (in %) during the ith interval on day t is calculated using the continuously compounded return formula given below:

$$R_{t_i} = 100 \times (\log P_{t_i} - \log P_{t_{i-1}}), \tag{1}$$

where P_{t_i} and $P_{t_{i-1}}$ are, respectively, the closing prices of the ith and the $(i-1)$th intervals on

[2] The night trading sessions run electronically during the following hours (Beijing time): 21:00 – 02:30 for gold and silver, 21:00 – 01:00 for aluminum and copper, and 21:00 – 23:30 for cotton, palm oil, soybean, and sugar. The trading venue for gold, silver, aluminum, and copper futures is the Shanghai Futures Exchange. Sugar and cotton futures are traded on the Zhengzhou Commodity Exchange, whereas soybean and palm oil futures are traded on the Dalian Commodity Exchange.

[3] The five-minute return estimation window provides a reasonable balance between blurring specific price reactions by sampling too infrequently and confounding market microstructure effects by sampling too frequently (Andersen, Bollerslev, Diebold, and Vega, 2007).

[4] We consider a longer examination window because the impact of news announcements on volatility lasts for a longer time period (see, for example, Balduzzi, Elton, and Green, 2001; Elder, Miao, and Ramchander, 2012).

day t. In line with Andersen and Bollerslev (1998), the realized volatility (in %) during an interval is computed as

$$\sigma_{t_i} = \left(\sum_{n=1}^{N} R_n^2 \right)^{1/2}, \tag{2}$$

where σ_{t_i} is the measure of realized volatility and N is the number of (squared) returns during the ith interval, so the realized variance for each 15-minute interval is obtained as the sum of three five-minute squared returns. The five-minute volume, i.e., the number of futures contracts traded, for a given interval on day t is computed as the cumulative trading volume during that time interval.

2.2 Macroeconomic news announcements

The data on macroeconomic news releases are obtained from the Bloomberg Terminal provided by the Bloomberg LP. We investigate 19 different types of US macroeconomic news announcements which have been found to influence movements in asset prices in prior empirical studies. All announcements are released on a monthly basis at pre-scheduled times. For each announcement, we collect both the actual (or realized) value and the market survey (median) expectation value, as the literature shows that only the surprise (or unanticipated) component of these announcements exhibits an impact on asset trading activities (see, among others, Andersen, Bollerslev, Diebold, and Vega, 2003, 2007; Balduzzi, Elton, and Green, 2001; Beber and Brandt, 2010; Kilian and Vega, 2011). Hence, we compute the unanticipated component, denoted SA, as the difference between the actual value and the corresponding survey (median) expectation value, normalized by its standard deviation. Formally, the standardized surprise component of the news announcement is defined as follows:

$$SA_{j,t_i} = \frac{A_{j,t_i} - E_{j,t_i}}{\hat{\sigma}_{j,t_i}}, \tag{3}$$

where A_{j,t_i} and E_{j,t_i} are, respectively, the actual (or released) value and the consensus market expectation value, proxied by the median professional survey forecast, for an announcement type j at time i, on day t; and $\hat{\sigma}_{j,t_i}$ is the sample standard deviation of the surprise component, $A_{j,t_i} - E_{j,t_i}$.[5] Since units of measurement differ across economic variables, standardization of surprise component of news facilitates meaningful comparisons of responses of different Chinese commodity futures to different US macroeconomic news announcements in consideration. At the same time, the standardization procedure leaves both the statistical significance of the

[5] Throughout this paper, by surprise or shock, we mean the standardized surprise.

response coefficient estimates and goodness of fit of the regression models (described in Section 3) unaffected. To further facilitate interpretation of our empirical results, we calibrate each surprise announcement component in a way that a positive (negative) value of SA indicates a stronger (weaker)-than-expected economic growth in the US.

The Beijing time leads the Eastern Standard Time by 13 hours but, with daylight saving in the US, in the summer the time difference reduces to 12 hours. Keeping this in mind, we classify the 19 different types of macroeconomic news announcements into three groups based on the US (Eastern Standard) time of each announcement converted to the Beijing time (i.e., 21:30, 22:15, and 23:00). We filter the news data using the following steps. First, during the daylight-saving time period, we exclude macroeconomic news announcements at 20:30, which are released at 08:30 in the US. The reason is that the night trading in China begins at 21:00, thus, the impact of an announcement at 20:30 on commodity futures can be a mixture of other influential events, leading to endogeneity. Second, we remove weekend announcements because night trading is open to investors only on weekdays. Third, weekdays with a low trading volume are excluded to minimize bias resulting from stale prices and nonsynchronous trading. Specifically, we eliminate those days from our sample where the number of five-minute price observations on commodity futures is less than 50% of the number of price observations in an average night trading session.

Table 2 lists the 19 different types of macroeconomic news announcements and the corresponding standard deviations of surprise components. There are 10 announcements at 21:30, two at 22:15, and seven at 23:00.[6] Among the 19 macroeconomic announcements: the advance retail sales, capacity utilization, change in nonfarm payrolls, personal income, unemployment rate, housing starts, industrial production, and Institute of Supply Management manufacturing index represent real economic activity; the personal consumption expenditure, new home sales, and trade balance represent consumption; the business inventories, durable goods orders, construction spending, and factory orders represent investment; the consumer price index and producer price index represent price dynamics; and the consumer confidence and leading indicators represent forward-looking variables. In our sample, there are a total of 629 news announcements and their distributions are plotted in Figure 1 in terms of the day of the week and the day of the month. We see that the minimum and maximum number of announcements are released on Mondays and Fridays, respectively. Announcements of the change in nonfarm payrolls and unemployment rate are usually released on Fridays, which makes Fridays the busiest during a week. We also notice that macroeconomic news releases are clustered around the

[6] Due to the daylight saving adjustment scheme in the US, there can be two sets of Beijing time when macroeconomic news are released. For example, 08:30 in the US corresponds to 20:30 (without daylight saving) and 21:30 (with daylight saving) in Beijing. In this paper, we use the latter times consistently in the empirical analyses, i.e., 21:30, 22:15, and 23:00.

middle of a month followed by the beginning of a month. Furthermore, both the beginning and the end of each month experience an elevated level of news releases.

3 Methodology

We begin our empirical analysis by examining the instantaneous responses of returns, trading volume, and volatility of Chinese commodity futures to US macroeconomic news announcements. We follow Ederington and Lee (1993) and Elder, Miao, and Ramchander (2012) and construct two samples. In the study sample, we include days with at least one macroeconomic news release, whereas the control sample comprise all non-announcement days. For example, the 21:30 study sample comprises all days with at least one macroeconomic news release at 21:30 and the corresponding 21:30 control sample contains all remaining non-announcement days. For each announcement time, namely 21:30, 22:15, and 23:30, the examination window covers five minutes prior to the news release and five minutes after the news release for returns and trading volumes. In the case of realized volatility, the examination window spreads over a 30-minute interval with 15 minutes prior to and 15 minutes after the news announcement.

Table 3 summarizes the number of usable observations in our study and control samples at different release times for all commodity futures. To examine whether the Chinese commodity futures market responds to US macroeconomic news releases, we conduct equality tests on the mean values of returns, trading volumes, and realized volatilities for commodity futures surrounding the pre-scheduled announcement times at 21:30, 22:15, and 23:00. Specifically, we test the equality in the: (1) average returns (volumes) over the five-minute intervals immediately before and after each set of announcements, for both the study sample and the control sample; and (2) the average returns (volumes) for the study sample and the control sample over the five-minute interval, both immediately before and after each set of announcements. A similar empirical procedure is followed for the means of realized volatilities but using observations based on 15-minute intervals immediately before and after each set of news releases.

The equality tests above tell us whether the pre-scheduled US macroeconomic news affects the trading activities of Chinese commodity futures pooled across different types of announcements. Next, we separately analyze the effect of each type of announcements. Specifically, we perform a univariate regression as follows:

$$R_{t_{i+1}} = \beta_0 + \beta_j SA_{j,t_i} + \epsilon_{t_{i+1}}, \tag{4}$$

where $R_{t_{i+1}}$ is the return at time interval $i+1$, in our case, the five-minute post-announcement

return on day t, SA_{j,t_i} is the standardized surprise component of the jth announcement at time i on day t, and β_0 and β_j are the coefficients to be estimated. It is worth mentioning that the coefficient β_j measures the response of $R_{t_{i+1}}$ to a one-standard deviation change in the surprise component of the macroeconomic news. Moreover, the coefficient estimates correspond only to days with at least one news release.

The univariate regression may omit the impact of other news releases which are announced at the same time. Our next step in the empirical analysis involves undertaking a multivariate regression as follows:

$$R_{t_{i+1}} = \beta_0 + \sum_{j=1}^{N} \beta_j SA_{j,t_i} + \epsilon_{t_{i+1}}. \tag{5}$$

We consider the impact of multiple announcements released at the same time in this regression. In doing so, we face a singularity problem due to a large array of regressors but a limited number of observations, especially for agricultural commodity futures as the night trading policy was introduced much later for these contracts in January 2015. To circumvent this issue, we adopt a stepwise regression framework. It chooses only variables from a given set of independent variables (in our case, macroeconomic announcements) which exhibit an impact on the dependent variable at the pre-specified significance level. There are three approaches in which a stepwise regression can be performed. They are the forward selection method, the backward elimination method, and the bi-directional elimination method. Throughout this paper, we perform the stepwise regressions using the bi-directional elimination method, where both the forward and backward selection criteria for variable significance are set at the 10% level.[7,8]

We follow a similar empirical framework to investigate the effects of macroeconomics news releases on the trading volume and realized volatility of commodity futures. The stepwise regressions are specified as follows:

$$V_{t_{i+1}} = \beta_0 + \sum_{j=1}^{N} \beta_j \text{ABS}(SA_{j,t_i}) + \sum_{s=1}^{3} \gamma_s V_{t_{i+1-s}} + \epsilon_{t_{i+1}}, \tag{6}$$

$$RV_{t_{i+1}} = \beta_0 + \sum_{j=1}^{N} \beta_j \text{ABS}(SA_{j,t_i}) + \gamma_1 RV_{t_i} + \epsilon_{t_{i+1}}, \tag{7}$$

[7] The forward selection method starts with no variable in the model and adds a variable with the lowest p-value, followed by a variable with the next lowest p-value. The process stops when none of the remaining variables are statistically significant. The backward elimination method starts with all variables in the model and eliminates a variable with the highest p-value, followed by a variable with the next highest p-value. The process continues until no insignificant variable remains. The bi-directional elimination method combines the forward selection and the backward elimination methods to add or remove a variable at each step.

[8] Although the stepwise regressions are prone to a pretest bias, the results from these regressions are informative in revealing macroeconomic announcements with the greatest explanatory power.

where $V_{t_{i+1}}$ is the volume at time interval $i+1$, in our case, the five-minute post-announcement trading volume, $RV_{t_{i+1}}$ is the realized volatility at time interval $i+1$, the 15-minute post-announcement realized volatility, $ABS(SA_{j,t_i})$ is the absolute value of the standardized surprise component corresponding to the jth macroeconomic announcement released at time i on day t, and β_0, β_j, and γ_s are regression coefficients. We include three lags of $V_{t_{i+1}}$ and one lag of $RV_{t_{i+1}}$ as additional regressors to control for persistence in volume and volatility.[9]

An extant literature documents that asset prices react asymmetrically to *good* news and *bad* news (see, among others, Conrad, Cornell, and Landsman, 2002; Elder, Miao, and Ramchander, 2012; Smales and Yang, 2015, and references therein). It is also possible that the effects of positive and negative news surprises may cancel out each other leaving some macroeconomic announcements statistically insignificant in the regression analyses. Considering these circumstances, we examine the asymmetric responses of returns, trading volume, and realized volatility to positive and negative news surprises using the stepwise regressions as follows:

$$R_{t_{i+1}} = \beta_0 + \sum_{j=1}^{N} \beta_j^+ SA_{j,t_i}^+ + \sum_{j=1}^{N} \beta_j^- SA_{j,t_i}^- + \epsilon_{t_{i+1}}, \tag{8}$$

$$V_{t_{i+1}} = \beta_0 + \sum_{j=1}^{N} \beta_j^+ SA_{j,t_i}^+ + \sum_{j=1}^{N} \beta_j^- SA_{j,t_i}^- + \sum_{s=1}^{3} \gamma_s V_{t_{i+1-s}} + \epsilon_{t_{i+1}}, \tag{9}$$

$$RV_{t_{i+1}} = \beta_0 + \sum_{j=1}^{N} \beta_j^+ SA_{j,t_i}^+ + \sum_{j=1}^{N} \beta_j^- SA_{j,t_i}^- + \gamma_1 RV_{t_i} + \epsilon_{t_{i+1}}, \tag{10}$$

where $SA_{j,t_i}^+ (SA_{j,t_i}^-)$ is the standardized surprise component of the jth macroeconomic announcement if it is positive (negative) and is zero for announcements at a different release time; and β_0, β_j^+, β_j^-, and γ_s are regression coefficients. In this framework, the asymmetric effect of a jth announcement variable can be observed in two ways. First, both positive and negative surprises have significant effects, but the magnitudes of their effects are statistically different from each other, that is, $|\beta_j^+| \neq |\beta_j^-|$. In this case, we perform a Wald test with the null hypothesis that $|\beta_j^+| = |\beta_j^-|$. Second, either positive surprise or negative surprise is statistically distinguishable from zero, that is, $\beta_j^+ \neq 0$, $\beta_j^- = 0$, or $\beta_j^+ = 0$, $\beta_j^- \neq 0$.

[9] Both the trading volume and the realized volatility exhibit significant persistence in our regressions. We do not report the coefficient estimates for lagged dependent variables in the paper because our focus is on the impact variables. The estimates for lagged dependent variables are available upon request from the authors.

4 Empirical results

4.1 Impact of news on returns, volume, and volatility

Table 4 summarizes empirical results for the equality tests of mean values of returns, volume, and volatility before and after news announcements for the study and control samples of metal futures. We can conclude that the US macroeconomic news announcement has an impact on the Chinese commodity futures, if the following conditions are met: (1) there is significant difference in returns, volume, and volatility before and after the news announcement in the study sample; (2) there is no significant difference in returns, volume, and volatility before and after the news announcement in the control sample; (3) there is significant difference between the study sample and the control sample after the news announcement; and (4) there is no significant difference between the study sample and the control sample before the news announcement. Looking at the 21:30 set of announcements, we notice that the change in average gold returns before and after announcements for the study sample is negative, with returns from -0.01% to -0.08%, and the difference is statistically significant at the 10% level. A qualitatively similar picture emerges for returns of aluminum around the same time. As for the comparison of the study sample and the control sample, it can be observed that average gold returns of the study sample before and after the macroeconomic news releases are less than those of the control sample by 0.01% and 0.07%, respectively. However, only the mean return difference of -0.07% is statistically significant at the 10% level. In the case of silver and copper futures, there is almost no evidence that the US macroeconomic news announcement drives significant response on the returns. When analyzing the results for the 22:15 set of announcements, we see that macroeconomic news fail to exert a significant impact on returns of commodity futures except for returns to aluminum futures. Silver and copper futures returns show a somewhat significant response to macroeconomic news announcements released at 23:00. Turning to the results for four agricultural commodity futures shown in Table A1 of the Appendix, only news releases at 23:00 show a significant impact on returns of palm oil contracts.[10]

We find evidence that trading volumes of some commodity futures respond strongly to macroeconomic news announcements at different times. For example, volumes of gold and silver futures for the study sample surge substantially after the announcements at 21:30, 22:15, and 23:00, and differences between the study and control samples are all positive and statistically significant at the 1% or 5% level. However, changes in trading volumes for aluminum for all three announcement times are statistically insignificant at conventional levels. For copper futures,

[10] To conserve space, all results for agricultural commodity futures are delegated to the Appendix.

macroeconomic news released at 21:30 significantly drive up its trading volume. Similarly, for agricultural commodity futures in Table A1, except sugar futures, there is evidence that their trading volumes are responsive to the US macroeconomic news announcements to some extent, especially for the 21:30 news releases.

