Trader Attention and Market Reaction to Fundamental News: Evidence from Natural Gas Futures

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Abstract

This paper examines the effect of trader attention on the response of the natural gas market to weekly U.S. Energy Information Administration announcements regarding changes in natural gas inventories. We find that lower trader attention hinders price discovery in the natural gas futures market. Based on our daily regression estimates, the market responds 74% weaker to inventory announcements released on Fridays, compared to those released on Thursdays. We attribute the findings to a lower trader attention in the natural gas market on Fridays compared to other weekdays. The results remain robust after controlling for the withdrawal and injection seasons in the natural gas market.

Keywords: Attention; Natural gas futures; Inventory announcements; Market reaction

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1. Introduction

Attention is a limited cognitive resource that helps investors process information and can impact their trading behavior. Prior attention related research has mainly focused on the stock market and has shown that investor attention is a key determinant for stock prices (Andrei and Hasler, 2015; Boulland and Dessaint, 2017; Lim and Teoh, 2010). In the same line of thought, investor distraction in the presence of several stimuli or attention-grabbing events can also impact stock prices. For example, investors tend to be more distracted when a greater number of firms release their earnings news on the same day (Hirshleifer, Lim, and Teoh, 2009),[1] when firms pre-announce the report date of their earnings on short notice (Boulland and Dessaint, 2017), around holidays (Hood and Lesseig, 2017), and also on Fridays, in anticipation of the impending weekend (DellaVigna and Pollet, 2009; Louis and Sun, 2010). Prior literature shows that investor inattention weakens the stock market response to earnings announcements and strengthens the post-announcement drift (Hirshleifer, Lim, and Teoh, 2009; Boulland and Dessaint, 2017; Ben-Rephael, Da, and Israelsen, 2017).

Our paper investigates whether trader attention in the natural gas market affects the response of the natural gas futures to fundamental news. We aim to contribute to the growing body of literature on investor attention (Fedyk, 2024; Barber and Odean, 2008; Cohen and Frazzini, 2008; Hirshleifer and Teoh, 2003; Huberman and Regev, 2001; Peng and Xiong, 2006, among others). Prior research has mainly focused on attention in the stock market and has shown that attention affects the trading behavior of both retail (Barber and Odean, 2008) and more sophisticated investors (Fedyk, 2024). In our case, natural gas is a consumption commodity and

[1] On the contrary, Hirshleifer and Sheng (2022) show that macro news and firm earnings news are attention complements. They find a stronger stock market response to earnings news and a weaker post-announcement drift, on days with macroeconomic news releases.

behaves differently from financial assets such as stocks. The price of consumption commodities is primarily influenced by demand and supply forces via the inventory channel. By far the most important fundamental news for the natural gas market is the weekly release of the natural gas inventory announcement. We find that greater investor attention in the natural gas market facilitates the response of the natural gas market to inventory announcements.

Despite the importance of the natural gas inventory release, in some circumstances, investors seem to be inattentive even to this fundamental news. The weekly natural gas storage report (WNGSR) is released by the U.S. Energy Information Administration (EIA) usually on Thursdays, at 10:30 a. m. Eastern Time. If a federal national holiday falls on a Thursday, then the inventory announcement is typically released either one day prior to or after the Thursday holiday, that is, either on a Wednesday or Friday. We show that on Fridays investors are distracted by the upcoming weekend and pay less attention to the natural gas inventory release. Consequently, the natural gas market does not incorporate the inventory news as quickly on Fridays as it does on Wednesdays or Thursdays. Our results show that lower investor attention on Fridays weakens the natural gas market response to weekly inventory releases.

The notion that investors are distracted on Fridays because of the approaching weekend has been examined in the literature mostly for the stock market. Prior research shows that in the stock market, investor inattention on Friday hinders price adjustment to corporate news (DellaVigna and Pollet, 2009; Louis and Sun, 2010). Investors initially underreact to fundamental information released in the stock market on Fridays. Later, investors understand they had neglected some information and then trade accordingly. DellaVigna and Pollet (2009) find a 70% stronger delayed stock response to earnings announcements released on Fridays than on other weekdays, while Louis and Sun (2010) find a weaker stock market response to corporate merger

announcements made on Fridays compared to announcements made on other weekdays. Both of these papers attribute their findings to lower investor attention on Fridays compared to other days of the week. In contrast, Michaely, Rubin, and Vedrashko (2016) argue that a weaker stock market response to Friday corporate announcements such as dividend changes, earnings, seasoned equity offerings, share repurchases, and mergers is the outcome of selection bias rather than investor inattention. Firms making announcements on Fridays also tend to have a weaker market response to the announcements released on other weekdays. We contribute to this strand of research by providing evidence that a Friday effect exists in the natural gas market. Our findings are not the result of selection bias. The date of the natural gas inventory release is not related to the importance of the announcement, but rather to whether a federal holiday falls on a Thursday.[2] We show that in the natural gas market, a greater investor distraction on Fridays delays the full price adjustment of natural gas futures to inventory releases. The magnitude of this effect is economically large. On the announcement day, the natural gas futures market responds 74% weaker to inventory announcements that are released on Fridays compared to those released on Thursdays.

Our main measure of investor attention is based on the Google Trends Search Volume Index (SVI) for 'natural gas' and mainly captures the attention of retail investors (according to Ben-Rephael, Da and Israelsen (2017)). The SVI on inventory announcement days is on average 57% lower on Fridays compared to Thursdays. We also consider the number of articles related to natural gas that were published on the Bloomberg platform (i.e., Bloomberg news heat or BB) to capture the attention of institutional investors (as in Boguth, Grégoire, and Martineau (2019)). The BB measure on inventory announcement days is significantly lower on Fridays than on Thursdays. In addition, we also find that analysts tend to pay lower attention to inventory news released on

[2] The release schedule is known in advance: https://ir.eia.gov/ngs/schedule.html.

Friday, compared to those released earlier during the week. The analysts provide a smaller number of forecasts for the inventory news released on Fridays, compared to those released on other weekdays. This specific pattern of investor attention we observe in the natural gas market is consistent with the literature on investor attention in the stock market, according to which investors pay less attention to the stock market on Fridays than on other weekdays (DellaVigna and Pollet, 2009).

We also examine other potential explanations for the weaker natural gas market response to WNGSR releases besides trader inattention, such as a lower information content of Friday surprises, greater disagreement among analysts regarding Friday surprises, stronger pre-announcement effect for Friday releases, and a holiday effect. Our findings do not support these alternative explanations. Overall, we find that trader attention in the natural gas market is lower on Friday announcement days and so leads to a weaker market response to inventory news. Traders need more time to fully process new information, when this information is released on Fridays.