Considering the realized volatility of returns to gold and silver futures, the results for the study sample are comparable to those based on volume around the 21:30 and 23:00 announcements. The average realized volatilities of these precious metal futures after news announcements are significantly higher at the 1% or 5% level than those before the announcements. With the exception of the 22:15 set of news releases, the average realized volatility of the study sample is also significantly higher at the 1% level than the control sample for each announcement. Volatilities of the two industrial metal futures respond significantly to news releases but mostly around the 22:15, whereas the agricultural commodity futures respond to some extent, in terms of the change in realized volatility, mostly to the 21:30 set of announcements.

To summarize, the key empirical findings from Table 4 are as follows. First, macroeconomic news announcements at three different times in the US show a limited instantaneous impact on returns of the Chinese commodity futures. Second, announcements of macroeconomic news exhibit a significantly positive impact on the volume and realized volatility of gold and silver futures but a significantly negative impact on the volume and realized volatility of cotton, palm oil, and soybean futures. Third, among our eight commodity futures, metals appear to be more responsive to macroeconomic news releases. Fourth, among the three pre-scheduled times, the announcements at 21:30, which contains news about 10 different economic variables, tends to exhibit the greatest impact on returns, volume, and volatility.

4.2 Marginal impact of news on returns

Table 5 reports the marginal impact of individual macroeconomic news announcements on returns to metal futures. The results are obtained by using the univariate regression model in equation (4). We observe that several macroeconomic releases at 21:30 exhibit a significant impact. In particular, change in nonfarm payrolls, durable goods orders, and unemployment rate show a negative effect on returns of gold and silver futures, while advance retail sales have a positive influence on the returns of copper futures. The coefficient estimates of these announcement variables are statistically significant at the 10% level at least. In terms of the adjusted R^2, we notice that the change in nonfarm payrolls has the highest explanatory power for gold futures returns (39%), whereas the unemployment rate possesses the highest explanatory power for silver returns (33%). These findings are consistent with prior empirical studies where the

employment or jobs report, comprising the nonfarm payrolls and unemployment rate, is identified as the *king* of all announcements due to its significant influence on most asset prices (see, for example, Andersen and Bollerslev, 1998). The news about capacity utilization and industrial production released at 22:15 exhibit a significant negative impact on returns to gold and silver futures. In addition, the analysis of results for macroeconomic announcements released at 23:00 suggests that surprises in consumer confidence, factory orders, supply management manufacturing index, and new home sales have a significant and negative impact on gold and silver futures prices. Furthermore, the supply management manufacturing index and new home sales exhibit the highest explanatory power for gold returns with adjusted R^2 values of 57% and 34%, respectively, for the 23:00 releases. Overall, the results clearly suggest that gold and silver are the most responsive futures to the US macroeconomic news releases in our sample.

Taken together, the univariate regression results in Table 5 reveal some notable findings. The returns to precious metal futures, gold and silver, respond negatively to news releases that reflect unanticipated improvement in the US economy. The list of those influential announcements includes the change in nonfarm payrolls, durable goods orders, unemployment rate, capacity utilization, industrial production, consumer confidence, factory orders, supply management manufacturing index, and new home sales. Elder, Miao, and Ramchander (2012) also report a qualitatively similar finding for gold and silver futures traded on the Chicago Mercantile Exchange. A possible explanation is that an unexpected improvement in the US economy may cause investors to reduce their appetite for precious metals, as an alternative investment vehicle, and therefore to rebalance portfolios by leaning more towards stocks and bonds.

As for the results of agricultural commodity futures, the impact of a news announcement is less profound than that on gold and silver futures. Out of the 19 different announcements, only two (i.e., capacity utilization and industrial production) exhibit a significant impact on returns to cotton futures, three (i.e., personal consumption, capacity utilization, and factory orders) on palm oil, three (i.e., housing starts, consumer confidence, and leading indicators) on soybean, and one (i.e., supply management manufacturing index) on sugar, as shown in Table A2.

The results based on the stepwise regressions in Table 6 are largely in line with those from the univariate regressions discussed above. Among the macroeconomic news announcements at 21:30, surprises in nonfarm payrolls, unemployment rate, and advance retail sales exert a significantly negative impact on gold and silver futures returns. The returns to copper are negatively influenced by surprises in nonfarm payrolls, while aluminum prices are positively influenced by trade balance surprises. Turning to the news released at 22:15 and 23:00, the only significant responses are for precious metals futures. Surprises in consumer confidence, factory

orders, supply management manufacturing index, and new home sales exhibit a significant and negative impact on gold and silver futures returns. For agricultural futures returns in Table A3, in eight out of 76 cases (19 macroeconomic releases for four commodity futures) macroeconomic announcements show a significant impact. In summary, gold and silver futures returns respond to nearly half of the macroeconomic news releases. Furthermore, the 21:30 set of announcements exhibits the greatest impact on a majority of our commodity futures and the change in nonfarm payrolls exerts varying levels of influences on four out of eight commodity futures.

4.3 Marginal impact of news on volume and volatility

The results from the stepwise regressions for trading volume, specified by equation (6), are summarized in Table 7. For the 21:30 announcements, we see that unanticipated news of the change in nonfarm payrolls and unemployment rate largely dominate volume changes of all metal futures. For example, all else being equal, a one-standard deviation absolute shock to the change in nonfarm payrolls results in an increase of 11902 (93022) contracts for gold (silver) futures. For the 22:15 news releases, capacity utilization shows a positive influence on the trading volume of silver futures. An examination of announcements at 23:00 reveals that shocks in supply management manufacturing index explains volume changes of gold, silver, and copper futures, whereas shocks in business inventories and new home sales show, respectively, a negative influence on the trading volumes of two precious metal futures and a positive impact on gold futures trading volume. However, almost no news announcement is able to move the trading volume of agricultural futures, except that industrial production exerts a strong and positive impact on sugar futures and advanced retail sales announcement shows a positive and significant impact on soybean futures, as reported in Table A4. Overall, we show that the trading volumes of metal futures are more sensitive to US macroeconomic announcements, especially to the news of change in nonfarm payrolls and unemployment rate released at 21:30.

For the realized volatility results in Table 8, based on equation (7), we notice that unemployment rate surprises at 21:30 exhibit a positive influence on the realized volatility of gold, silver, and copper futures. The change in nonfarm payrolls shocks markedly elevate the realized volatility of gold and silver futures but fail to move the realized volatility of two industrial metal futures. The advance retail sales, representing real economic activities, show a negative influence on the realized volatility of aluminum futures. For the 23:00 set of news releases, we see that unanticipated news in new home sales increases the realized volatility of gold and silver futures and the supply management manufacturing index shows a significant influence on only gold futures. The news release of leading indicators exerts a positive impact on volatility of

silver futures. In Table A5, only a few cases show that macroeconomic news releases matter for volatility of agricultural futures. Collectively, we observe once again that gold and silver futures stand out, as their volatilities are most responsive to macroeconomic news announcements.

4.4 Asymmetric impact of news on returns, volume, and volatility

Based on equation (8), we now examine the asymmetric impact of news releases on our commodity futures returns. In Table 9, for the two precious metal futures, it can be observed that both positive and negative surprises for the change in nonfarm payrolls and consumer confidence show a negative and significant impact on gold returns. Moreover, the p-values for the Wald test statistics are well above the conventional 10% level, suggesting that the negative coefficients for positive and negative surprises are indistinguishable from each other. However, economically, the negative coefficients for negative surprises push up futures returns, whereas the negative coefficients for positive surprises push down futures returns, highlighting the asymmetric economic outcome of the coefficient estimates. Among the remaining macroeconomic news announcements, gold returns are also influenced by positive surprises (i.e., *good* news) in unemployment rate, supply management manufacturing index, and factory orders, and negative surprises (i.e., *bad* news) in advance retail sales, personal consumption, and industrial production. In the case of silver, the Wald test indicates that only unemployment rate has a significant asymmetric impact on silver returns. The absolute magnitude of the impact of positive surprises is about four times larger than that of the negative surprises (i.e., $|\beta_{UR}^{+}| = 1.46 \neq |\beta_{UR}^{-}| = 0.37$). For the two industrial metal futures, we observe that only positive surprises of the change in nonfarm payrolls tend to have a significant impact on both aluminum and copper returns. In addition, aluminum returns are also significantly influenced by positive surprises in trade balance and negative surprises in personal consumption.

Looking at the results in Table A6, although agricultural commodity futures returns show almost no significant responses to macroeconomic news announcements in univariate regression analysis, there are nine out of 12 cases (three release times for four commodity futures) that agricultural futures returns react to either positive and/or negative surprises of a number of news releases, underscoring the asymmetric impact of macroeconomic announcements. For example, cotton futures returns are significantly influenced by positive surprises in housing starts and capacity utilization, and negative surprises in trade balance and unemployment rate. We also see that the positive surprises of capacity utilization exhibit a significantly larger impact than the negative surprises (i.e., $|\beta_{CU}^{+}| = 0.19 \neq |\beta_{CU}^{-}| = 0.09$) on sugar futures returns.

Table 10 reports the asymmetric impact of macroeconomic news announcements on trading

volume. For gold volume, the Wald test indicates that positive and negative surprises in unemployment rate have an asymmetric impact, with $|\beta_{UR}^{+}| = 20690 \neq |\beta_{UR}^{-}| = 7900$. The trading volume of gold is also significantly influenced by positive surprises of the change in nonfarm payrolls, supply management manufacturing index, and factory orders, and negative surprises of new home sales, business inventories, and consumer confidence. Similar asymmetric effects on volumes can also be found on the remaining three metal futures. For the results of agricultural commodity futures reported in Table A7, asymmetries are observed for soybean and sugar futures trading volumes due to news releases. The positive and negative surprises in industrial production have an asymmetric influence on sugar trading volume as suggested by the Wald test. Sugar trading volume is also influenced by positive surprises of both housing starts and change in nonfarm payrolls. On the other hand, soybean trading volume tends to respond to negative surprises in advance retail sales and industrial production only.

We report the asymmetric impact of news announcements on realized volatility in Table 11. The results are obtained from the stepwise regressions given by equation (10). We find that both positive and negative unemployment rate surprises have an impact on the volatility of gold and silver futures. More importantly, the impact is significantly asymmetric in nature, both for gold (i.e., $|\beta_{UR}^{+}| = 0.75 \neq |\beta_{UR}^{-}| = 0.29$) and silver (i.e., $|\beta_{UR}^{+}| = 1.37 \neq |\beta_{UR}^{-}| = 0.37$). The result is similar to those of returns and volumes: when both surprises have significant impact on futures contracts, the positive surprises in general have a larger magnitude than the negative surprises do in terms of impact. For our two industrial metal futures, aluminum and copper, either positive or negative surprises in five out of 19 economic variables have a statistically significant influence on realized volatility, including surprises in advance retail sales, consumer confidence, change in nonfarm payrolls, unemployment rate, and supply management manufacturing index. Overall, the change in nonfarm payrolls and unemployment rate surprises again dominate in showing asymmetric effects on all but aluminum futures. Similar to the results of trading volume, the signs of the coefficients of positive/negative surprises are opposite, indicating both surprises push up volatility of metal futures.

The empirical results for the realized volatility of four agricultural commodity futures are shown in Table A8 and we observe many cases of asymmetric impact of news releases. For example, we find that for cotton futures, surprises in housing starts exert asymmetric impact, with $|\beta_{HS}^{+}| = 0.13 \neq |\beta_{HS}^{-}| = 0.08$. The impact of unemployment rate surprises on realized volatility of sugar futures is also significantly asymmetric, with $|\beta_{UR}^{+}| = 0.33 \neq |\beta_{UR}^{-}| = 0.24$, as the null hypothesis of equality of coefficients is rejected at the 1% level. We emphasize that positive and/or negative surprises in many of our macroeconomic news announcements have

significant asymmetric effects on the realized volatilities of agricultural commodity futures.

Taken together, the results suggest the following. First, positive and/or negative surprises of US macroeconomic news largely have significant asymmetric effects on commodity futures returns, volume, and realized volatility with gold and silver futures being influenced by more announcements. Second, among the three sets of macroeconomic announcements at 21:30, 22:15, and 23:00, news releases at 21:30 dominate futures price movements. Third, between positive and negative surprises, we find that *good* news (i.e., positive economic surprises) tend to have a stronger impact than *bad* news (i.e., negative economic surprises), especially for gold and silver futures. This is not contrary to evidence in the literature on equity markets whereby *bad* news causes more profound impact on the market than *good* news. We interpret this as evidence that an unexpected improvement in the US economy may reduce investment in the precious metal (or other commodities) market, which are usually used for hedging financial risk. Hence, it represents a *bad* news to precious metal futures market, causing larger reactions from returns, volume, and realized volatility. Finally, the positive and negative surprises drive futures returns in opposite direction, while both of them push up futures volume and volatility.

4.5 Impact on US gold and silver futures

Thus far, we have documented that the Chinese gold and silver futures contracts are the most responsive to surprises in US macroeconomic news announcements. Hence, a natural question is: What is the channel through which US macroeconomic releases impact Chinese commodity futures? To address this question, we obtain intraday data of US gold and silver futures traded on the Commodity Exchange (COMMEX) in New York over the same sample period from TickData LLC. We construct continuous time series from the most liquid contracts, i.e., June and December contracts for gold futures and March, May, July, September, and December contracts for silver futures, and conduct the same econometric analyses.

Our findings are summarized in Tables 12 through 14. In Table 12, we notice that more macroeconomic announcements exhibit a larger impact on these two futures products compared with Chinese gold and silver futures. These include not only the change in nonfarm payrolls and unemployment rate but also advance retail sales, capacity utilization, industrial production, supply management manufacturing index, and new home sales, all of which are statistically significant at the 1% level for both precious metal futures. In Table 13, we identify the most influential news announcements on returns, volume, and volatility of US gold and silver futures in Panels A, B and C, respectively, using the stepwise regressions. Again, we see that the change in nonfarm payrolls and unemployment rate are highly significant for both gold and silver

futures in all three panels, which is in line with results using the Chinese data. Furthermore, an asymmetric effect exists between positive and negative surprises of news announcements on the US gold and silver futures in Table 14. Overall, the results of the US precious metal futures are in line with those documented in Elder, Miao, and Ramchander (2012) and qualitatively similar to, but with a larger magnitude than, the results for China. One possible explanation is that the US precious metal futures contracts respond to the macroeconomic environment in the US and the reactions transmit to the Chinese market due to information linkage of the two markets.

4.6 Robustness: Alternative volatility measures

To show that our empirical results of the impact of US macroeconomic news announcements on Chinese commodity futures volatility are not affected by our choice of the 15-minute realized volatility, we further examine the impact on realized volatility constructed by: (1) aggregating five-minute squared returns over 25-minute intervals; and (2) absolute price changes over 15-minute intervals. In Tables 15 and 16, we summarize the stepwise regression results for the impact and the asymmetric impact, respectively, of news releases on the 25-minute realized volatility.[11] We find that the results are qualitatively similar to those reported in Table 8. The same set of macroeconomic news announcements, i.e., change in nonfarm payrolls, unemployment rate, supply management manufacturing index, new home sales, and leading indicators, significantly affect realized volatility of precious metal futures. For aluminum and copper futures, advance retail sales and unemployment rate exhibit a significantly negative and positive impact, respectively. A very similar pattern also emerges when comparing the results of asymmetric impact of news releases on volatility between Tables 16 and 11 in the type of significant news announcements and the way they asymmetrically affect realized volatility. The results based on realized volatility estimated by the 15-minute absolute price changes are reported in Tables A11 and A12, and they are qualitatively similar to our baseline results from the 15-minute realized volatility estimated as the sum of three five-minute squared returns. Hence, the empirical results on the impact of macroeconomic news releases on commodity futures volatility are robust with respect to the specific measure of realized volatility.