Our paper also contributes to the natural gas pricing literature by showing that the response of natural gas prices to fundamental information depends on the level of investor attention in the natural gas market. Prior research finds clear evidence that the fundamental information released through the weekly EIA announcements regarding the natural gas inventories is crucial for the natural gas prices (Chiou-Wei, Linn, and Zhu, 2014) and the volatility of natural gas prices on announcement days (Linn and Zhu, 2004). Gay, Simkins, and Turac (2009) and Halova, Kurov and Kucher (2014) show that the response of the natural gas futures market to inventory news is weaker in withdrawal season. Gu and Kurov (2018) find evidence of informed trading in the natural gas futures market 90 minutes prior to the release of these inventory announcements. We contribute to this literature by showing that the response of the natural gas futures market to

inventory releases depends on the level of investor attention. The market response to inventory releases is weaker for Friday announcements, compared to non-Friday announcements. When the natural gas inventory announcement is released on a Friday, there is a delayed market response to the news, compared to announcements made earlier in the week. We attribute this finding to the lower investor attention in the natural gas market on Fridays, relative to other weekdays.

The rest of the paper is structured as follows. Section 2 describes our data. Sections 3 and 4 discuss our empirical results, while Section 5 concludes.

2. Data

2.1. Natural Gas Storage Announcements

The U.S. Energy Information Administration (EIA) provides a weekly report on the changes in the working natural gas in underground storage in the lower 48 U.S. states and the five U.S. regions (East, Midwest, Mountain, Pacific, South Central), for the prior week ending on Friday. Each week, the EIA collects survey data from a sample of underground natural gas storage operators regarding the working gas in storage as of 9 a. m. Central Time on the Friday of the prior week. About 133 operators provide information, at approximately 410 storage fields. This information is generally shared with the EIA by 5 p. m. Eastern Time of the following Monday, or by 5 p. m. Eastern Time of the following Tuesday if that Monday is a federal holiday. Then, the standard weekly EIA public release time for these reports is Thursdays at 10:30 a. m. Eastern Time, unless noted differently. Natural gas storage announcements are not publicly released by the EIA on national federal holidays such as Christmas Day, New Year's Day, Inauguration Day, Veterans Day, Thanksgiving Day, National Independence Day, etc. If such a national holiday falls on a

Thursday, then the natural gas storage announcements are generally publicly released either one day before or after the holiday, that is, either on Wednesdays or Fridays.

Our sample period includes 1,120 WNGSR releases from May 2002 until December 2023. Table 1 reveals that about 94.23% of the announcements in our analysis, that is 1,062 announcements, were released on the standard Thursday announcement day. A smaller proportion of about 2.93% (2.77%) of announcements, that is 33 (31) natural gas storage announcements are released on Wednesdays (on Fridays). Only one announcement was released on Tuesday, October 22, 2013.

[Insert Table 1 about here]

Prior literature shows that the natural gas market immediately incorporates the natural gas inventory announcement released every week (Chiou-Wei, Linn, and Zhu, 2014). To be more precise, the market responds to the unexpected portion of the WNGSR announcement. We follow Gu and Kurov (2018) and proxy the market expectations regarding the change in natural gas inventories by the Bloomberg consensus forecast.[3] Then, we measure the unexpected component of the announcement, or the announcement surprise (S), by the difference between the actual released change in the natural gas storage (A) and the Bloomberg consensus forecast (F).

$$S_t = A_t - F_t \tag{1}$$

We conjecture that investor attention can affect the natural gas market response to the WNGSR releases. We anticipate that when investor attention is low, the natural gas market takes longer to fully incorporate the WNGSR news. Our conjecture is in line with the prior research on investor attention in the stock market, where higher (lower) investor attention was found to

[3] About 20 analysts submit their predictions regarding the change in natural gas storage every week. The Bloomberg consensus forecast is the median of these analysts' forecasts.

facilitate (weaken) price adjustment to news (Ben-Rephael, Da, and Israelsen, 2017; DellaVigna and Pollet, 2009; Louis and Sun, 2010).

2.2. Investor Attention around the Release of Natural Gas Storage Announcements

We mainly measure investor attention in the natural gas market based on the Google Trends Search Volume Index (SVI) for 'natural gas' worldwide in the Finance category. Within the Finance category, we use the Commodities & Futures Trading subcategory. Daily SVI data can be downloaded for a period of less than or equal to eight months at a time. The SVI is scaled so that the maximum value of 100 represents the peak of search activity for the given search term during the selected period. We download daily SVI data for seven-month periods with one-month overlaps. We then use the first period as a base and add the newer data six months at a time. In this process, we use the mean of the ratio of the overlapping SVI values to rescale the SVI in the newly added six-month period. After constructing the SVI for the entire sample period, we rescale it, so that the maximum value is 100. Since the Google Trends data has many missing values in the early part of our sample period, the sample of the SVI data begins in January 2010. A higher level of SVI denotes an increased level of interest and attention towards natural gas. Our measure of investor attention reflects the interest of potential traders in the natural gas market, revealed through the online search volume.

Figure 1 shows the average daily level of investor attention over the window [-2 days; +2 days] around the release of natural gas storage reports. Day 0 denotes the announcement day of the natural gas storage report. We distinguish among releases occurring on Wednesdays, Thursdays, and Fridays. Over the window [-2 days; +2 days] around the release of the WNGSR, investor attention is the greatest on day 0, that is on the announcement day, and then declines immediately after. On announcement days, the average investor attention is the greatest on

Thursday announcement days and is the lowest on Friday announcement days. This particular pattern of investor attention we observe in the natural gas market is somewhat consistent with the prior literature on investor attention in the stock market, according to which investors pay less attention to the stock market on Fridays than on other weekdays (DellaVigna and Pollet, 2009).

[Insert Figure 1 about here]

3. Market Reaction to the Natural Gas Storage Report

3.1. Daily Analysis

To investigate the response of the natural gas market to inventory releases, we first use an event study approach to examine the daily and intraday response to such releases. We estimate the regression in equation (2) over our entire sample period.

$$R_t = a_0 + b_1 AnnWed_t + b_2 AnnFri_t + b_3 Withdrawal_t + c_1 S_t + c_2 S_t AnnWed_t + c_3 S_t AnnFri_t + c_4 S_t Withdrawal_t + e_t \quad (2)$$

R_t is the daily return (expressed in percent) on the Henry Hub natural gas futures, while S_t is the natural gas inventory surprise for announcement day t, calculated as described in Section 2. $AnnWed$ ($AnnFri$) is a dummy variable which equals one when the natural gas storage report is released on Wednesdays (Fridays) and takes values of zero otherwise. The coefficient c_1 captures the response of the natural gas futures market to WNGSR releases that occur on the regular Thursday announcement days. The coefficients c_2 and c_3 measure the difference in the market response to WNGSR announcements that are released on Wednesday and Friday, respectively, relative to the market response to the announcements made on Thursday. The model also includes a $Withdrawal$ dummy which equals one when the natural gas storage report is released during the withdrawal season and takes values of zero otherwise. We include this variable because natural

gas storage levels have a strong seasonality (e.g., Gu and Kurov, 2018). More precisely, storage levels rise during the injection season (from the month of April to October) and fall during the withdrawal season (from the month of November to March).[4] Gay, Simkins, and Turac (2009) and Halova, Kurov and Kucher (2014) show that the response of the natural gas futures market to inventory news is weaker in withdrawal season. By adding the $Withdrawal$ dummy to our regression and by interacting it with the surprise S_t, we can test whether the natural gas market responds differently to WNGSR releases during injection and withdrawal seasons.

[Insert Table 2 about here]

The estimates for the model in (2) are reported in Table 2. The natural gas futures market responds negatively to a positive surprise S_t in natural gas storage levels, released on a typical Thursday announcement day. This result is expected. Greater than expected storage levels for natural gas reveal either a lower-than-expected natural gas demand or larger supply, and so it has a negative impact on natural gas prices. Column (3) of Table 2 reveals that this negative impact is somewhat weaker during the withdrawal season, compared to the injection season. The positive and significant estimate of coefficient c_3 from the same column denotes a weaker reaction of the natural gas market to WNGSR announcements released on Friday, relative to those released on Thursday. The sum of the c_1 and c_3 estimates (about -0.052 and statistically insignificant) further indicates that the overall reaction of the natural gas market to Friday news is small. We attribute the weaker market response to Friday announcements to a lower investor attention on Fridays, relative to Thursdays. Consistent with the previous literature (Gay, Simkins, and Turac, 2009;

[4] In the U.S. from April to October, the demand for natural gas decreases while production continues. The excess of natural gas can then be stored leading to an increase in inventories. This period is known as the injection season. During colder months, usually from November to March, due to an increased demand for heating, the demand for natural gas also increases, and so inventories decrease. This period is known as the withdrawal season.

Halova, Kurov and Kucher, 2014), we also find that the natural gas market response to inventory surprises is weaker during the withdrawal season, compared to the injection season.[5]

The negative and significant estimate of coefficient c_2 from column (3) of Table 2 reveals that the natural gas market reacts stronger to releases of the natural gas storage report on Wednesdays relative to Thursdays. We associate this stronger reaction to the release of other EIA important announcements on Wednesdays. The EIA releases the weekly Petroleum Status Report on Wednesdays at 10:30 a.m. Eastern Time.[6] The release of the crude oil inventory announcement on Wednesdays, the most important weekly information in the commodity market, could facilitate the incorporation process of the simultaneously released natural gas storage information. This is in line with the findings of Hirshleifer and Sheng (2022), who show that the stock market's response to firm specific news is stronger on days with important macroeconomic releases.

3.2. Intraday Analysis

Prior research shows that the natural gas market responds to the WNGSR very quickly, in a matter of minutes. For instance, Gay, Simkins, and Turac (2009) and Halova, Kurov, and Kucher (2014) find a significant market response to WNGSR in the 15-minute interval containing the announcement. In our paper, to understand better the role of investor attention on the natural gas market response to WNGSR, we also perform our analysis at the intraday level.

To visualize the adjustment of the natural gas futures prices to inventory news, we plot the cumulative average returns (CARs) of the nearby natural gas futures contract in an intraday event window around the announcement. Following Gu and Kurov (2018), we multiply the returns for positive surprises by minus one. This allows aggregating CARs for negative and positive surprises.

[5] The regression results are very similar when using the outlier-robust MM estimator of Yohai (1987) instead of OLS.
[6] https://www.eia.gov/petroleum/supply/weekly/schedule.php

Figure 2 plots the CAR in the interval from three hours before the announcement to three hours after the announcement separately for the WNGSR announcements released on Thursdays, Wednesdays, and Fridays. Consistent with Gu and Kurov (2018), the figure shows some evidence of pre-announcement drift in the direction of the market response to the announcement. For the regular Thursday announcements, this drift amounts to about 0.2% on average, and the overall market move before and after the announcement is about 1% on average. The average market reaction to inventory news released on Fridays is noticeably smaller, and some of it seems to reverse in the three hours after the announcement. This finding is consistent with the insignificant average response to Friday announcements based on the daily regression results reported in Table 2.

[Insert Figure 2 about here]

We re-run the regression in (2) where R_t now denotes the 5-minute return (expressed in percent) on the natural gas futures right after the natural gas announcement.[7] The other variables in the model remain the same. The results are reported in Table 3. These results are consistent with our previous findings. We find a negative response of the natural gas futures market to a positive surprise S_t in natural gas storage levels, released on a typical Thursday announcement day. The negative response is weaker during the withdrawal season, compared to the injection season. Also, the market response to WNGSR releases is stronger for announcements released on Wednesdays, and weaker for announcements released on Fridays, compared to the announcements released on Thursdays.

[Insert Table 3 about here]

[7] The results remain similar if we alternatively calculate the natural gas futures return R_t over the 15-minute window after the natural gas inventory announcement.

3.3. Bootstrapping

To assess the robustness of our findings and to alleviate potential concerns regarding the small number of announcements released on Wednesdays and Fridays, we replicate the bootstrapping approach used by Lucca and Moench (2015) and analyze the empirical distribution of the key coefficient estimates in model (2). Specifically, we draw 1,000 random samples with replacement from the natural gas futures returns, natural gas storage surprises and all dummy variables for Wednesday, Friday and Withdrawal seasons. For each sample, we estimate equation (2) and compute the mean and standard deviation of the estimated coefficients for c_1, c_2 and c_3. The bootstrapping results reported in Table 4 are similar to the baseline estimates from Tables 2 and 3.