[11] As we need more five-minute intervals for constructing the 25-minute realized volatility and lagged volatility to control for persistence, we abstain from examining the impact of news releases at 22:15. This mitigates possible contamination of the results by the announcements at 21:30.

5 Conclusion

Motivated by the significant effect of US macroeconomic announcements on financial markets of the US and other markets and the information spillover between the US and China, this paper documents the impact of US macroeconomic news releases on Chinese commodity futures during night trading sessions. We undertake a comprehensive examination of the response of commodity futures returns, trading volume, and realized volatility for four metal futures and four agricultural futures to 19 different types of US macroeconomic news releases over the sample period from July 2013 to June 2016, with five-minute intraday data.

Our results show that US macroeconomic surprises, in particular those to the change in nonfarm payrolls and unemployment rate, exhibit a significant impact on market activities of Chinese commodity futures, especially metal futures. We also find that gold and silver futures are the most responsive to US macroeconomic news. Meanwhile, the asymmetric effect of negative and positive surprises of macroeconomic news are observed. We observe a similar pattern when using intraday US gold and silver futures data over the same sample period. Our results offer a number of economic implications for investors and regulators and enables us to make investment decisions in hedging and/or perhaps speculating in the Chinese commodity futures market with reference to the influence of the US macroeconomy.

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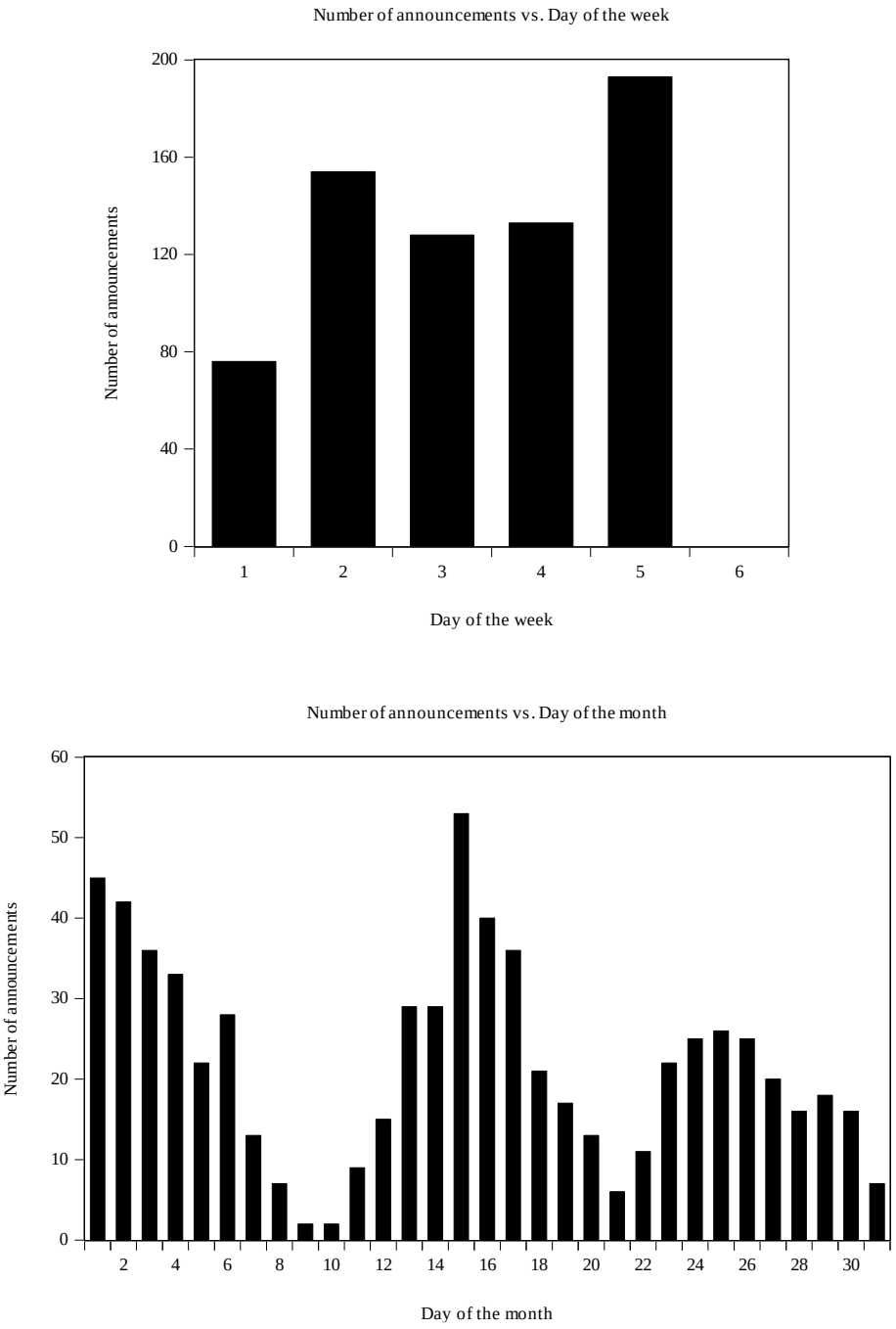
Figure 1
Distribution of macroeconomic news announcements



The upper and lower panels of the figure plot the number of announcements versus day of the week and the number of announcements versus day of the month, respectively. The sample period is from July 2013 to June 2016.

Table 1
Summary statistics

The table reports summary statistics of logarithmic returns (in %) during night trading sessions (in daily frequency) for four metal and four agricultural futures in China. The night trading sessions in Beijing time start at 21:00 and end at 02:30 next day for gold and silver futures; 01:00 next day for aluminum and copper futures; and 23:30 for cotton, palm oil, soybean, and cotton futures. The sample period is from July 2013 to June 2016.

	Gold	Silver	Aluminum	Copper	Cotton	Palm oil	Soybean	Sugar
Mean	0.0083	0.0152	−0.0139	0.0560	0.0609	0.0017	0.0338	0.0496
Median	−0.0201	−0.0245	−0.0348	0.0515	0.0000	0.0000	0.0290	0.0567
Standard deviation	0.6359	0.9198	0.4908	0.7258	0.7073	0.7569	0.6464	0.6404
Skewness	0.9310	0.9152	0.2428	0.2703	2.7063	−0.4501	−0.3437	−0.1488
Kurtosis	8.4151	13.862	6.2801	11.819	24.503	4.6828	6.2151	10.664
Jarque−Bera	1171	2667	17.37	1880	7170	53.35	157.80	858
p-value	(0.0000)	(0.0000)	(0.0002)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Night trading starts	Jul 2013	Jul 2013	Jan 2014	Jan 2014	Jan 2015	Jan 2015	Jan 2015	Jan 2015
No. of observations	610	708	586	609	350	351	351	350

Table 2
US macroeconomic news announcements

The table lists 19 US macroeconomic news announcements and the corresponding standard deviations of the surprise components. The surprise component is computed as the difference between the actual (or realized) value and the survey (median) expectation value. The sample period is from July 2013 to June 2016.

Time	Announcements	Total	Std. Dev. of surprise components
21:30	Advance retail sales (ARS)	34	0.0030
	Change in nonfarm payrolls (CNP)	36	59030
	Consumer price index (CPI)	35	0.1711
	Durable goods orders (DGO)	34	0.0311
	Housing starts (HS)	36	71677
	Personal consumption (PC)	31	0.0041
	Personal income (PI)	28	0.0013
	Producer price index (PPI)	34	0.0028
	Trade balance (TB)	30	3.7E+09
	Unemployment rate (UR)	27	0.0011
22:15	Capacity utilization (CU)	36	0.0036
	Industrial production (IP)	36	0.0033
23:00	Business inventories (BI)	36	0.0016
	Consumer confidence (CC)	35	4.7364
	Construction spending (CS)	34	0.0085
	Factory orders (FO)	34	0.0043
	Leading indicators (LI)	33	0.0019
	Institute of Supply Management manufacturing index (ISM)	26	1.5412
	New home sales (NHS)	34	4.59E+05
	Total	**629**	

Table 3
Study and control samples for empirical analyses

The table reports the total number of observations in the study and control samples for the US macroeconomic announcements at 21:30, 22:15, and 23:00. The sample period is from July 2013 to June 2016.

Market	Study sample			Control sample		
	21:30	22:15	23:00	21:30	22:15	23:00
Gold	86	34	182	325	325	325
Silver	86	35	186	325	325	325
Aluminum	70	29	157	271	271	271
Copper	70	29	157	271	271	271
Cotton	41	17	91	165	165	165
Palm oil	40	17	92	165	165	165
Soybean	40	17	92	165	165	165
Sugar	41	17	91	165	165	165

Table 4
Tests of equality in mean returns, volumes, and volatilities around macroeconomic news announcements

The table reports mean values of returns, volumes, and realized volatilities for gold, silver, aluminum, and copper futures surrounding the US macroeconomic news announcements at 21:30, 22:15, and 23:00. Returns (in %) and volumes (i.e., number of contracts traded) of commodity futures are computed over five-minute intervals, whereas realized volatilities (in %) are computed over 15-minute intervals before and after three pre-scheduled news announcement times. The tests of equality in mean returns, volumes, and realized volatilities are based on the Welch t-test. The first and second t-statistics in the Welch t-test column are for tests comparing mean values before and after announcements, and for control and study samples, respectively. The third and fourth t-statistics in the Welch t-test column are for tests comparing mean values of control and study samples, and before and after announcements, respectively. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016.

Gold	Sample	21:30 Announcement		Test of equality in means	22:15 Announcement		Test of equality in means	23:00 Announcement		Test of equality in means
		21:25−21:30	21:30−21:35	Welch t-test	22:10−22:15	22:15−22:20	Welch t-test	22:55−23:00	23:00−23:05	Welch t-test
Returns	Control	0.0014	−0.0079	−1.5041	−0.0002	−0.0036	−0.7430	−0.0032	−0.0047	−0.3744
	Study	−0.0118	−0.0774	−1.6987*	0.0015	0.0047	0.1626	−0.0102	0.0045	1.1999
	Difference	−0.0132		−0.9883	0.0017		0.1207	−0.0070		−1.3857
	Difference		−0.0695	−1.8159*		0.0083	0.5560		0.0092	0.7732
Volume	Control	3361	3747	1.7429*	3314	3327	0.0749	2708	3433	4.5279***
	Study	4234	11623	6.9570***	3183	4768	3.2116***	3059	6177	7.1003***
	Difference	873		2.2267**	−131		−0.3855	351		1.5792
	Difference		7876	7.7872***		1441	3.6199***		2744	6.6663***
		21:15−21:30	21:30−21:45		22:00−22:15	22:15−22:30		22:45−23:00	23:00−23:15	
Realized volatility	Control	0.1251	0.1176	−1.0679	0.1334	0.1113	−4.3106***	0.0951	0.0997	1.1785
	Study	0.1492	0.2762	3.7398***	0.1223	0.1140	−0.5231	0.1102	0.1489	3.3708***
	Difference	0.0241		1.7038*	−0.0111		−0.8240	0.0151		2.1405**
	Difference		0.1586	5.0092***		0.0027	0.2900		0.0491	4.9690***
Silver	Sample	21:30 Announcement		Test of equality in means	22:15 Announcement		Test of equality in means	23:00 Announcement		Test of equality in means
		21:25−21:30	21:30−21:35	Welch t-test	22:10−22:15	22:15−22:20	Welch t-test	22:55−23:00	23:00−23:05	Welch t-test
Returns	Control	0.0020	−0.0075	−0.9617	0.0000	0.0006	0.0870	−0.0033	−0.0029	0.0653
	Study	−0.0356	−0.0710	−0.6688	−0.0035	0.0177	0.6815	−0.0135	0.0144	1.9384*
	Difference	−0.0377		−1.8782*	−0.0034		−0.1916	−0.0102		−1.4454
	Difference		−0.0635	−1.2742		0.0171	0.6475		0.0173	1.2686
Volume	Control	23603	23757	0.0828	21858	21507	−0.2720	15718	18607	2.8117***
	Study	33981	80956	5.1668***	22733	33604	1.9998**	17918	31963	4.9380***
	Difference	10378		2.9547***	875		0.2784	2200		1.4704
	Difference		57199	6.6592***		12097	2.6191**		13356	5.0818***
		21:15−21:30	21:30−21:45		22:00−22:15	22:15−22:30		22:45−23:00	23:00−23:15	
Realized volatility	Control	0.1892	0.1545	−2.5740**	0.1989	0.1572	−4.6851***	0.1284	0.1283	−0.0105
	Study	0.2038	0.3220	2.5956**	0.1909	0.1641	−0.8086	0.1396	0.1798	2.3185**
	Difference	0.0146		0.6115	−0.0081		−0.2919	0.0112		0.9315
	Difference		0.1675	4.0766***		0.0069	0.3382		0.0515	3.6673***

Table 4 – *Continued*

Aluminum	Sample	21:30 Announcement		Test of equality in means	22:15 Announcement		Test of equality in means	23:00 Announcement		Test of equality in means
		21:25-21:30	21:30-21:35	Welch t-test	22:10-22:15	22:15-22:20	Welch t-test	22:55-23:00	23:00-23:05	Welch t-test
Returns	Control	−0.0147	0.0010	1.4239	0.0057	−0.0022	−1.1569	−0.0024	−0.0020	0.0846
	Study	0.0065	−0.0232	−1.9289*	−0.0308	0.0200	1.8612*	0.0074	−0.0055	−1.1786
	Difference	0.0212		1.6491	−0.0365		−1.5908	0.0098		1.0679
	Difference		−0.0242	−1.7403*		0.0222	1.3631		−0.0035	−0.4579
Volume	Control	1684	1622	−0.2812	1659	1629	−0.1746	976.10	1044	0.6658
	Study	1269	1513	0.7898	1573	1545	−0.0477	978.10	1071	0.4461
	Difference	−415		−1.5959	−86		−0.1906	2		0.0115
	Difference		−109	−0.3984		−84	−0.2032		27	0.1760
		21:15−21:30	21:30−21:45		22:00−22:15	22:15−22:30		22:45−23:00	23:00−23:15	
Realized volatility	Control	0.1527	0.1256	−2.3362**	0.1782	0.1314	−5.1746***	0.1018	0.1022	0.0736
	Study	0.1243	0.1247	0.0265	0.1883	0.1038	−2.7900***	0.1164	0.1054	−0.8945
	Difference	−0.0283		−2.0894**	0.0101		0.3488	0.0146		1.3353
	Difference		−0.0009	−0.0623		−0.0276	−2.1967**		0.0033	0.4289
Copper	Sample	21:30 Announcement		Test of equality in means	22:15 Announcement		Test of equality in means	23:00 Announcement		Test of equality in means
		21:25−21:30	21:30−21:35	Welch t-test	22:10−22:15	22:15−22:20	Welch t-test	22:55−23:00	23:00−23:05	Welch t-test
Returns	Control	−0.0087	0.0079	1.6862*	0.0016	0.0013	−0.0403	0.0015	−0.0054	−1.2361
	Study	0.0054	−0.0188	−1.2632	−0.0182	−0.0259	−0.3174	0.0097	0.0127	0.2836
	Difference	0.0142		1.0622	−0.0198		−1.1081	0.0082		1.0138
	Difference		−0.0268	−1.5753		−0.0272	−1.5172		0.0182	2.0641**
Volume	Control	5232	5343	0.2642	5386	5075	−1.0186	3831	3972	0.6209
	Study	4601	6602	2.5009**	5137	5136	−0.0005	3332	4166	2.1404**
	Difference	−631		−1.0468	−249		−0.3403	−499		−1.5840
	Difference		1259	1.8768*		61	0.1062		194	0.6006
		21:15−21:30	21:30−21:45		22:00−22:15	22:15−22:30		22:45−23:00	23:00−23:15	
Realized volatility	Control	0.1689	0.1552	−1.0302	0.1909	0.1417	−5.4507***	0.1322	0.1234	−1.4291
	Study	0.1390	0.1581	1.0145	0.1694	0.1243	−2.1052**	0.1222	0.1379	1.4499
	Difference	−0.0299		−1.8852*	−0.0215		−1.1092	−0.0100		−1.1060
	Difference		0.0029	0.1717		−0.0173	−1.3599		0.0145	1.6911*

Table 5
Impact of macroeconomic news announcements on returns: Univariate regressions

The table reports the results from the univariate regressions specified by equation (4). $R_{t_{i+1}}$ denotes the five-minute post-announcement return. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 for abbreviations of different macroeconomic announcements.