[Insert Table 4 about here]

4. Causes of the Weaker Reaction to Friday Announcements

What drives our previous findings? Why do we observe a weaker market response to natural gas storage reports released on Fridays, compared to those released on Thursdays? In this section, we investigate several potential explanations for our findings: lower investor attention on Fridays, lower information content of Friday surprises, greater disagreement among analysts regarding Friday surprises, longer information processing time for Friday releases, pre-announcement effect, and holiday effect.

4.1. Investor Attention Around Natural Gas Storage Announcements

We first investigate whether the weaker natural gas market response to inventory announcements released on Friday is associated with investor attention being lower on Fridays, compared to other weekdays. The Friday effect is well documented in the stock market (DellaVigna and Pollet, 2009; Louis and Sun, 2010). Traders in the stock market are found to be distracted on Fridays due to the

upcoming weekend. They tend to pay less attention to news released on Fridays, leading to a reduced stock market response to Friday announcements (DellaVigna and Pollet, 2009; Louis and Sun, 2010).

To test whether traders pay less attention to the natural gas inventory news on Fridays, we use an event study methodology and estimate the regression in (3). The dependent variable Y_t denotes either the number of estimates provided by economists regarding the changes in natural gas storage, the Google Trends Search Volume (SVI) for 'natural gas', or the natural logarithm of the number of articles related to natural gas that were published on the Bloomberg platform (BB). Analyst coverage can be informative about the attention of analysts with respect to natural gas storage release. Google Trends SVI has been associated in the literature with retail investor attention (Ben-Rephael, Da and Israelsen, 2017), while the Bloomberg news heat has been used in the literature as a proxy for institutional investors' attention (Boguth, Grégoire, and Martineau, 2019). As independent variables, we use $AnnWed$ ($AnnFri$), which is a dummy variable taking values of one when the natural gas storage report is released on Wednesdays (Fridays) and values of zero otherwise. $Withdrawal$ is a dummy variable which equals one when the natural gas storage report is released during the withdrawal season and takes values of zero otherwise. The regression uses data only for inventory announcement days.

$$Y_t = a_0 + b_1 AnnWed_t + b_2 AnnFri_t + b_3 Withdrawal_t + e_t \quad (3)$$

The regression estimates reported in Table 5 reveal that analysts tend to pay lower attention to natural gas inventory news released on Friday, compared to those released on Thursday. Fewer analysts provide estimates for Friday announcements compared to Thursday announcements. Also, fewer analysts provide forecasts during the withdrawal season, compared to the injection season. When the SVI is the dependent variable, the Google search volume for the term 'natural gas' is

significantly lower on Friday announcement days compared to Thursday announcement days. That is, retail investor attention is significantly lower on Fridays relative to Thursdays. The same pattern is observed for the attention of institutional investors ('BB' column), who seem to be significantly more inattentive on Fridays relative to Thursdays. Overall, the results of our event study analysis are consistent with the hypothesis that trader attention in the natural gas market is lower on Friday announcement days.

[Insert Table 5 about here]

4.2. Disagreement among Analysts and the Accuracy of Analysts Forecasts

Lobo, Song, and Stanford (2017) find a stronger investor reaction to earnings news when there is a greater consensus among analysts regarding their earnings forecast revisions. Similarly, in our paper, a greater disagreement among analysts regarding their forecasts for the Friday natural gas storage releases compared to Thursday releases could also lead to a weaker response of natural gas futures to Friday versus Thursday announcements. The accuracy of these analyst forecasts, or the informational content of the inventory surprise, might also play a role. If Friday inventory releases are less informative (the inventory surprise is smaller in magnitude, the analysts' forecast are more accurate) compared to Thursday releases, this could also lead to a weaker market response to Friday versus Thursday news. Here we investigate these two potential alternative explanations, by re-running the regression in (3) and using as dependent variable either the level of disagreement among the analysts making forecasts for the upcoming release (i.e., the standard deviation of the analysts' forecasts) or the accuracy of these forecasts (i.e., the absolute value of the announcement surprise). The results reported in Table 6 show no significant difference in the standard deviation of the forecasts made by analysts for announcements released on Fridays or Wednesdays, compared to those released on Thursdays. That is, there is no significant difference in the

disagreement among these analysts regarding natural gas storage announcements made on different weekdays. Furthermore, we do not observe a significant difference in the accuracy of the analysts' estimates for announcements made on Fridays or Wednesdays, relative to the announcements made on Thursdays. Overall, the results show that the disagreement among analysts or the information content of the WNGSR release are unlikely to cause the weaker response of the natural gas market to inventory releases on Fridays.

[Insert Table 6 about here]

4.3. Delayed Market Reaction to Natural Gas Storage Releases

The weaker market reaction to Friday inventory announcements may be explained by the longer information processing time for Friday versus non-Friday announcements. Friday announcements are followed by a two-day break, and so investors might need more time to process the information. To test this explanation, we first investigate whether there is a delay in the natural gas market response to inventory releases and whether the delay varies for different announcement days. We re-run the regression (2) in a slightly different setup. This time, R_t denotes the continuously compounded futures return (expressed in percent) calculated from the announcement day close to the open of the next trading day.[8]

The estimation results are reported in Panel A of Table 7 and show that the natural gas futures market continues to adjust to the WNGSR news even after the close of the announcement day. The positive and significant coefficients c_1 from columns (2) and (3) of Table 7 reveal that there seems to be a small adjustment, a correction in the initial negative (Table 2) market response to an increased S_t. In other words, the positive coefficient c_1 reveals a correction to an initial

[8] The daily closing price in the natural gas futures market is determined at about 2:30 p.m. ET and the opening time is 6:00 p.m. ET.

market overreaction to Thursday announcements. We attribute this finding to greater investor attention on the regular Thursday announcement day compared to other weekdays. The negative and significant coefficients c_3 from columns (2) and (3) of the same table also show that the natural gas futures market continues to adjust to the natural gas storage releases made on Fridays, even after the close of the announcement day. The negative coefficient c_3 provides evidence of a delayed reaction in the market response to inventory announcements released on Friday. We do not observe a significant coefficient for c_2 in columns (2) or (3) of Table 7. That is, there seems to be no significant adjustment in the market response to Wednesday releases, after the announcement day close.

[Insert Table 7 about here]

Next, we re-run the regression in (2), where R_t denotes the continuously compounded futures return (expressed in percent) calculated from the previous day close (day prior to announcement day) to the open of the next trading day (i.e., the day following the announcement day). The wider time window allows traders more time to respond and thereby reduce the underreaction to natural gas storage news. The results are shown in Panel B of Table 7. The market responds negatively to a positive surprise in the natural gas storage report in the wide window. The Friday effect becomes weaker, if we compare the smaller size of the estimate of c_3 from Table 7 with the size of the same coefficient estimate in Table 2. However, the market response is still weaker for announcements released on Friday, compared to those released on Thursday. These findings reveal that giving traders more time to process the information cannot fully explain the apparent underreaction to Friday announcements. Furthermore, when using the wide time window, there is no statistically significant difference in the response of the natural gas market to Wednesday releases relative to Thursday announcements.

4.4. Pre-Announcement Effect

The weaker natural gas market response to Friday versus Thursday inventory releases could also be the result of a pre-announcement effect. Gu and Kurov (2018) show that natural gas futures start to adjust to information in natural gas storage reports 90 minutes before the announcement, due to informed trading. If we find evidence that this pre-announcement drift exists for Friday announcements only, or that the pre-announcement drift is stronger for Friday versus Thursday releases, this could potentially explain the weaker response of natural gas futures to Friday inventory announcements.

To investigate this potential explanation, we re-run the regression in (2) where R_t denotes the continuously compounded futures return (expressed in percent) calculated from 90 minutes before announcement to 5 minutes before announcement. The regression estimates are reported in Table 8. We find evidence of a significant pre-announcement drift in the natural gas futures market, consistent with Gu and Kurov (2018). That is, the natural gas futures market seems to respond to the WNGSR releases before the announcement release time. The findings hold for Thursday announcements (the coefficient c_1 is negative and significant at the 1% significance level), but also for Wednesday and Friday releases (as revealed by the negative sum of the coefficients $c_1 + c_2$ and $c_1 + c_3$). However, the pre-announcement drift is not stronger for Friday versus Thursday announcements. In conclusion, the pre-announcement effect does not seem to explain our previous findings from Section 3.1. of a weaker market response of natural gas futures to Friday versus Thursday releases.

[Insert Table 8 about here]

4.5. Friday Effect vs. Post-Holiday Effect

Our findings so far reveal a weaker market response to inventory news released on Fridays and we attribute the findings to lower investor attention in the natural gas market on Fridays compared to other weekdays. However, there might be concerns that investor attention is lower on Friday announcement days not because the announcement day is a Friday but rather because it is the day following a federal holiday.[9] To alleviate these concerns and to distinguish between a Friday effect and a potential post-holiday effect, we estimate the following regression:

$$R_t = a_0 + \mathrm{c}_1 Holiday_t + c_2 S_t + \mathrm{c}_3 S_t Holiday_t + e_t, \quad (4)$$

where R_t denotes the natural gas futures return, while S_t is the natural gas inventory surprise for the Thursday announcement day t. $Holiday_t$ is a dummy variable, which is equal to one for the regular WNGSR Thursday announcements that are released after a federal holiday (i.e., the day prior to the announcement is a federal holiday) and equal to zero for the regular WNGSR Thursday announcements that are not preceded by a federal holiday. If we observe a weaker market response to the WNGSR announcements that are released one day after a federal holiday, compared to regular releases (on Thursdays that do not follow after a Wednesday holiday), this would be evidence of a post-holiday effect in the market response to inventory news.

The regression results are shown in Table 9. R_t denotes the daily return (expressed in percent) on the natural gas futures in column (1) of Table 9 and denotes the 5-minute return (expressed in percent) on the natural gas futures right after the natural gas announcement in column (2) of the same table. The intraday results from column (2) reveal no significant difference in the response of the natural gas market to Thursday announcements that follow a federal holiday, compared to regular Thursday announcements (i.e., those that do not follow a federal holiday). If

[9] The WNGSR are released usually every week on Thursday. WNGSR are released on Fridays (and sometimes Wednesdays) if Thursday is a federal holiday.

we expand the time window we look at and examine the daily results from Panel A, we do not observe a weaker market response to WNGSR releases on the Thursdays following a federal holiday, compared to regular Thursdays. These results show that following a federal holiday, we would not necessarily expect a weaker market response to WNGSR news. That is, we do not find evidence supporting a post-holiday effect.[10] Overall, this additional test solidifies our previous finding that a weaker natural gas market response to inventory news released on Fridays is due to lower investor attention to Friday announcements.

[Insert Table 9 about here]

5. Conclusion

This paper provides evidence that the level of investor attention in the natural gas market facilitates the price discovery process in this market. We investigate the response of natural gas futures to weekly natural gas storage report (WNGSR) releases and find that greater investor attention strengthens the market response to such news.

Even though the WNGSR release is the most important fundamental news for the natural gas market, we provide evidence that traders are inattentive even to this news when the announcement is released on Fridays. We observe a weaker market reaction to natural gas inventory news released on Fridays compared to other weekdays and attribute the finding to lower investor attention on Fridays relative to other days of the week.

Our findings can improve our understanding of the role played by investor attention in financial markets. The findings have implications for various stakeholders, including traders,

[10] A shortcoming of our test is the fact that the natural gas inventory news released on Thursdays following a federal holiday may be accompanied by the simultaneous release of other EIA important announcements, such as the weekly Petroleum Status report. Crude oil inventory announcements are usually scheduled for release on Wednesdays, but when Wednesday is a federal holiday, the crude oil inventory news can be released on Thursday as well.

academic scholars, and regulators. Commodity traders may use investor attention as a signal in trading strategies, betting that commodity prices will gradually adjust to fundamental news after Friday announcements. In addition, the dynamics of investor attention can provide insights into the microstructure of commodity markets, improving our understanding of price formation around news releases. Lastly, our findings could benefit regulators, as they can monitor investor attention as part of their efforts to promote reliable price discovery in commodity futures markets.

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Table 1. Natural Gas Storage Announcements Released on Various Weekdays

Announcement Day	% of announcements	Nr. of Announcements
Wednesday	2.93%	33
Thursday	94.23%	1062
Friday	2.75%	31

The table reports the number of natural gas storage announcements released on various days of the week. The sample period is from May 2002 until December 2023. [11]

[11] Our subsequent empirical analysis only includes 29 Friday announcements, because there are no trading data for natural gas futures for two Friday announcements: July 05, 2002 and November 29, 2002.