Time	Macroeconomic announcements	Gold $R_{t_{i+1}}$			Silver $R_{t_{i+1}}$			Aluminum $R_{t_{i+1}}$			Copper $R_{t_{i+1}}$		
		$\hat{\beta}_j$	t-statistic	Adj. R^2	$\hat{\beta}_j$	t-statistic	Adj. R^2	$\hat{\beta}_j$	t-statistic	Adj. R^2	$\hat{\beta}_j$	t-statistic	Adj. R^2
21:30	ARS	−0.0428	−1.4359	0.1729	−0.0506	−1.0524	0.0033	0.0161	0.7900	−0.0135	0.0461	2.0500**	0.1031
	CNP	−0.3533	−4.2056***	0.3909	−0.4139	−3.5866***	0.3133	−0.0069	−0.1600	−0.0512	−0.0519	−1.3400	0.0380
	CPI	−0.0027	−0.1111	−0.0299	0.0215	0.5378	−0.0207	0.0075	0.3800	−0.0305	0.0002	0.0100	−0.0357
	DGO	−0.0400	−1.6889*	0.0531	−0.0746	−1.8270*	0.0626	−0.0156	−0.3800	−0.0315	0.0089	0.3400	−0.0326
	HS	0.0068	0.3100	−0.0311	−0.0048	−0.1546	−0.0325	−0.0044	−0.2400	−0.0348	−0.0003	−0.0100	−0.0370
	PC	0.0421	0.7296	−0.0158	0.0209	0.2796	−0.0306	−0.0081	−0.3100	−0.0375	−0.0089	−0.2900	−0.0380
	PI	−0.0314	−0.7112	−0.0186	−0.0431	−0.8677	−0.0092	0.0862	1.3500	0.0375	0.0049	0.1300	−0.0491
	PPI	−0.0156	−0.5626	−0.0212	−0.0150	−0.4016	−0.0253	−0.0330	−1.6400	0.0572	0.0221	0.8800	−0.0082
	TB	0.0402	0.7092	−0.0174	−0.0260	−0.2830	−0.0328	0.0187	0.4900	−0.0329	0.0038	0.0600	−0.0433
	UR	−0.2762	−2.8671***	0.2174	−0.4280	−3.7076***	0.3290	0.0560	1.2700	0.0316	−0.0003	−0.0100	−0.0526
22:15	CU	−0.0398	−3.0076***	0.1960	−0.0696	−2.9017***	0.1791	0.0005	0.0300	−0.0370	−0.0053	−0.3000	−0.0337
	IP	−0.0379	−2.9069***	0.1842	−0.0628	−2.6230**	0.1475	0.0029	0.1900	−0.0357	0.0037	0.2100	−0.0353
23:00	BI	0.0029	0.0947	−0.0310	−0.0077	−0.2481	−0.0293	0.0094	0.5700	−0.0248	−0.0269	−1.3000	0.0239
	CC	−0.0705	−2.9618***	0.2005	−0.0763	−2.6209**	0.1550	−0.0142	−1.0500	0.0039	−0.0146	−0.8900	−0.0079
	CS	0.0048	0.1521	−0.0407	0.0026	0.0853	−0.0414	−0.0054	−0.3600	−0.0431	0.0024	0.1100	−0.0494
	FO	−0.0547	−2.9306***	0.2194	−0.0598	−2.6405**	0.1811	0.0075	0.4500	−0.0358	−0.0088	−0.5600	−0.0308
	LI	0.0082	0.3524	−0.0281	0.0176	0.4470	−0.0249	−0.0192	−1.1700	0.0129	−0.0186	−0.9100	−0.0061
	ISM	−0.1564	−5.7756***	0.5742	−0.1180	−3.8716***	0.3682	0.0328	1.5800	0.0670	0.0150	0.4500	−0.0395
	NHS	−0.1103	−4.2771***	0.3439	−0.0982	−4.2596***	0.3352	0.0007	0.0400	−0.0357	0.0068	0.4400	−0.0286

Table 6
Impact of macroeconomic news announcements on returns: Stepwise regressions

The table reports the results from the stepwise regressions specified by equation (5). The stepwise regressions choose only announcement variables which have an impact on the five-minute returns of commodity futures at the 10% significance level. $R_{t_{i+1}}$ denotes the five-minute post-announcement return. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 for abbreviations of different macroeconomic announcements.

	Gold $R_{t_{i+1}}$			Silver $R_{t_{i+1}}$			Aluminum $R_{t_{i+1}}$			Copper $R_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic
21:30	CNP	−0.4813	−7.1399***	CNP	−0.4364	−4.7407***	TB	0.0658	2.0564**	CNP	−0.0821	−2.5076**
	ARS	−0.1658	−2.4515**	UR	−0.4052	−4.0935***	Intercept	−0.0208	−1.6736*	Intercept	−0.0140	−0.9295
	UR	−0.1461	−2.0159**	ARS	−0.1959	−2.1210**						
	Intercept	−0.0617	−2.1822**	Intercept	−0.0780	−2.0221**						
	Adj. R^2	0.4995		Adj. R^2	0.4474		Adj. R^2	0.0447		Adj. R^2	0.0712	
	F-statistic	29.2729***		F-statistic	23.9415***		F-statistic	4.2288**		F-statistic	6.2882**	
22:15	CU	−0.0398	−3.0076***	CU	−0.0696	−2.9017***	Intercept	0.0200	1.2709	Intercept	−0.0259	−1.4970
	Intercept	−0.0008	−0.0587	Intercept	0.0073	0.3064						
	Adj. R^2	0.1960		Adj. R^2	0.1791		Adj. R^2	0.0000		Adj. R^2	0.0000	
	F-statistic	9.0456***		F-statistic	8.4196***		F-statistic	0.0000		F-statistic	0.0000	
23:00	ISM	−0.1546	−5.3939***	NHS	−0.0952	−3.3197***	Intercept	−0.0055	−0.7960	Intercept	0.0127	1.6245
	NHS	−0.1069	−4.3945***	ISM	−0.1193	−3.4029***						
	CC	−0.0659	−2.7200***	CC	−0.0720	−2.4831**						
	FO	−0.0526	−2.1643**	FO	−0.0592	−1.9917**						
	Intercept	0.0096	0.9662	Intercept	0.0170	1.4090						
	Adj. R^2	0.2411		Adj. R^2	0.1377		Adj. R^2	0.0000		Adj. R^2	0.0000	
	F-statistic	15.4340***		F-statistic	8.3882***		F-statistic	0.0000		F-statistic	0.0000	

Table 7
Impact of macroeconomic news announcements on volume: Stepwise regressions

The table reports the results from the stepwise regressions specified by equation (6). The stepwise regressions choose only announcement variables which have an impact on the five-minute volume of commodity futures at the 10% significance level. $V_{t_{i+1}}$ denotes the five-minute post-announcement trading volume. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 for abbreviations of different macroeconomic announcements.

	Gold $V_{t_{i+1}}$			Silver $V_{t_{i+1}}$			Aluminum $V_{t_{i+1}}$			Copper $V_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic
21:30	ABS(CNP)	11902.29	5.96***	ABS(UR)	93022.60	5.70***	ABS(CNP)	1411.08	4.11***	ABS(CNP)	5399.01	4.24***
	ABS(UR)	4115.61	1.99**	ABS(CNP)	55935.56	3.54***	ABS(UR)	−919.17	−2.42**	ABS(UR)	−2758.26	−1.98**
	Intercept	4814.71	3.61***	ABS(ARS)	26675.43	1.86*	ABS(HS)	781.36	1.83*	Intercept	1564.65	2.03**
				Intercept	35624.69	4.24***	Intercept	−66.52	−0.40			
	Adj. R^2	0.51		Adj. R^2	0.59		Adj. R^2	0.76		Adj. R^2	0.51	
	F-statistic	22.86***		F-statistic	31.13***		F-statistic	45.42***		F-statistic	18.95***	
22:15	Intercept	2460.62	4.05***	ABS(CU)	12560.39	1.76*	Intercept	165.75	1.76*	Intercept	2414.65	3.53***
				Intercept	4927.29	0.55						
	Adj. R^2	0.36		Adj. R^2	0.29		Adj. R^2	0.96		Adj. R^2	0.45	
	F-statistic	19.20***		F-statistic	7.78***		F-statistic	682.69***		F-statistic	24.03***	
23:00	ABS(ISM)	3519.47	3.86***	ABS(ISM)	15657.27	2.55**	Intercept	350.59	4.45***	ABS(ISM)	1921.40	2.90***
	ABS(BI)	−1742.60	−2.47**	ABS(BI)	−12301.17	−2.53**				Intercept	1205.31	4.27***
	ABS(NHS)	1763.40	2.28**	Intercept	9605.05	3.14***						
	Intercept	1645.01	3.24***									
	Adj. R^2	0.44		Adj. R^2	0.36		Adj. R^2	0.74		Adj. R^2	0.59	
	F-statistic	24.24***		F-statistic	26.75***		F-statistic	151.91***		F-statistic	56.10***	

Table 8
Impact of macroeconomic news announcements on volatility: Stepwise regressions

The table reports the results from the stepwise regressions specified by equation (7). The stepwise regressions choose only announcement variables which have an impact on the 15-minute realized volatility of commodity futures at the 10% significance level. $RV_{t_{i+1}}$ denotes the 15-minute post-announcement realized volatility. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 for abbreviations of different macroeconomic announcements.

	Gold $RV_{t_{i+1}}$			Silver $RV_{t_{i+1}}$			Aluminum $RV_{t_{i+1}}$			Copper $RV_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic
21:30	ABS(CNP)	0.3709	5.6886***	ABS(UR)	0.3326	3.4294***	ABS(ARS)	−0.0533	−1.7625*	ABS(UR)	0.1768	6.1176***
	ABS(UR)	0.1691	2.4758**	ABS(CNP)	0.2967	3.2041***	Intercept	0.0740	3.3577***	Intercept	0.0988	5.0365***
	Intercept	0.2011	8.2314***	Intercept	0.2397	6.9089***						
	Adj. R^2	0.4668		Adj. R^2	0.3524		Adj. R^2	0.0949		Adj. R^2	0.3778	
	F-statistic	38.2101***		F-statistic	24.1191***		F-statistic	4.6191**		F-statistic	21.9499***	
22:15	Intercept	0.1140	12.8592***	Intercept	0.1641	8.5253***	Intercept	0.0647	4.1515***	Intercept	0.1243	11.0321***
	Adj. R^2	0.0000		Adj. R^2	0.0000		Adj. R^2	0.2482		Adj. R^2	0.0000	
	F-statistic	0.0000		F-statistic	0.0000		F-statistic	10.2439***		F-statistic	0.0000	
23:00	ABS(ISM)	0.0790	2.8644***	ABS(NHS)	0.0911	2.8038***	Intercept	0.0652	8.5399***	Intercept	0.0892	8.2243***
	ABS(NHS)	0.0508	2.1574**	ABS(LI)	0.0577	1.8424*						
	Intercept	0.1013	6.5560***	Intercept	0.1200	6.3881***						
	Adj. R^2	0.0776		Adj. R^2	0.0857		Adj. R^2	0.2832		Adj. R^2	0.1712	
	F-statistic	6.1190***		F-statistic	6.7768***		F-statistic	61.7686***		F-statistic	33.2326***	

Table 9
Asymmetric impact of macroeconomic news announcements on returns

The table reports the results from the stepwise regressions, for the asymmetric response of news on returns, specified by equation (8). The stepwise regressions choose only announcement variables which have an impact on the five-minute returns of commodity futures at the 10% significance level. $R_{t_{i+1}}$ denotes the five-minute post-announcement return. The results of tests for equality of coefficients on positive and negative surprises are also reported if both of them are significant. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 for abbreviations of different macroeconomic announcements.

	Gold $R_{t_{i+1}}$			Silver $R_{t_{i+1}}$			Aluminum $R_{t_{i+1}}$			Copper $R_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic
21:30	CNP^+	−0.5215	−6.8156***	UR^+	−1.4642	−5.8371***	TB^+	0.0901	2.4158**	CNP^+	−0.1075	−2.4649**
	CNP^-	−0.5127	−5.2521***	UR^-	−0.3706	−2.6656***	CNP^+	−0.0757	−2.2115**	Intercept	−0.0070	−0.4474
	UR^+	−0.8160	−4.3072***	CNP^+	−0.4931	−5.0067***	PC^-	0.2096	2.1440**			
	ARS^-	−0.1604	−2.2858**	CNP^-	−0.2391	−1.6542*	Intercept	−0.0022	−0.1697			
	PC^-	0.3842	1.7350*	ARS^-	−0.1934	−2.0864**						
	Intercept	−0.0282	−0.9972	Intercept	−0.0454	−1.2491						
	Adj. R^2	0.5722		Adj. R^2	0.5570		Adj. R^2	0.1579		Adj. R^2	0.0685	
	F-statistic	23.7362***		F-statistic	22.3771***		F-statistic	5.3135**		F-statistic	6.0757**	
22:15	IP^-	−0.0757	−3.3069***	IP^-	−0.1318	−3.1664***	Intercept	0.0200	1.2709	Intercept	−0.0259	−1.4970
	Intercept	−0.0334	−1.9381*	Intercept	−0.0480	−1.5483						
	Adj. R^2	0.2314		Adj. R^2	0.2098		Adj. R^2	0.0000		Adj. R^2	0.0000	
	F-statistic	10.9354***		F-statistic	10.0261***		F-statistic	0.0000		F-statistic	0.0000	
23:00	ISM^+	−0.1824	−5.4138***	ISM^+	−0.1382	−3.2777***	Intercept	−0.0055	−0.7960	Intercept	0.0127	1.6245
	NHS^-	−0.1767	−4.8150***	NHS^+	−0.0798	−1.9085*						
	FO^+	−0.0973	−2.4589**	NHS^-	−0.1177	−2.7552***						
	CC^+	−0.0833	−2.2775**	CC^-	−0.0811	−1.9318*						
	CC^-	−0.0621	−1.8515*	FO^-	−0.1002	−2.0225**						
	Intercept	0.0128	1.1364	Intercept	0.0203	1.4507						
	Adj. R^2	0.2656		Adj. R^2	0.1257		Adj. R^2	0.0000		Adj. R^2	0.0000	
	F-statistic	14.1504***		F-statistic	6.3187***		F-statistic	0.0000		F-statistic	0.0000	

Wald test of equality of coefficients

Null hypothesis	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value
$\lvert\beta_{CNP}^+\rvert = \lvert\beta_{CNP}^-\rvert$	0.0084	0.9288	1.0912	0.3004				
$\lvert\beta_{UR}^+\rvert = \lvert\beta_{UR}^-\rvert$			13.8685	0.0004				
$\lvert\beta_{CC}^+\rvert = \lvert\beta_{CC}^-\rvert$	0.1523	0.6798						
$\lvert\beta_{NHS}^+\rvert = \lvert\beta_{NHS}^-\rvert$			0.3844	0.5392				

Table 10
Asymmetric impact of macroeconomic news announcements on volume

The table reports the results from the stepwise regressions, for the asymmetric response of news on trading volume, specified by equation (9). The stepwise regressions choose only announcement variables which have an impact on the five-minute volume of commodity futures at the 10% significance level. $V_{t_{i+1}}$ denotes the five-minute post-announcement trading volume. The results of tests for equality of coefficients on positive and negative surprises are also reported if both of them are significant. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 for abbreviations of different macroeconomic announcements.

	Gold $V_{t_{i+1}}$			Silver $V_{t_{i+1}}$			Aluminum $V_{t_{i+1}}$			Copper $V_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic
21:30	CNP^+	14804.96	8.47***	UR^+	228990.70	6.28***	CNP^+	1390.10	4.20***	CNP^+	6738.39	5.90***
	UR^+	20690.57	4.58***	UR^-	−68463.87	−4.58***	HS^-	−855.35	−1.89*	HS^+	−7172.07	−1.92*
	UR^-	−7900.75	−5.07***	CNP^+	70967.33	5.04***	Intercept	−96.32	−0.61	Intercept	1784.01	2.65***
	Intercept	5262.30	4.86***	Intercept	28418.24	3.71***						
	Adj. R^2	0.65		Adj. R^2	0.68		Adj. R^2	0.77		Adj. R^2	0.60	
	F-statistic	40.06***		F-statistic	46.96***		F-statistic	58.08***		F-statistic	27.36***	
22:15	Intercept	2460.62	4.05***	Intercept	16101.11	2.49**	IP^-	294.91	2.26**	Intercept	2414.65	3.53***
							Intercept	294.67	2.82***			
	Adj. R^2	0.36		Adj. R^2	0.24		Adj. R^2	0.97		Adj. R^2	0.45	
	F-statistic	19.20***		F-statistic	11.73***		F-statistic	396.01***		F-statistic	24.03***	
23:00	ISM^+	5604.20	5.83***	ISM^+	25092.06	3.70***	ISM^+	−760.53	−2.08**	ISM^+	−3190.45	−3.33***
	NHS^-	−4430.38	−4.24***	BI^+	−12442.97	−2.42**	Intercept	314.36	3.93***	CS^+	2190.00	2.58**
	BI^-	2998.09	1.92*	NHS^-	−14860.72	−2.15**				Intercept	1115.55	4.09***
	CC^-	−1899.39	−1.99**	Intercept	8312.37	2.78***						
	FO^+	1978.37	1.76*									
	Intercept	1245.45	2.53**									
	Adj. R^2	0.50		Adj. R^2	0.39		Adj. R^2	0.75		Adj. R^2	0.61	
	F-statistic	26.78***		F-statistic	20.58***		F-statistic	117.47***		F-statistic	49.54***	
Wald test of equality of coefficients												
Null hypothesis	Chi-square	p-value		Chi-square	p-value		Chi-square	p-value		Chi-square	p-value	
$\lvert\beta_{UR}^+\rvert = \lvert\beta_{UR}^-\rvert$	34.72	0.00		54.61	0.00							

Table 11
Asymmetric impact of macroeconomic news announcements on volatility

The table reports the results from the stepwise regressions, for the asymmetric response of news on realized volatility, specified by equation (10). The stepwise regressions choose only the announcement variables which have an impact on the 15-minute realized volatility of commodity futures at the 10% significance level. $RV_{t_{i+1}}$ denotes the 15-minute post-announcement realized volatility. The results of tests for equality of coefficients on positive and negative surprises are also reported if both of them are significant. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 for abbreviations of different macroeconomic announcements.

	Gold $RV_{t_{i+1}}$			Silver $RV_{t_{i+1}}$			Aluminum $RV_{t_{i+1}}$			Copper $RV_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic
21:30	CNP^+	0.4168	6.8827***	UR^+	1.3737	6.2917***	ARS^-	0.0570	1.7731*	UR^-	−0.1981	−6.8521***
	UR^+	0.7460	4.7647***	UR^-	−0.3709	−4.9230***	Intercept	0.0708	3.1726***	CNP^+	0.0594	1.8988*
	UR^-	−0.2937	−5.4371***	CNP^+	0.3117	3.6915***				Intercept	0.0935	5.0406***
	Intercept	0.1881	8.4958***	Intercept	0.2254	7.3008***						
	Adj. R^2	0.5704		Adj. R^2	0.4968		Adj. R^2	0.0954		Adj. R^2	0.4493	
	F-statistic	38.6123***		F-statistic	28.9686***		F-statistic	4.6394**		F-statistic	19.7614***	
22:15	Intercept	0.1140	12.8592***	CU^-	−0.0723	−2.3634**	Intercept	0.0647	4.1515***	Intercept	0.1243	11.0321***
				Intercept	0.0867	2.6357**						
	Adj. R^2	0.0000		Adj. R^2	0.1581		Adj. R^2	0.2482		Adj. R^2	0.0000	
	F-statistic	0.0000		F-statistic	4.1928**		F-statistic	10.2439***		F-statistic	0.0000	
23:00	NHS^-	−0.1116	−3.3683***	NHS^-	−0.1104	−2.4616**	CC^-	0.0310	1.6909*	ISM^-	−0.0612	−1.6673*
	ISM^+	0.0991	3.2565***	LI^-	−0.1018	−2.0183**	Intercept	0.0665	8.7357***	Intercept	0.0859	7.8324***
	Intercept	0.1027	7.0004***	Intercept	0.1298	7.2724***						
	Adj. R^2	0.1200		Adj. R^2	0.0841		Adj. R^2	0.7492		Adj. R^2	0.1806	
	F-statistic	9.2871***		F-statistic	6.6607***		F-statistic	33.9432***		F-statistic	18.1970***	

Wald test of equality of coefficients

Null hypothesis	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value
$\lvert\beta_{UR}^+\rvert = \lvert\beta_{UR}^-\rvert$	38.2605	0.0000	55.3836	0.0000				

Table 12
Impact of macroeconomic news announcements on US gold and silver returns: Univariate regressions

The table reports the results from the univariate regressions specified by equation (4). $R_{t_{i+1}}$ denotes the US five-minute post-announcement returns for gold and silver futures. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 for abbreviations of different macroeconomic announcements. The first column shows the US time of announcement.

Time	Macroeconomic	Gold $R_{t_{i+1}}$			Silver $R_{t_{i+1}}$		
	announcements	$\hat{\beta}_j$	t-statistic	Adj. R^2	$\hat{\beta}_j$	t-statistic	Adj. R^2
8:30	ARS	−0.1959	−3.2057***	0.0357	−0.2323	−2.6681***	0.0238
	CNP	−0.6391	−11.0924***	0.3279	−0.7293	−8.2537***	0.2115
	CPI	−0.0518	−0.8712	−0.0010	−0.0440	−0.5204	−0.0029
	DGO	−0.0528	−0.9323	−0.0005	−0.0878	−1.0919	0.0008
	HS	−0.0938	−1.5912	0.0061	−0.1194	−1.4286	0.0041
	PC	−0.0591	−0.8689	−0.0010	−0.0204	−0.2102	−0.0038
	PI	−0.0372	−0.5611	−0.0027	−0.0554	−0.5910	−0.0026
	PPI	−0.0550	−0.9100	−0.0007	−0.0142	−0.1675	−0.0039
	TB	0.0301	0.5000	−0.0030	0.0253	0.2923	−0.0037
	UR	−0.3809	−6.0883***	0.1263	−0.6256	−7.2611***	0.1714
9:15	CU	−0.0462	−3.1708***	0.2105	−0.0886	−3.2012***	0.2138
	IP	−0.0475	−3.3904***	0.2356	−0.0911	−3.4215***	0.2391
10:00	BI	0.0034	0.1200	−0.0054	0.0233	0.6808	−0.0029
	CC	−0.0768	−2.5725**	0.0293	−0.0928	−2.5621**	0.0291
	CS	0.0275	0.9011	−0.0011	0.0169	0.4506	−0.0043
	FO	−0.0546	−1.7609*	0.0112	−0.0747	−1.9868**	0.0158
	LI	0.0011	0.0412	−0.0054	0.0179	0.5126	−0.0040
	ISM	−0.2086	−6.2306***	0.1698	−0.1954	−4.6308***	0.0994
	NHS	−0.1107	−3.8217***	0.0685	−0.1220	−3.4518***	0.0558

Table 13
Impact of macroeconomic news announcements on US gold and silver futures: Stepwise regressions

The table reports the results from the stepwise regressions specified by equations (5), (6), and (7), respectively. The stepwise regressions choose only the announcement variables which have an impact on the five-minute returns (Panel A), trading volume (Panel B), and realized volatility (Panel C) of commodity futures at the 10% significance level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 for abbreviations of different macroeconomic announcements. The first column shows the US time of announcement.

Panel A: Returns

	Gold $R_{t_{i+1}}$			Silver $R_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic
8:30	CNP	−0.5648	−9.72***	CNP	−0.5648	−6.43***
	ARS	−0.1964	−4.07***	UR	−0.4445	−5.32***
	UR	−0.1989	−3.60***	ARS	−0.2371	−3.25***
	HS	−0.0949	−2.07**	HS	−0.1220	−1.76*
	Intercept	−0.0283	−1.61	Intercept	−0.0392	−1.48
	Adj. R^2	0.4001		Adj. R^2	0.3161	
	F-statistic	42.68***		F-statistic	29.89***	
9:15	IP	−0.0475	−3.39***	IP	−0.0911	−3.42***
	Intercept	0.0028	0.20	Intercept	−0.0155	−0.58
	Adj. R^2	0.2356		Adj. R^2	0.2391	
	F-statistic	11.48***		F-statistic	11.68***	
10:00	ISM	−0.2083	−6.68***	ISM	−0.1949	−4.89***
	NHS	−0.1078	−4.22***	NHS	−0.1184	−3.63***
	CC	−0.0723	−2.80***	CC	−0.0877	−2.66***
	FO	−0.0533	−2.01**	FO	−0.0734	−2.17**
	Intercept	0.0077	0.71	Intercept	0.0187	1.36
	Adj. R^2	0.2787		Adj. R^2	0.1991	
	F-statistic	18.87***		F-statistic	12.49***	

Table 13 – *Continued*

Panel B: Volume

	Gold $V_{t_{i+1}}$			Silver $V_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic
8:30	ABS(CNP)	7213.56	8.24***	ABS(CNP)	4526.37	8.78***
	ABS(UR)	4227.41	5.02***	ABS(UR)	1039.15	2.15**
	ABS(ARS)	1660.82	2.89***	ABS(ARS)	563.88	1.67*
	Intercept	2614.79	8.55***	Intercept	339.23	2.03**
	Adj. R^2	0.56		Adj. R^2	0.57	
	F-statistic	65.36***		F-statistic	68.06***	
9:15	Intercept	1073.27	4.10***	ABS(IP)	300.03	2.52**
				Intercept	−33.53	−0.21
	Adj. R^2	0.34		Adj. R^2	0.52	
	F-statistic	18.42***		F-statistic	13.36***	
10:00	ABS(ISM)	2961.05	6.12***	ABS(CS)	870.34	4.33***
	ABS(NHS)	1149.24	2.88***	ABS(FO)	414.11	2.01**
	ABS(CC)	1125.83	2.73***	Intercept	241.62	2.15**
	ABS(FO)	991.13	2.42**			
	ABS(LI)	869.46	2.24**			
	Intercept	1294.74	4.16***			
	Adj. R^2	0.24		Adj. R^2	0.49	
	F-statistic	9.43***		F-statistic	45.61***	

Panel C: Volatility

	Gold $RV_{t_{i+1}}$			Silver $RV_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic
8:30	ABS(CNP)	0.3661	6.10***	ABS(UR)	0.4355	4.80***
	ABS(UR)	0.1668	2.79***	ABS(CNP)	0.2144	2.28**
	Intercept	0.1482	6.53***	Intercept	0.2255	6.04***
	Adj. R^2	0.4252		Adj. R^2	0.3025	
	F-statistic	62.63***		F-statistic	37.14***	
9:15	Intercept	0.1180	13.99***	Intercept	0.1465	5.03***
	Adj. R^2	0.0000		Adj. R^2	0.1469	
	F-statistic	0.0000		F-statistic	6.86**	
10:00	ABS(ISM)	0.1121	3.58***	ABS(ISM)	0.1015	2.54**
	Intercept	0.1405	7.79***	ABS(NHS)	0.0710	2.15**
				Intercept	0.1877	8.59***
	Adj. R^2	0.0667		Adj. R^2	0.0570	
	F-statistic	7.61***		F-statistic	4.73***	

Table 14
Asymmetric impact of macroeconomic news announcements on US gold and silver futures

The table reports the stepwise regression results for the asymmetric response of news on returns (Panel A), trading volume (Panel B), and realized volatility (Panel C). The results of tests for equality of coefficients on positive and negative surprises are also reported if both of them are significant. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 for abbreviations of different macroeconomic announcements. The first column shows the US time of announcement.

Panel A: Returns

	Gold $R_{t_{i+1}}$			Silver $R_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic
8:30	CNP^-	−0.4050	−3.38***	CNP^-	−0.3230	−1.77*
	CNP^+	−0.6350	−8.17***	CNP^+	−0.6972	−5.88***
	ARS^-	−0.2296	−4.19***	UR^-	−0.6106	−4.71***
	UR^-	−0.3208	−3.78***	ARS^-	−0.2705	−3.24***
	DGO^-	−0.1951	−2.34**	DGO^-	−0.2566	−2.02**
	HS^-	−0.1037	−1.69*	Intercept	−0.0614	−2.16**
	Intercept	−0.0518	−2.69***			
	Adj. R^2	0.4071		Adj. R^2	0.3102	
	F-statistic	29.61***		F-statistic	23.49***	
9:15	IP^-	−0.0947	−3.89***	IP^-	−0.1670	−3.49***
	Intercept	−0.0374	−2.06**	Intercept	−0.0853	−2.39**
	Adj. R^2	0.2937		Adj. R^2	0.2469	
	F-statistic	15.13***		F-statistic	12.15***	
10:00	ISM^+	−0.2521	−6.95***	ISM^+	−0.2363	−4.97***
	NHS^-	−0.1726	−4.70***	NHS^-	−0.1687	−3.50***
	FO^+	−0.1096	−2.57**	CC^+	−0.1060	−2.14**
	CC^+	−0.0909	−2.41**	FO^+	−0.1143	−2.05**
	CC^-	−0.0663	−1.83*	CC^-	−0.0829	−1.75*
	Intercept	0.0144	1.19	Intercept	0.0258	1.63
	Adj. R^2	0.3158		Adj. R^2	0.2004	
	F-statistic	18.08***		F-statistic	10.27***	

Wald test of equality of coefficients

Null Hypothesis	Chi-square	p-value	Chi-square	p-value
$\lvert\beta_{CNP}^+\rvert = \lvert\beta_{CNP}^-\rvert$	2.14	0.1445	2.43	0.1201
$\lvert\beta_{CC}^+\rvert = \lvert\beta_{CC}^-\rvert$	0.21	0.6499	0.11	0.7458