Table 2. Event Study Regression with Daily Returns

	(1)	(2)	(3)
$Intercept$	-0.356 (0.099)***	-0.393 (0.101)***	-0.238 (0.124)*
$AnnWed$		0.309 (0.570)	0.514 (0.583)
$AnnFri$		0.064 (0.623)	0.285 (0.653)
$Withdrawal$			-0.374 (0.208)*
S	-0.133 (0.015)***	-0.134 (0.015)***	-0.197 (0.025)***
$S * AnnWed$		-0.106 (0.074)	-0.146 (0.075)**
$S * AnnFri$		0.163 (0.048)***	0.145 (0.044)***
$S * Withdrawal$			0.103 (0.030)***
$c_1 + c_2$		-0.241 (0.073)***	-0.343 (0.079)***
$c_1 + c_3$		0.029 (0.046)	-0.052 (0.048)
N	1120	1120	1120
$Adj\ R^2$*(%)*	11.57	12.48	14.10

The table reports the estimates for the following model: $R_t = a_0 + b_1 AnnWed_t + b_2 AnnFri_t + b_3 Withdrawal_t + c_1 S_t + c_2 S_t AnnWed_t + c_3 S_t AnnFri_t + c_4 S_t Withdrawal_t + e_t$, where R_t denotes the daily return (expressed in percent) on the natural gas futures, while S_t is the natural gas inventory surprise for announcement day *t*. $AnnWed$ ($AnnFri$) is a dummy variable which equals one when the natural gas storage report is released on Wednesdays (Fridays) and takes values of zero otherwise. $Withdrawal$ is a dummy variable which equals one when the natural gas storage report is released during the withdrawal season and takes values of zero otherwise. The sample period is from May 2002 through December 2023 and contains 1,120 announcements. The regressions are estimated using OLS with the White (1980) heteroskedasticity consistent covariance matrix. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% significance levels, respectively.

Table 3. Event Study Regression with Intraday Returns

	(1)	(2)	(3)
$Intercept$	-0.114 (0.040)***	-0.127 (0.041)***	-0.061 (0.053)
$AnnWed$		-0.049 (0.165)	0.034 (0.170)
$AnnFri$		0.269 (0.256)	0.371 (0.250)
$Withdrawal$			-0.153 (0.082)*
S	-0.103 (0.007)***	-0.105 (0.008)***	-0.143 (0.015)***
$S * AnnWed$		-0.020 (0.015)	-0.045 (0.015)***
$S * AnnFri$		0.058 (0.019)***	0.047 (0.019)**
$S * Withdrawal$			0.063 (0.017)***
$c_1 + c_2$		-0.125 (0.012)***	-0.187 (0.021)***
$c_1 + c_3$		-0.046 (0.017)***	-0.095 (0.022)***
N	1120	1120	1120
$Adj\ R^2$ *(%)*	32.60	33.10	35.92

The table reports the estimates for the following model: $R_t = a_0 + b_1 AnnWed_t + b_2 AnnFri_t + b_3 Withdrawal_t + c_1 S_t + c_2 S_t AnnWed_t + c_3 S_t AnnFri_t + c_4 S_t Withdrawal_t + e_t$, where R_t denotes the 5-minute return (expressed in percent) on the natural gas futures right after the natural gas announcement, while S_t is the natural gas inventory surprise for announcement day *t*. $AnnWed$ ($AnnFri$) is a dummy variable which equals one when the natural gas storage report is released on Wednesdays (Fridays) and takes values of zero otherwise. $Withdrawal$ is a dummy variable which equals one when the natural gas storage report is released during the withdrawal season and takes values of zero otherwise. The sample period is from May 2002 through December 2023 and contains 1,120 announcements. The regressions are estimated using OLS with the White (1980) heteroskedasticity consistent covariance matrix. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% significance levels, respectively.

Table 4. Empirical distribution of the estimated coefficients

	Daily Data		Intraday Data	
	Mean	Standard Deviation	Mean	Standard Deviation
S	-0.198	0.024	-0.145	0.014
$S * AnnWed$	-0.138	0.080	-0.043	0.016
$S * AnnFri$	0.149	0.047	0.047	0.021

The table reports means and standard deviations of the estimated coefficient for the following model: $R_t = a_0 + b_1 AnnWed_t + b_2 AnnFri_t + b_3 Withdrawal_t + c_1 S_t + c_2 S_t AnnWed_t + c_3 S_t AnnFri_t + c_4 S_t Withdrawal_t + e_t$, where R_t denotes the 5-minute natural gas futures return (expressed in percent) right after the natural gas announcement, or the daily return (expressed in percent) on the natural gas futures on announcement days, while S_t is the natural gas inventory surprise for announcement day t. $AnnWed$ ($AnnFri$) is a dummy variable which equals one when the natural gas storage report is released on Wednesdays (Fridays) and takes values of zero otherwise. $Withdrawal$ is a dummy variable which equals one when the natural gas storage report is released during the withdrawal season and takes values of zero otherwise. The sample period is from May 2002 through December 2023 and contains 1,120 announcements. The regressions are estimated using OLS with the White (1980) heteroskedasticity consistent covariance matrix. *, **, *** indicate statistical significance at the 10%, 5%, and 1% significance levels, respectively. The means and standard deviations are estimated using the bootstrapping exercise described in Section 3.3.

Table 5. Event Study Regression for Investor Attention

	$Nr.of\ Estimates$	SVI	BB
$Intercept$	19.69 (0.19)***	10.46 (0.26)***	7.16 (0.03) ***
$AnnWed$	-0.96 (0.98)	-1.76 (1.36)	-0.23 (0.16)
$AnnFri$	-2.34 (1.31)*	-3.63 (0.88)***	-0.38 (0.15)**
$Withdrawal$	-0.62 (0.35)	3.07 (0.57)***	-0.04 (0.05)
$Nr.Obs.$	1095	728	1120
$Adj\ R^2(\%)$	0.78	4.49	0.40

The table reports the estimates of the following model: $Y_t = a_0 + b_1 AnnWed_t + b_2 AnnFri_t + b_3 Withdrawal_t + e_t$, where Y_t denotes either the number of estimates provided by economists regarding the changes in natural gas storage ($Nr.of\ Estimates$), the Google Trends Search Volume for 'natural gas' (SVI), or the natural logarithm of the number of articles related to natural gas that were published on the Bloomberg platform (BB). $AnnWed$ ($AnnFri$) is a dummy variable which equals one when the natural gas storage report is released on Wednesdays (Fridays) and takes values of zero otherwise. $Withdrawal$ is a dummy variable which equals one when the natural gas storage report is released during the withdrawal season and takes values of zero otherwise. The sample period is from May 2002 through December 2023 and contains 1,120 announcements. For the SVI column, the sample period is from January 2010 through December 2023 and contains 728 announcements. The regressions are estimated using OLS with the Newey-West heteroskedasticity and autocorrelation consistent covariance matrix. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6. Disagreement among Analysts and the Accuracy of Analysts' Forecasts

	$Forecast\ Std.Dev.$	$Forecast\ Error$
$Intercept$	5.40 (0.08)***	5.34 (0.18)***
$AnnWed$	-0.87 (0.73)	0.910 (1.41)
$AnnFri$	-0.45 (0.62)	1.31 (1.49)
$Withdrawal$	3.47 (0.24)***	2.84 (0.41)***
$Nr.Obs.$	1079	1120
$Adj\ R^2$ *(%)*	20.45	5.41

The table reports the estimates of the following model: $Y_t = a_0 + b_1 AnnWed_t + b_2 AnnFri_t + b_3 Withdrawal_t + e_t$, where Y_t denotes either the forecast standard deviation of analysts' estimates or the absolute value of the forecast error of these estimates. $AnnWed$ ($AnnFri$) is a dummy variable which equals one when the natural gas storage report is released on Wednesdays (Fridays) and takes values of zero otherwise. $Withdrawal$ is a dummy variable which equals one when the natural gas storage report is released during the withdrawal season and takes values of zero otherwise. The sample period is from May 2002 through December 2023 and contains 1,120 announcements. For the SVI column, the sample period is from January 2010 through December 2023 and contains 728 announcements. The regressions are estimated using OLS with the Newey-West heteroskedasticity and autocorrelation consistent covariance matrix. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 7. Event Study Regression for Delayed Reaction

	(1)	(2)	(3)
Panel A. Return from the Announcement Day Close to the Open of the Next Trading Day			
$Intercept$	0.062 (0.029)**	0.068 (0.027)**	0.014 (0.030)
$AnnWed$		0.026 (0.371)	-0.051 (0.371)
$AnnFri$		-0.005 (0.425)	-0.073 (0.424)
$Withdrawal$			0.139 (0.059)**
S	0.004 (0.004)	0.006 (0.003)**	0.012 (0.004)***
$S * AnnWed$		0.000 (0.050)	0.004 (0.050)
$S * AnnFri$		-0.057 (0.026)**	-0.055 (0.026)**
$S * Withdrawal$			-0.010 (0.006)
N	1120	1120	1120
$Adj\ R^2$ *(%)*	0.04	0.86	1.31
Panel B. Return from the Previous Day Close to the Open of the Next Trading Day			
$Intercept$	-0.293 (0.103)***	-0.324 (0.104)***	-0.224 (0.125)*
$AnnWed$		0.335 (0.614)	0.464 (0.628)
$AnnFri$		0.059 (0.849)	0.213 (0.867)
$Withdrawal$			-0.235 (0.217)
S	-0.129 (0.016)***	-0.128 (0.015)***	-0.184 (0.025)***
$S * AnnWed$		-0.106 (0.102)	-0.143 (0.102)
$S * AnnFri$		0.106 (0.046)**	0.090 (0.044)**
$S * Withdrawal$			0.093 (0.031)***
N	1120	1120	1120
$Adj\ R^2$ *(%)*	10.30	10.72	11.85

The table reports the estimates of the following model: $R_t = a_0 + b_1 AnnWed_t + b_2 AnnFri_t + b_3 Withdrawal_t + c_1 S_t + c_2 S_t AnnWed_t + c_3 S_t AnnFri_t + c_4 S_t Withdrawal_t + e_t$, where R_t denotes the continuously compounded futures return (expressed in percent) around the natural gas announcement. S_t is the natural gas inventory surprise for day *t*. $AnnWed$ ($AnnFri$) is a dummy variable which equals one when the natural gas storage report is released on Wednesdays (Fridays) and takes values of zero otherwise. $Withdrawal$ is a dummy variable which equals one when the natural gas storage report is released during the withdrawal season and takes values of zero otherwise. The sample period is from May 2002 through December 2023 and contains 1,120 announcements. The regressions are estimated using OLS with the White (1980) heteroskedasticity consistent covariance matrix. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% significance levels, respectively.

Table 8. Event Study Regression for Pre-announcement Reaction

	(1)	(2)	(3)
$Intercept$	-0.092 (0.036)**	-0.107 (0.037)***	-0.129 (0.049)***
$AnnWed$		0.207 (0.171)	0.173 (0.174)
$AnnFri$		0.384 (0.208)	0.362 (0.210)*
$Withdrawal$			0.061 (0.072)
S	-0.020 (0.005)***	-0.021 (0.005)***	-0.026 (0.006)***
$S * AnnWed$		-0.002 (0.018)	-0.006 (0.019)
$S * AnnFri$		-0.005 (0.016)	-0.006 (0.016)
$S * Withdrawal$			0.010 (0.010)
$c_1 + c_2$		-0.024 (0.017)	-0.032 (0.019)*
$c_1 + c_3$		-0.025 (0.015)*	-0.032 (0.016)**
N	1120	1120	1120
$Adj\ R^2$ *(%)*	2.25	2.22	2.23