Table 14 – *Continued*

Panel B: Volume	Gold $V_{t_{i+1}}$			Silver $V_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic
8:30	UR^-	−3591.88	−3.68***	CNP^-	−8299.63	−10.80***
	UR^+	9650.66	6.45***	CNP^+	3574.69	7.08***
	CNP^+	7741.28	8.59***	UR^+	3156.08	3.77***
	CNP^-	−5635.27	−4.10***	ARS^+	1713.42	2.53**
	ARS^-	−1921.96	−3.17***	UR^-	1052.29	1.94*
	HS^+	1510.05	1.88*	Intercept	557.48	4.27***
	Intercept	2515.09	8.67***			
	Adj. R^2	0.59		Adj. R^2	0.64	
	F-statistic	53.44***		F-statistic	74.48***	
9:15	Intercept	1073.27	4.10***	Intercept	360.77	3.59***
	Adj. R^2	0.34		Adj. R^2	0.41	
	F-statistic	18.42***		F-statistic	25.09***	
10:00	ISM^+	3524.20	6.98***	CS^-	−810.11	−3.62***
	NHS^-	−1911.70	−3.74***	CS^+	903.61	2.24**
	CC^-	−1590.31	−3.15***	FO^+	684.80	2.13**
	FO^+	1556.41	2.62**	BI^-	830.92	1.88*
	LI^+	749.45	1.74*	Intercept	286.67	2.62
	Intercept	1492.11	5.53***			
	Adj. R^2	0.32		Adj. R^2	0.50	
	F-statistic	13.32***		F-statistic	31.54***	
Wald test of equality of coefficients						
Null Hypothesis	Chi-square		p-value	Chi-square		p-value
$\lvert\beta_{CNP}^+\rvert = \lvert\beta_{CNP}^-\rvert$	52.27		0.0000	131.41		0.0000
$\lvert\beta_{UR}^+\rvert = \lvert\beta_{UR}^-\rvert$	45.02		0.0000	3.65		0.0574
$\lvert\beta_{CS}^+\rvert = \lvert\beta_{CS}^-\rvert$				13.26		0.0004

Table 14 – *Continued*

Panel C: Volatility	Gold $RV_{t_{i+1}}$			Silver $RV_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic
8:30	UR^-	−0.1812	−2.52**	UR^-	−0.5921	−7.91***
	CNP^+	0.3912	6.11***	UR^+	0.6279	3.97***
	CNP^-	−0.3032	−3.11***	PI^-	0.1405	1.82*
	UR^+	0.2654	2.48**	Intercept	0.2332	6.26***
	ARS^-	−0.0799	−1.86*			
	Intercept	0.1389	6.04***			
	Adj. R^2	0.4301		Adj. R^2	0.2950	
	F-statistic	32.45***		F-statistic	27.15***	
9:15	IP^-	−0.0254	−1.71*	Intercept	0.1465	5.03***
	Intercept	0.1054	9.54***			
	Adj. R^2	0.0537		Adj. R^2	0.1469	
	F-statistic	2.93*		F-statistic	6.86**	
10:00	ISM^+	0.1458	4.20***	ISM^+	0.1063	2.36**
	NHS^-	−0.1022	−2.91***	NHS^-	−0.1076	−2.35**
	Intercept	0.1340	7.60***	Intercept	0.1932	9.10***
	Adj. R^2	0.1163		Adj. R^2	0.0596	
	F-statistic	9.11***		F-statistic	4.91**	
Wald test of equality of coefficients						
Null Hypothesis	Chi-square		p-value	Chi-square		p-value
$\lvert\beta_{CNP}^+\rvert = \lvert\beta_{CNP}^-\rvert$	27.96		0.0000			
$\lvert\beta_{UR}^+\rvert = \lvert\beta_{UR}^-\rvert$	9.57		0.0022	47.27		0.0000

Table 15
Impact of macroeconomic news announcements on 25-minute realized volatility

The table reports the results from the stepwise regressions specified by equation (7). The stepwise regressions choose only the announcement variables which have an impact on the 25-minute realized volatility of commodity futures at the 10% significance level. RV_{25} denotes the 25-minute post-announcement realized volatility. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 for abbreviations of different macroeconomic announcements.

	Gold RV_{25}			Silver RV_{25}			Aluminum RV_{25}			Copper RV_{25}		
	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic
21:30	ABS(CNP)	0.3928	6.2305***	ABS(UR)	0.3108	3.1288***	ABS(ARS)	−0.0479	−1.7422*	ABS(UR)	0.1674	6.2462***
	ABS(UR)	0.1233	1.7529*	ABS(CNP)	0.3126	3.7974***	Intercept	0.0830	3.6293***	Intercept	0.0890	4.8765***
	Intercept	0.1715	4.2507***	Intercept	0.2506	7.3096***						
	Adj. R^2	0.5032		Adj. R^2	0.3908		Adj. R^2	0.1148		Adj. R^2	0.3408	
	F-statistic	29.6901***		F-statistic	26.1225***		F-statistic	6.1205***		F-statistic	16.2586***	
23:00	ABS(ISM)	0.0761	2.9648***	ABS(NHS)	0.0864	2.5818**	Intercept	0.0728	7.8290***	Intercept	0.0805	7.9265***
	ABS(NHS)	0.0463	2.1027**	ABS(LI)	0.0615	2.0820**						
	Intercept	0.1253	7.4236***	Intercept	0.1086	5.7285***						
	Adj. R^2	0.0801		Adj. R^2	0.0920		Adj. R^2	0.2521		Adj. R^2	0.1809	
	F-statistic	5.7927***		F-statistic	6.1760***		F-statistic	56.5245***		F-statistic	38.2643***	

Table 16
Asymmetric impact of macroeconomic news announcements on 25-minute realized volatility

The table reports the results from the stepwise regressions, for the asymmetric response of news on realized volatility, specified by equation (10). The stepwise regressions choose only the announcement variables which have an impact on the 25-minute realized volatility of commodity futures at the 10% significance level. RV_{25} denotes the 25-minute post-announcement realized volatility. The results of tests for equality of coefficients on positive and negative surprises are also reported if both of them are significant. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 for abbreviations of different macroeconomic announcements.

	Gold RV_{25}			Silver RV_{25}			Aluminum RV_{25}			Copper RV_{25}		
	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic
21:30	CNP^+	0.4275	7.1926***	UR^+	1.3907	6.4625***	ARS^-	0.0628	1.8254*	UR^-	−0.2015	−7.0026***
	UR^+	0.7387	4.8098***	UR^-	−0.3409	−4.7652***	Intercept	0.0725	3.3322***	CNP^+	0.0553	1.9625*
	UR^-	−0.2984	−5.6310***	CNP^+	0.3072	3.4729***				Intercept	0.0825	4.7839***
	Intercept	0.2137	9.8325***	Intercept	0.2106	6.9275***						
	Adj. R^2	0.5868		Adj. R^2	0.4865		Adj. R^2	0.1186		Adj. R^2	0.4386	
	F-statistic	41.2339***		F-statistic	26.2874***		F-statistic	6.0025**		F-statistic	18.0264***	
23:00	NHS^-	−0.1016	−3.1686***	NHS^-	−0.1092	−2.3208**	CC^-	0.0365	1.8184*	ISM^-	−0.0627	−1.8263*
	ISM^+	0.1021	3.9533***	LI^-	−0.1258	−2.5238**	Intercept	0.0531	6.2641***	Intercept	0.0926	8.0261***
	Intercept	0.0927	6.5304***	Intercept	0.1302	7.5244***						
	Adj. R^2	0.1086		Adj. R^2	0.0926		Adj. R^2	0.6825		Adj. R^2	0.1722	
	F-statistic	10.2471***		F-statistic	7.0251***		F-statistic	26.3719***		F-statistic	16.0902***	

Wald test of equality of coefficients

Null hypothesis	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value
$\lvert\beta_{UR}^+\rvert = \lvert\beta_{UR}^-\rvert$	36.2981	0.0000	48.2610	0.0000				

Appendix A

Table A1

Tests of equality in mean returns, volumes, and volatilities around macroeconomic news announcements for agricultural futures

The table reports mean values of returns, volumes, and realized volatilities for cotton, palm oil, soybean, and sugar futures surrounding the US macroeconomic news announcements at 21:30, 22:15, and 23:00. Returns (in %) and volumes (i.e., number of contracts traded) of commodity futures are computed over five-minute intervals, whereas realized volatilities (in %) are computed over 15-minute intervals before and after three pre-scheduled news announcement times. The tests of equality in mean returns, volumes, and realized volatilities are based on the Welch t-test. The first and second t-statistics in the Welch t-test column are for tests comparing mean values before and after announcements, and for control and study samples, respectively. The third and fourth t-statistics in the Welch t-test column are for tests comparing mean values of control and study samples, and before and after announcements, respectively. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016.

Cotton	Sample	21:30 Announcement		Test of equality in means	22:15 Announcement		Test of equality in means	23:00 Announcement		Test of equality in means
		21:25-21:30	21:30-21:35	Welch t-test	22:10-22:15	22:15-22:20	Welch t-test	22:55-23:00	23:00-23:05	Welch t-test
Returns	Control	−0.0120	0.0019	0.8755	−0.0001	0.0021	0.2234	−0.0003	0.0089	1.0708
	Study	−0.0024	−0.0214	−1.1567	0.0348	−0.0312	−0.9342	0.0017	−0.0098	−0.8983
	Difference	0.0097		0.6347	0.0349		0.6672	0.0020		0.2036
	Difference		−0.0233	−1.3640		−0.0333	−0.6860		−0.0187	−1.5738
Volume	Control	3984	4339	0.4657	4359	3583	−1.3547	2703	2901	0.3903
	Study	1894	2213	0.7355	6635	5749	−0.2058	2196	2876	0.7824
	Difference	−2090		−4.0253***	2276		0.7002	−507		−0.8418
	Difference		−2126	−3.0117***		2166	0.7533		−25	−0.0302
		21:15−21:30	21:30−21:45		22:00−22:15	22:15−22:30		22:45−23:00	23:00−23:15	
Realized volatility	Control	0.1951	0.1656	−1.7099*	0.2135	0.1600	−3.5398***	0.1346	0.1312	−0.2863
	Study	0.1315	0.1089	−1.3350	0.2244	0.1672	−0.9325	0.1268	0.1155	−0.7076
	Difference	−0.0636		−3.6100***	0.0109		0.2157	−0.0079		−0.5101
	Difference		−0.0567	−3.4281***		0.0072	0.1899		−0.0158	−1.2529
Palm oil	Sample	21:30 Announcement		Test of equality in means	22:15 Announcement		Test of equality in means	23:00 Announcement		Test of equality in means
		21:25−21:30	21:30−21:35	Welch t-test	22:10−22:15	22:15−22:20	Welch t-test	22:55−23:00	23:00−23:05	Welch t-test
Returns	Control	0.0054	0.0236	1.0967	−0.0075	0.0010	0.7104	0.0057	−0.0129	−2.0201**
	Study	0.0076	−0.0135	−1.2185	−0.0384	−0.0450	−0.1126	−0.0165	0.0218	1.8796*
	Difference	0.0022		0.1483	−0.0309		−0.6523	−0.0222		−1.2493
	Difference		−0.0371	−1.9640*		−0.0460	−1.2154		0.0348	2.5546**
Volume	Control	11557	16161	3.9429***	12539	11307	−1.4932	9243	9590	0.5021
	Study	7497	8865	0.9352	12206	11825	−0.1196	9629	10055	0.3159
	Difference	−4060		−3.6491***	−333		−0.1463	386		0.3676
	Difference		−7296	−4.8493***		518	0.2166		465	0.4245
		21:15−21:30	21:30−21:45		22:00−22:15	22:15−22:30		22:45−23:00	23:00−23:15	
Realized volatility	Control	0.2047	0.2244	0.9391	0.2504	0.1797	−4.1373***	0.1673	0.1681	0.0846
	Study	0.1379	0.1368	−0.0653	0.2444	0.1904	−0.9733	0.1630	0.1671	0.2183
	Difference	−0.0668		−3.2302***	−0.0060		−0.1263	−0.0043		−0.2798
	Difference		−0.0876	−5.0364***		0.0107	0.3196		−0.0010	−0.0696

Table A1 – *Continued*

Soybean	Sample	21:30 Announcement		Test of equality in means	22:15 Announcement		Test of equality in means	23:00 Announcement		Test of equality in means
		21:25-21:30	21:30-21:35	Welch t-test	22:10-22:15	22:15-22:20	Welch t-test	22:55-23:00	23:00-23:05	Welch t-test
Returns	Control	0.0136	0.0097	−0.2074	0.0141	−0.0009	−1.3352	−0.0015	0.0021	0.4439
	Study	−0.0111	−0.0109	0.0141	−0.0234	−0.0002	0.6676	−0.0270	0.0112	1.5927
	Difference	−0.0247		−1.4295	−0.0376		−1.4565	−0.0255		−1.2787
	Difference		−0.0206	−1.1666		0.0007	0.0273		0.0091	0.5849
Volume	Control	2531	3413	1.6724*	2427	2285	−0.5673	1703	1921	1.0729
	Study	1264	1230	−0.1048	2156	1519	−1.1708	2369	2299	−0.0849
	Difference	−1267		−2.9127***	−271		−0.5784	666		1.0169
	Difference		−2183	−4.9477***		−766	−2.0581**		378	0.7048
		21:15−21:30	21:30−21:45		22:00−22:15	22:15−22:30		22:45−23:00	23:00−23:15	
Realized volatility	Control	0.1875	0.1790	−0.4415	0.2218	0.1587	−4.3871***	0.1371	0.1384	0.1331
	Study	0.1161	0.1100	−0.3283	0.2282	0.1525	−1.5407	0.1512	0.1443	−0.2776
	Difference	−0.0715		−3.4123***	0.0065		0.1690	0.0141		0.6741
	Difference		−0.0691	−4.1610***		−0.0062	−0.1824		0.0058	0.3436
Sugar	Sample	21:30 Announcement		Test of equality in means	22:15 Announcement		Test of equality in means	23:00 Announcement		Test of equality in means
		21:25−21:30	21:30−21:35	Welch t-test	22:10−22:15	22:15−22:20	Welch t-test	22:55−23:00	23:00−23:05	Welch t-test
Returns	Control	−0.0030	0.0080	0.9364	0.0064	0.0124	0.7101	0.0011	−0.0078	−1.4384
	Study	−0.0186	0.0059	0.8788	−0.0239	−0.0304	−0.1768	0.0022	0.0014	−0.0520
	Difference	−0.0155		−0.7858	−0.0303		−1.0717	0.0010		0.1079
	Difference		−0.0021	−0.0929		−0.0428	−1.7416*		0.0092	0.7032
Volume	Control	17980	17357	−0.3863	17231	16740	−0.4559	11563	12626	1.2339
	Study	21250	17937	−0.8732	20685	21685	0.1422	11984	14984	1.4816
	Difference	3270		0.9261	3454		1.0367	421		0.3533
	Difference		580	0.2725		4945	0.7864		2358	1.2741
		21:15−21:30	21:30−21:45		22:00−22:15	22:15−22:30		22:45−23:00	23:00−23:15	
Realized volatility	Control	0.1580	0.1379	−1.4149	0.1953	0.1304	−4.6619***	0.1138	0.1175	0.5408
	Study	0.1423	0.1501	0.2917	0.1827	0.1471	−0.7580	0.1117	0.1196	0.5952
	Difference	−0.0157		−0.7390	−0.0126		−0.3904	−0.0022		−0.2269
	Difference		0.0122	0.5626		0.0167	0.4530		0.0022	0.1870

Table A2
Impact of macroeconomic news announcements on returns for agricultural futures: Univariate regressions

The table reports the results from the univariate regressions specified by equation (4) in the main paper. $R_{t_{i+1}}$ denotes the five-minute post-announcement return. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 in the main paper for abbreviations of different macroeconomic announcements.

Time	Macroeconomic announcements	Cotton $R_{t_{i+1}}$			Palm oil $R_{t_{i+1}}$			Soybean $R_{t_{i+1}}$			Sugar $R_{t_{i+1}}$		
		$\hat{\beta}_j$	t-statistic	Adj. R^2	$\hat{\beta}_j$	t-statistic	Adj. R^2	$\hat{\beta}_j$	t-statistic	Adj. R^2	$\hat{\beta}_j$	t-statistic	Adj. R^2
21:30	ARS	0.0041	0.0700	−0.0082	0.0118	0.1500	−0.1084	−0.1488	−1.1800	0.0335	0.0377	0.3300	−0.0982
	CNP	−0.0637	−0.8800	−0.0018	0.0977	0.8600	−0.0243	0.0850	0.7600	−0.0500	−0.0002	0.0000	−0.1000
	CPI	0.0246	0.4100	−0.0068	0.0657	0.4600	−0.0646	0.0086	0.0900	−0.0661	−0.0104	−0.1400	−0.0699
	DGO	0.0817	0.9000	−0.0016	−0.0707	−0.5700	−0.0474	−0.0931	−0.6800	−0.0370	−0.1406	−0.6400	−0.0436
	HS	−0.0792	−1.3400	0.0064	0.0265	0.2300	−0.0942	−0.2122	−2.2400**	0.2115	0.0597	0.7400	−0.0315
	PC	0.0606	0.5000	−0.0061	0.7230	2.6600**	0.3559	0.3021	1.0700	0.0116	−0.1711	−0.7900	−0.0318
	PI	−0.0595	−0.5700	−0.0055	0.0378	0.1500	−0.1219	−0.1805	−0.8200	−0.0480	0.0550	0.2800	−0.1144
	PPI	0.0175	0.3200	−0.0072	0.0157	0.1600	−0.0810	−0.0814	−1.0000	0.0005	−0.1302	−1.4000	0.0744
	TB	−0.0471	−0.8000	−0.0029	0.1690	1.1200	0.0203	0.1397	1.5600	0.0932	−0.0277	−0.1900	−0.0801
	UR	−0.0583	−0.6400	−0.0048	0.2130	1.4000	0.1594	0.2330	1.0700	0.0360	−0.1533	−1.3000	0.1037
22:15	CU	−0.0984	−1.7300*	0.1100	−0.0830	−1.9400*	0.1473	−0.0075	−0.2300	−0.0628	−0.0318	−1.0600	0.0080
	IP	−0.1084	−2.1400**	0.1823	−0.0295	−0.6700	−0.0353	−0.0258	−0.8800	−0.0142	−0.0221	−0.7800	−0.0248
23:00	BI	0.0148	0.6600	−0.0063	−0.0770	−0.7100	−0.0465	−0.0422	−0.4300	−0.0889	0.1464	1.6100	0.1381
	CC	−0.0102	−0.4900	−0.0085	0.0351	0.2700	−0.0920	−0.2049	−1.9700*	0.1823	−0.0680	−0.5900	−0.0525
	CS	0.0035	0.1500	−0.0110	0.0628	0.5400	−0.0692	0.1406	0.6500	−0.1076	−0.0071	−0.0500	−0.1107
	FO	0.0035	0.1300	−0.0110	−0.2976	−2.5000**	0.3235	−0.0855	−0.5400	−0.0760	0.1543	1.1600	0.0300
	LI	−0.0142	−0.6600	−0.0063	−0.0573	−0.5300	−0.0704	0.1829	1.9300*	0.1850	0.1011	1.3200	0.0640
	ISM	−0.0460	−1.0400	0.0009	0.1807	0.8500	−0.0257	0.3118	0.8300	−0.0540	−0.4994	−3.1500***	0.4484
	NHS	0.0017	0.0700	−0.0112	0.0414	0.3700	−0.0709	0.1080	1.4000	0.0683	−0.0172	−0.1400	−0.0654

Table A3
Impact of macroeconomic news announcements on returns for agricultural futures: Stepwise regressions

The table reports the results from the stepwise regressions specified by equation (5) in the main paper. The stepwise regressions choose only announcement variables which have an impact on the five-minute returns of commodity futures at the 10% significance level. $R_{t_{i+1}}$ denotes the five-minute post-announcement return. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 in the main paper for abbreviations of different macroeconomic announcements.

	Cotton $R_{t_{i+1}}$			Palm oil $R_{t_{i+1}}$			Soybean $R_{t_{i+1}}$			Sugar $R_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic
21:30	UR	−0.0927	−1.7579*	Intercept	−0.0135	−1.0117	ARS	−0.0741	−3.2375***	CNP	−0.1398	−2.7145***
	TB	−0.0513	−1.7024*				Intercept	−0.0202	−1.8047*	HS	0.1331	2.2261**
	Intercept	−0.0266	−2.0948**							Intercept	0.0314	1.5097
	Adj. R^2	0.0941		Adj. R^2	0.0000		Adj. R^2	0.1956		Adj. R^2	0.1956	
	F-statistic	3.0779*		F-statistic	0.0000		F-statistic	10.4811***		F-statistic	5.8623***	
22:15	IP	−0.1084	−2.1373**	CU	−0.0830	−1.9401*	Intercept	−0.0002	−0.0067	Intercept	−0.0304	−1.2706
	Intercept	−0.0664	−1.4296	Intercept	−0.0707	−1.9394*						
	Adj. R^2	0.1823		Adj. R^2	0.1473		Adj. R^2	0.0000		Adj. R^2	0.0000	
	F-statistic	4.5680**		F-statistic	3.7640*		F-statistic	0.0000		F-statistic	0.0000	
23:00	Intercept	−0.0098	−0.9589	Intercept	0.0218	1.8417*	BI	−0.0538	−1.7305*	Intercept	0.0014	0.1129
							Intercept	0.0137	0.9633			
	Adj. R^2	0.0000		Adj. R^2	0.0000		Adj. R^2	0.0406		Adj. R^2	0.0000	
	F-statistic	0.0000		F-statistic	0.0000		F-statistic	2.9946**		F-statistic	0.0000	

Table A4
Impact of macroeconomic news announcements on volume for agricultural futures: Stepwise regressions

The table reports the results from the stepwise regressions specified by equation equation (6) in the main paper. The stepwise regressions choose only announcement variables which have an impact on the five-minute volume of commodity futures at the 10% significance level. $V_{t_{i+1}}$ denotes the five-minute post-announcement trading volume. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 in the main paper for abbreviations of different macroeconomic announcements.

	Cotton $V_{t_{i+1}}$			Palm oil $V_{t_{i+1}}$			Soybean $V_{t_{i+1}}$			Sugar $V_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic
21:30	Intercept	879.45	1.86*	Intercept	1767.73	0.96	ABS(ARS)	489.22	2.24**	Intercept	11392.85	5.06***
							Intercept	125.41	0.80			
	Adj. R^2	0.24		Adj. R^2	0.34		Adj. R^2	0.73		Adj. R^2	0.28	
	F-statistic	13.64***		F-statistic	21.50***		F-statistic	35.33***		F-statistic	16.62***	
22:15	Intercept	587.40	0.90	Intercept	−374.56	−0.27	Intercept	133.32	0.50	ABS(IP)	24539.99	3.45***
										Intercept	−34630.51	−3.70***
	Adj. R^2	0.96		Adj. R^2	0.88		Adj. R^2	0.73		Adj. R^2	0.76	
	F-statistic	212.72***		F-statistic	117.25***		F-statistic	44.23***		F-statistic	25.79***	
23:00	Intercept	−87.98	−0.22	Intercept	1355.72	1.22	Intercept	559.84	2.52**	Intercept	8226.67	3.11***
	Adj. R^2	0.77		Adj. R^2	0.51		Adj. R^2	0.65		Adj. R^2	0.10	
	F-statistic	103.10***		F-statistic	47.01***		F-statistic	165.64***		F-statistic	10.75***	

Table A5
Impact of macroeconomic news announcements on volatility for agricultural futures: Stepwise regressions

The table reports the results from the stepwise regressions specified by equation equation (7) in the main paper. The stepwise regressions choose only announcement variables which have an impact on the 15-minute realized volatility of commodity futures at the 10% significance level. $RV_{t_{i+1}}$ denotes the 15-minute post-announcement realized volatility. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 in the main paper for abbreviations of different macroeconomic announcements.

	Cotton $RV_{t_{i+1}}$			Palm oil $RV_{t_{i+1}}$			Soybean $RV_{t_{i+1}}$			Sugar $RV_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic
21:30	ABS(HS)	0.0810	2.2133**	Intercept	0.1368	11.8033***	ABS(UR)	0.1464	2.4998**	ABS(UR)	0.2983	3.9943***
	Intercept	0.1002	8.4075***				Intercept	0.1035	8.9625***	Intercept	0.1309	7.3439***
	Adj. R^2	0.0888		Adj. R^2	0.0000		Adj. R^2	0.1186		Adj. R^2	0.2721	
	F-statistic	4.8988**		F-statistic	0.0000		F-statistic	6.2491**		F-statistic	15.9541***	
22:15	Intercept	0.0632	1.3636	Intercept	0.1022	2.1254**	Intercept	0.0527	0.9791	Intercept	0.1471	4.0662***
	Adj. R^2	0.3291		Adj. R^2	0.2084		Adj. R^2	0.1945		Adj. R^2	0.0000	
	F-statistic	8.8496***		F-statistic	5.2114**		F-statistic	4.8637**		F-statistic	0.0000	
23:00	Intercept	0.0539	4.9290***	ABS(CS)	0.0823	2.9498***	ABS(CS)	0.0711	2.6491***	Intercept	0.1196	11.4611***
				Intercept	0.1150	6.0159***	Intercept	0.0613	4.0755***			
	Adj. R^2	0.3982		Adj. R^2	0.1084		Adj. R^2	0.1397		Adj. R^2	0.0000	
	F-statistic	60.5507***		F-statistic	7.8794***		F-statistic	35.7176***		F-statistic	0.0000	

Table A6
Asymmetric impact of macroeconomic news announcements on returns for agricultural futures

The table reports the results from the stepwise regressions, for the asymmetric response of news on returns, specified by equation (8) in the main paper. The stepwise regressions choose only announcement variables which have an impact on the five-minute returns of commodity futures at the 10% significance level. $R_{t_{i+1}}$ denotes the five-minute post-announcement return. The results of tests for equality of coefficients on positive and negative surprises are also reported if both of them are significant. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 in the main paper for abbreviations of different macroeconomic announcements.

	Cotton $R_{t_{i+1}}$			Palm oil $R_{t_{i+1}}$			Soybean $R_{t_{i+1}}$			Sugar $R_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic
21:30	HS^+	0.2841	3.4881***	DGO^+	−0.2453	−2.6167**	ARS^-	−0.0741	−3.2375***	HS^+	0.4930	4.1969***
	TB^-	−0.0564	−1.9217*	Intercept	−0.0035	−0.2657	Intercept	−0.0202	−1.8047*	UR^-	0.2067	2.3221**
	UR^-	−0.1043	−1.7583*							CNP^+	−0.0886	−1.9554*
	Intercept	−0.0401	−3.2877***							Intercept	0.0117	0.6506
	Adj. R^2	0.2682		Adj. R^2	0.1304		Adj. R^2	0.1956		Adj. R^2	0.4296	
	F-statistic	5.8873**		F-statistic	6.8471**		F-statistic	10.4811***		F-statistic	11.0424***	
22:15	CU^+	−0.2321	−2.1220**	CU^+	−0.4606	−4.9959***	Intercept	−0.0002	−0.0067	CU^+	−0.1908	−3.2997***
	Intercept	0.0179	0.3634	IP^+	0.2999	3.8915***				CU^-	0.0861	1.8775*
				Intercept	−0.0177	−0.6580				Intercept	0.0549	1.4617
	Adj. R^2	0.1796		Adj. R^2	0.5894		Adj. R^2	0.0000		Adj. R^2	0.3572	
	F-statistic	4.5030*		F-statistic	12.4847***		F-statistic	0.0000		F-statistic	5.4458**	
23:00	Intercept	−0.0098	−0.9589	Intercept	0.0218	1.8417*	LI^-	−0.0837	−1.8069*	Intercept	0.0014	0.1129
							BI^+	−0.0581	−1.7235*			
							Intercept	0.0105	0.7114			
	Adj. R^2	0.0000		Adj. R^2	0.0000		Adj. R^2	0.0481		Adj. R^2	0.0000	
	F-statistic	0.0000		F-statistic	0.0000		F-statistic	3.2982*		F-statistic	0.0000	

Wald test of equality of coefficients

Null hypothesis	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value
$\lvert\beta_{CU}^+\rvert = \lvert\beta_{CU}^-\rvert$							9.1478	0.0091

Table A7
Asymmetric impact of macroeconomic news announcements on volume for agricultural futures

The table reports the results from the stepwise regressions, for the asymmetric response of news on trading volume, specified by equation (9) in the main paper. The stepwise regressions choose only announcement variables which have an impact on the five-minute volume of commodity futures at the 10% significance level. $V_{t_{i+1}}$ denotes the five-minute post-announcement trading volume. The results of tests for equality of coefficients on positive and negative surprises are also reported if both of them are significant. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 in the main paper for abbreviations of different macroeconomic announcements.

	Cotton $V_{t_{i+1}}$			Palm oil $V_{t_{i+1}}$			Soybean $V_{t_{i+1}}$			Sugar $V_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic
21:30	Intercept	879.45	1.86*	Intercept	1767.73	0.96	ARS$^-$	−489.22	−2.24**	HS$^+$	50668.96	6.22***
							Intercept	125.41	0.80	CNP$^+$	5927.24	1.98*
										Intercept	5926.95	2.90***
	Adj. R^2	0.24		Adj. R^2	0.34		Adj. R^2	0.73		Adj. R^2	0.65	
	F-statistic	13.64***		F-statistic	21.50***		F-statistic	35.33***		F-statistic	19.17***	
22:15	Intercept	587.40	0.90	Intercept	−374.56	−0.27	IP$^-$	663.33	2.18**	IP$^+$	30433.91	4.17***
							Intercept	490.31	1.69	IP$^-$	−20928.39	−2.76**
										Intercept	−35038.62	−3.77***
	Adj. R^2	0.96		Adj. R^2	0.88		Adj. R^2	0.78		Adj. R^2	0.80	
	F-statistic	212.72***		F-statistic	117.25***		F-statistic	29.99***		F-statistic	16.70***	
23:00	Intercept	−87.98	−0.22	Intercept	727.05	0.67	Intercept	559.84	2.52**	Intercept	8226.67	3.11
	Adj. R^2	0.77		Adj. R^2	0.60		Adj. R^2	0.84		Adj. R^2	0.10	
	F-statistic	103.10***		F-statistic	70.67***		F-statistic	472.21***		F-statistic	10.75***	
Wald test of equality of coefficients												
Null hypothesis		Chi-square	p-value		Chi-square	p-value		Chi-square	p-value		Chi-square	p-value
$\lvert\beta_{IP}^+\rvert = \lvert\beta_{IP}^-\rvert$											15.38	0.00

Table A8
Asymmetric impact of macroeconomic news announcements on volatility for agricultural futures

The table reports the results from the stepwise regressions, for the asymmetric response of news on realized volatility, specified by equation (10) in the main paper. The stepwise regressions choose only the announcement variables which have an impact on the 15-minute realized volatility of commodity futures at the 10% significance level. $RV_{t_{i+1}}$ denotes the 15-minute post-announcement realized volatility. The results of tests for equality of coefficients on positive and negative surprises are also reported if both of them are significant. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 in the main paper for abbreviations of different macroeconomic announcements.