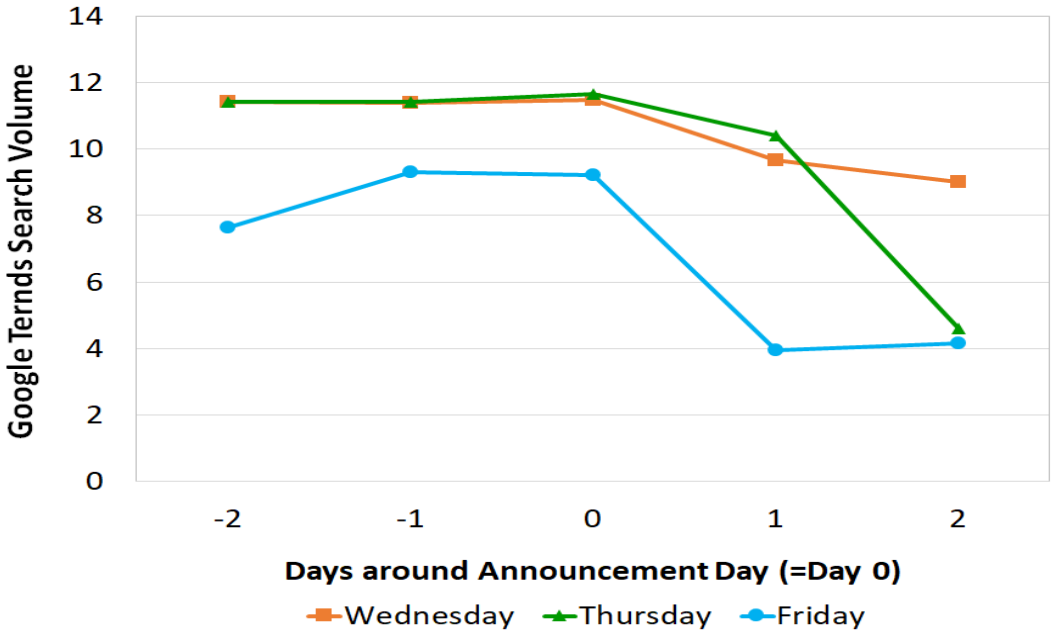
The table reports the estimates of the following model: $R_t = a_0 + b_1 AnnWed_t + b_2 AnnFri_t + b_3 Withdrawal_t + c_1 S_t + c_2 S_t AnnWed_t + c_3 S_t AnnFri_t + c_4 S_t Withdrawal_t + e_t$, where R_t denotes the continuously compounded futures return (expressed in percent) calculated from 90 minutes before announcement to 5 minutes before announcement. S_t is the natural gas inventory surprise for day *t*. $AnnWed$ ($AnnFri$) is a dummy variable which equals one when the natural gas storage report is released on Wednesdays (Fridays) and takes values of zero otherwise. $Withdrawal$ is a dummy variable which equals one when the natural gas storage report is released during the withdrawal season and takes values of zero otherwise. The sample period is from May 2002 through December 2023 and contains 1,120 announcements. The regressions are estimated using OLS with the White (1980) heteroskedasticity consistent covariance matrix. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% significance levels, respectively.

Table 9. Friday Effect vs. Post-Holiday Effect

	(1) Daily Data	(2) Intraday Data
$Intercept$	-0.396 (0.107)***	-0.113 (0.044)**
$Holiday$	0.097 (0.334)	-0.111 (0.119)
S	-0.126 (0.016)***	-0.104 (0.009)***
$S * Holiday$	-0.067 (0.040)*	-0.007 (0.021)
N	1057	1057
$Adj\ R^2$ *(%)*	11.56	32.04

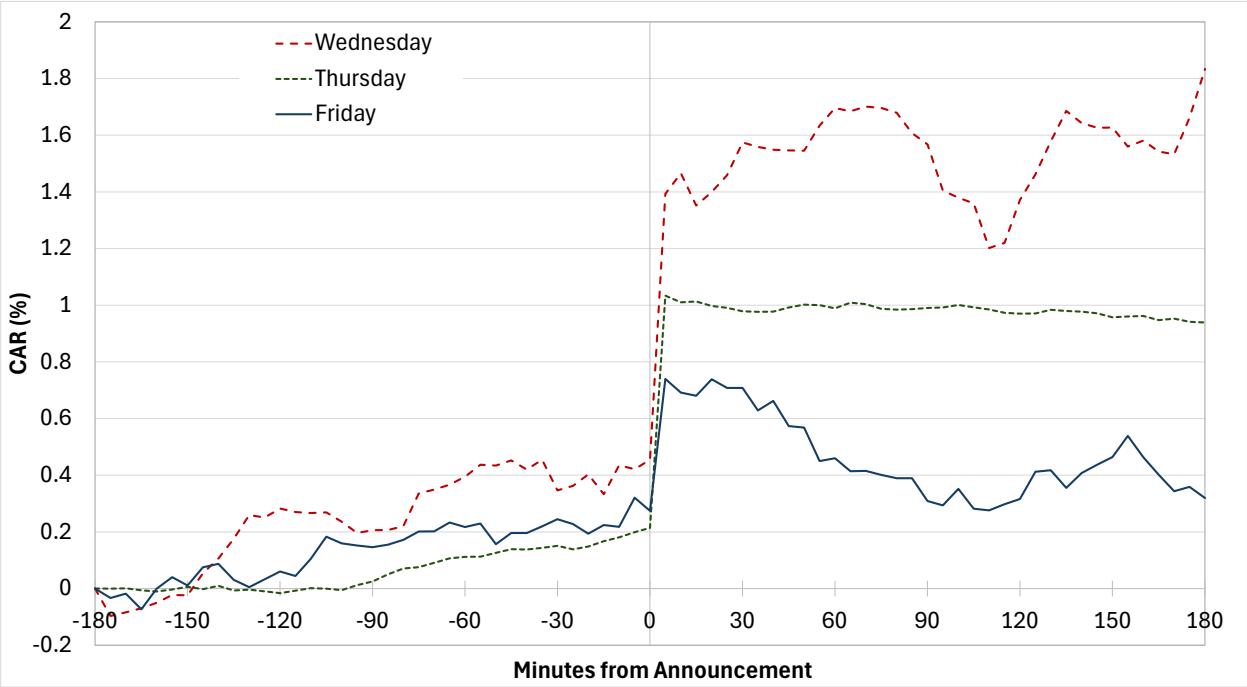
The table reports the estimates for the following model: $R_t = a_0 + \mathrm{c}_1 Holiday_t + c_2 S_t + \mathrm{c}_3 S_t Holiday_t + e_t$, where S_t is the natural gas inventory surprise for the Thursday announcement day t. $Holiday_t$ is a dummy variable equal to one for the WNGSR Thursday announcements that are released after a federal holiday (i.e., the day prior to the announcement is a federal holiday) and equal to zero for regular WNGSR Thursday announcements that are not preceded by a federal holiday. R_t denotes the daily return (expressed in percent), or the 5-minute return (expressed in percent) on the natural gas futures right after the natural gas announcement. The sample period is from May 2002 through December 2023 and contains 1,057 announcements. The regressions are estimated using OLS with the White (1980) heteroskedasticity consistent covariance matrix. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% significance levels, respectively.

Figure 1. Investor Attention around Natural Gas Storage Announcements



This figure plots the investor attention in the natural gas market around the release of natural gas storage announcements. Investor attention is measured by the Google Trends Search Volume for the term 'natural gas'. Days 0 refers to the announcement day. The announcements made on various days of the week (Wednesday, Thursday, or Friday) are identified using different colors.

Figure 2. Cumulative Average Returns around Natural Gas Inventory Announcements



This figure shows cumulative average returns around natural gas inventory announcements. The sample period is from May 2002 through December 2023. The returns around positive inventory surprises are multiplied by minus one.