	Cotton $RV_{t_{i+1}}$			Palm oil $RV_{t_{i+1}}$			Soybean $RV_{t_{i+1}}$			Sugar $RV_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic
21:30	DGO^+	0.2658	3.4689***	PPI^+	0.1253	2.5861**	UR^-	−0.1920	−2.3829**	UR^+	0.3320	3.0299***
	HS^+	0.1328	1.8316*	HS^-	0.0782	1.9550*	PPI^-	−0.0590	−1.7658*	UR^-	−0.2387	−2.9484***
	HS^-	−0.0845	−2.3774**	Intercept	0.1351	11.9043***	Intercept	0.1026	9.0165***	HS^+	0.3951	3.7107***
	Intercept	0.0877	7.8339***							CNP^+	0.0828	1.9886*
	Adj. R^2	0.2791		Adj. R^2	0.1339		Adj. R^2	0.1445		Adj. R^2	0.4664	
	F-statistic	6.1630***		F-statistic	4.0139**		F-statistic	4.2930**		F-statistic	9.7415***	
22:15	CU^+	0.1361	1.9279*	CU^+	0.2808	3.0699***	CU^+	0.1629	2.5808**	IP^+	0.2787	2.7444**
	Intercept	0.0387	0.8687	IP^+	−0.1710	−2.2345**	Intercept	0.0316	0.6786	CU^+	−0.2262	−1.8615*
				Intercept	0.0808	1.9699*				Intercept	0.1297	3.6596***
	Adj. R^2	0.4320		Adj. R^2	0.4712		Adj. R^2	0.4152		Adj. R^2	0.2617	
	F-statistic	7.0847***		F-statistic	5.7532***		F-statistic	6.6798***		F-statistic	3.8359**	
23:00	Intercept	0.0539	4.9290***	CS^-	−0.0756	−2.1366**	CS^-	−0.1152	−3.8380***	LI^-	−0.0741	−2.0641**
				ISM^+	0.2076	1.7659*	Intercept	0.0603	4.2191***	Intercept	0.1150	10.9542***
				CC^+	0.0628	1.6777*						
				Intercept	0.1060	5.5038***						
	Adj. R^2	0.3982		Adj. R^2	0.1740		Adj. R^2	0.4750		Adj. R^2	0.0350	
	F-statistic	60.5507***		F-statistic	5.7926***		F-statistic	42.1612***		F-statistic	4.2603**	

Wald test of equality of coefficients

Null hypothesis	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value
$\lvert\beta_{UR}^+\rvert = \lvert\beta_{UR}^-\rvert$								
$\lvert\beta_{HS}^+\rvert = \lvert\beta_{HS}^-\rvert$	6.8797	0.0126					41.4925	0.0000

Table A9
Impact of macroeconomic news announcements on 25-minute realized volatility for agricultural futures

The table reports the results from the stepwise regressions specified by equation (7) in the main paper. The stepwise regressions choose only announcement variables which have an impact on the 25-minute realized volatility of commodity futures at the 10% significance level. RV_{25} denotes the 25-minute post-announcement realized volatility. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 in the main paper for abbreviations of different macroeconomic announcements.

	Cotton RV_{25}			Palm oil RV_{25}			Soybean RV_{25}			Sugar RV_{25}		
	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic
21:30	ABS(HS)	0.0780	2.3502**	Intercept	0.1402	10.3521***	ABS(UR)	0.1310	2.3622**	ABS(UR)	0.2758	3.8961***
	Intercept	0.1305	8.9428***				Intercept	0.0962	7.2756***	Intercept	0.1285	7.1093***
	Adj. R^2	0.1028		Adj. R^2	0.0000		Adj. R^2	0.1205		Adj. R^2	0.2592	
	F-statistic	4.6352**		F-statistic	0.0000		F-statistic	5.9739**		F-statistic	12.4724***	
23:00	Intercept	0.0634	4.9902***	ABS(CS)	0.0782	3.1241***	ABS(CS)	0.0834	2.9240***	Intercept	0.1008	10.2657***
				Intercept	0.1365	6.8346***	Intercept	0.0732	6.0980***			
	Adj. R^2	0.3728		Adj. R^2	0.0988		Adj. R^2	0.1512		Adj. R^2	0.0000	
	F-statistic	55.8209***		F-statistic	7.1062***		F-statistic	32.9750***		F-statistic	0.0000	

Table A10
Asymmetric impact of macroeconomic news announcements on 25-minute realized volatility for agricultural futures

The table reports the results from the stepwise regressions, for the asymmetric response of news on realized volatility, specified by equation (10) in the main paper. The stepwise regressions choose only the announcement variables which have an impact on the 25-minute realized volatility of commodity futures at the 10% significance level. RV_{25} denotes the 25-minute post-announcement realized volatility. The results of tests for equality of coefficients on positive and negative surprises are also reported if both of them are significant. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 in the main paper for abbreviations of different macroeconomic announcements.

	Cotton RV_{25}			Palm oil RV_{25}			Soybean RV_{25}			Sugar RV_{25}		
	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic
21:30	DGO^+	0.2520	3.0857***	PPI^+	0.1328	2.9260**	UR^-	−0.1879	−2.1906**	UR^+	0.3402	3.6955***
	HS^+	0.1382	1.9202*	HS^-	0.0837	2.2805*	PPI^-	−0.0548	−1.7102*	UR^-	−0.2406	−3.0176***
	HS^-	−0.0905	−2.7291**	Intercept	0.1295	9.2710***	Intercept	0.0926	8.3710***	HS^+	0.37238	3.5298***
	Intercept	0.0725	6.2758***							CNP^+	0.0795	1.8752*
	Adj. R^2	0.2682		Adj. R^2	0.1408		Adj. R^2	0.1642		Adj. R^2	0.4208	
	F-statistic	5.9274***		F-statistic	4.5278**		F-statistic	6.0625**		F-statistic	8.9268***	
23:00	Intercept	0.0634	4.9902***	CS^-	−0.0728	−2.0856**	CS^-	−0.1202	−3.9808***	LI^-	−0.0716	−2.0120**
				ISM^+	0.2162	1.8620*	Intercept	0.0720	4.4282***	Intercept	0.1078	10.1003***
				CC^+	0.0638	1.6608*						
				Intercept	0.1208	5.9265***						
	Adj. R^2	0.3728		Adj. R^2	0.1827		Adj. R^2	0.4328		Adj. R^2	0.0560	
	F-statistic	55.8209***		F-statistic	6.2653***		F-statistic	39.1720***		F-statistic	5.0812**	

Wald test of equality of coefficients

Null hypothesis	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value
$\lvert\beta_{UR}^+\rvert = \lvert\beta_{UR}^-\rvert$							38.5694	0.0000
$\lvert\beta_{HS}^+\rvert = \lvert\beta_{HS}^-\rvert$	8.2754	0.0102						

Table A11
Impact of macroeconomic news announcements on volatility (estimated by absolute price changes)

The table reports the results from the stepwise regressions specified by equation (7) in the main paper. The stepwise regressions choose only announcement variables which have an impact on the 15-minute realized volatility, estimated by the absolute price changes of commodity futures, at the 10% significance level. $RV_{t_{i+1}}$ denotes the 15-minute post-announcement realized volatility. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 in the main paper for abbreviations of different macroeconomic announcements.

	Gold $RV_{t_{i+1}}$			Silver $RV_{t_{i+1}}$			Aluminum $RV_{t_{i+1}}$			Copper $RV_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic
21:30	ABS(CNP)	0.4433	8.0123***	ABS(UR)	0.2126	2.4265**	ABS(ARS)	−0.0483	−1.8225*	ABS(UR)	0.1945	6.7416***
	Intercept	0.1551	6.3019***	ABS(CNP)	0.3967	5.2531***	Intercept	0.0953	4.2855***	Intercept	0.0887	6.1425***
				Intercept	0.2397	6.9089***						
	Adj. R^2	0.4260		Adj. R^2	0.3464		Adj. R^2	0.1884		Adj. R^2	0.3635	
	F-statistic	64.0920***		F-statistic	47.8563***		F-statistic	5.1245**		F-statistic	23.6723***	
22:15	Intercept	0.0731	10.0631***	Intercept	0.1364	7.5573***	Intercept	0.0578	7.3451***	Intercept	0.1325	10.8465***
	Adj. R^2	0.0000		Adj. R^2	0.0000		Adj. R^2	0.1097		Adj. R^2	0.0000	
	F-statistic	0.0000		F-statistic	0.0000		F-statistic	9.1436***		F-statistic	0.0000	
23:00	ABS(ISM)	0.0842	3.3248***	ABS(NHS)	0.0781	2.7486***	Intercept	0.0724	10.6837***	Intercept	0.0638	6.5673***
	ABS(NHS)	0.0609	2.8032***	ABS(LI)	0.0690	2.1424**						
	Intercept	0.0622	5.0533***	Intercept	0.1042	5.3642***						
	Adj. R^2	0.0943		Adj. R^2	0.0902		Adj. R^2	0.2922		Adj. R^2	0.1532	
	F-statistic	7.3210***		F-statistic	6.5832***		F-statistic	54.6356***		F-statistic	29.2926***	

Table A11 – *Continued*

	Cotton $RV_{t_{i+1}}$			Palm oil $RV_{t_{i+1}}$			Soybean $RV_{t_{i+1}}$			Sugar $RV_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic	Optimal regressors	$\hat{\beta}_j$	t-statistic
21:30	ABS(HS)	0.0934	2.6156***	Intercept	0.1463	10.6374***	ABS(UR)	0.1526	2.9462***	ABS(UR)	0.2682	3.4518***
	Intercept	0.0956	8.0956***				Intercept	0.1356	9.5342***	Intercept	0.1493	9.3422***
	Adj. R^2	0.1154		Adj. R^2	0.0000		Adj. R^2	0.1312		Adj. R^2	0.2913	
	F-statistic	5.0947**		F-statistic	0.0000		F-statistic	6.9535**		F-statistic	18.2622***	
22:15	Intercept	0.0735	1.5341	Intercept	0.0947	2.3298**	Intercept	0.0415	0.8533	Intercept	0.1671	6.2564***
	Adj. R^2	0.3095		Adj. R^2	0.2409		Adj. R^2	0.1758		Adj. R^2	0.0000	
	F-statistic	9.8445***		F-statistic	6.8512***		F-statistic	5.9322**		F-statistic	0.0000	
23:00	Intercept	0.0639	4.9681***	ABS(CS)	0.0952	3.2514***	ABS(CS)	0.0827	2.8591***	Intercept	0.1025	9.1142***
				Intercept	0.0976	5.0759***	Intercept	0.0534	4.5289***			
	Adj. R^2	0.3782		Adj. R^2	0.1148		Adj. R^2	0.1578		Adj. R^2	0.0000	
	F-statistic	53.5522***		F-statistic	10.4522***		F-statistic	42.1865***		F-statistic	0.0000	

Table A12
Asymmetric impact of macroeconomic news announcements on volatility (estimated by absolute price changes)

The table reports the results from the stepwise regressions, for the asymmetric response of news on realized volatility, specified by equation (10) in the main paper. The stepwise regressions choose only the announcement variables which have an impact on the 15-minute realized volatility, estimated by the absolute price changes of commodity futures, at the 10% significance level. $RV_{t_{i+1}}$ denotes the 15-minute post-announcement realized volatility. The results of tests for equality of coefficients on positive and negative surprises are also reported if both of them are significant. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from July 2013 to June 2016. See also Table 2 in the main paper for abbreviations of different macroeconomic announcements.

	Gold $RV_{t_{i+1}}$			Silver $RV_{t_{i+1}}$			Aluminum $RV_{t_{i+1}}$			Copper $RV_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic
21:30	CNP^+	0.4222	6.8741***	UR^+	1.4208	7.1580***	ARS^-	0.0612	2.1841**	UR^-	−0.2150	−6.9862***
	CNP^-	−0.4058	4.9617***	CNP^-	−0.2902	−4.1629***	Intercept	0.0598	3.0625***	CNP^+	0.0516	1.8812*
	UR^+	0.7264	4.5728***	CNP^+	0.3406	3.9866***				Intercept	0.0986	5.2587***
	Intercept	0.1441	6.4522***	Intercept	0.2019	6.8920***						
	Adj. R^2	0.5335		Adj. R^2	0.4668		Adj. R^2	0.1108		Adj. R^2	0.4285	
	F-statistic	33.3241***		F-statistic	29.9052***		F-statistic	5.1259**		F-statistic	21.0572***	
22:15	Intercept	0.0731	10.0631***	CU^-	−0.0825	−2.5620**	Intercept	0.0578	7.3451***	Intercept	0.1325	10.8465***
				Intercept	0.0955	2.9724**						
	Adj. R^2	0.0000		Adj. R^2	0.1628		Adj. R^2	0.1962		Adj. R^2	0.0000	
	F-statistic	0.0000		F-statistic	6.5820***		F-statistic	8.2752***		F-statistic	0.0000	
23:00	NHS^-	−0.1359	−4.5285***	NHS^-	−0.1285	−3.1428***	CC^-	0.0382	2.5629**	ISM^-	−0.0720	−1.9259*
	ISM^+	0.1090	3.9835***	LI^-	−0.0985	−2.0327**	Intercept	0.0527	8.1262***	Intercept	0.0902	9.4280***
	Intercept	0.0626	5.0472***	Intercept	0.0826	6.5722***						
	Adj. R^2	0.1682		Adj. R^2	0.1326		Adj. R^2	0.6620		Adj. R^2	0.2052	
	F-statistic	13.5782***		F-statistic	9.2751***		F-statistic	29.4572***		F-statistic	19.2720***	

Wald test of equality of coefficients

Null hypothesis	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value
$\lvert\beta_{CNP}^+\rvert = \lvert\beta_{CNP}^-\rvert$	0.0167	0.8965	0.0725	0.7926				

Table A12 – *Continued*

	Cotton $RV_{t_{i+1}}$			Palm oil $RV_{t_{i+1}}$			Soybean $RV_{t_{i+1}}$			Sugar $RV_{t_{i+1}}$		
	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic	Optimal regressors	$\hat{\beta}_j^+(\hat{\beta}_j^-)$	t-statistic
21:30	DGO^+	0.2382	3.2685***	PPI^+	0.1274	2.6210**	UR^-	−0.2030	−2.7310**	UR^+	0.3608	3.7280***
	HS^+	0.1482	2.8624**	HS^-	0.0984	2.4527**	PPI^-	−0.0536	−1.7026*	UR^-	−0.2260	−2.6258**
	Intercept	0.0936	8.1352***	Intercept	0.0925	7.2871***	Intercept	0.1026	9.0165***	HS^+	0.3625	3.5840***
										CNP^+	0.0926	2.0527**
	Adj. R^2	0.2827		Adj. R^2	0.1480		Adj. R^2	0.1364		Adj. R^2	0.4329	
	F-statistic	6.2759***		F-statistic	5.2751**		F-statistic	4.0926**		F-statistic	9.2610***	
22:15	CU^+	0.1275	1.8937*	CU^+	0.2946	3.2627***	CU^+	0.1834	2.9846**	IP^+	0.2525	2.6522**
	Intercept	0.0520	1.2641	IP^+	−0.1862	−2.5269**	Intercept	0.0843	0.7392	CU^+	−0.2574	−2.1780*
				Intercept	0.0946	2.1752*				Intercept	0.0956	2.7452***
	Adj. R^2	0.4628		Adj. R^2	0.4309		Adj. R^2	0.3927		Adj. R^2	0.3240	
	F-statistic	8.9210***		F-statistic	5.9275***		F-statistic	7.2075***		F-statistic	4.6287**	
23:00	Intercept	0.0639	4.9681***	CS^-	−0.0926	−2.5236**	CS^-	−0.1027	−3.5728***	LI^-	−0.0926	−2.3980**
				ISM^+	0.2309	2.0074*	Intercept	0.0838	4.9173***	Intercept	0.0920	8.2856***
				CC^+	0.0686	1.7343*						
				Intercept	0.0527	4.8025***						
	Adj. R^2	0.3782		Adj. R^2	0.2506		Adj. R^2	0.4276		Adj. R^2	0.0524	
	F-statistic	53.5522***		F-statistic	14.2751***		F-statistic	39.5720***		F-statistic	5.2807**	

Wald test of equality of coefficients

Null hypothesis	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value	Chi-square	p-value
$\lvert\beta_{UR}^+\rvert = \lvert\beta_{UR}^-\rvert$							39.7302	0.0000