The Impact of Monetary Policy Surprises on Energy Prices

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This paper examines the effect of monetary policy surprises on energy prices at intraday, daily, and monthly frequencies. We measure monetary policy shocks using changes in interest rate futures prices that capture unexpected changes in the fed funds target rate. We find a significant response of energy prices to surprise changes in the fed funds target rate in an intraday window immediately following the monetary announcement. However, the accumulated responses of energy prices to monetary shocks over a period of several days after the announcement are statistically insignificant. We also use fed funds futures data to identify the contemporaneous impact of monetary policy shocks on oil prices in a monthly structural vector autoregressive (VAR) setup. We find no statistically significant effect of federal funds rate shocks on oil prices. The VAR estimates support the assumption of no contemporaneous feedback from monetary policy to energy prices. © 2013 Wiley Periodicals, Inc. Jrl Fut Mark 35:87–103, 2015

1. INTRODUCTION

This study contributes to the literature examining feedback from monetary policy to energy prices. Empirical support for this feedback effect has been weak. Barsky and Kilian (2002) make the case that global monetary conditions were an important factor behind the high oil prices and high inflation of the 1970s. Kilian and Vega (2011) conduct a comprehensive event study analysis of the effect of U.S. macroeconomic news, including monetary news, on energy prices. Using daily returns data, they find no evidence that the price of crude oil responds immediately to macroeconomic news. They conclude that oil prices can be treated as predetermined with respect to U.S. macroeconomic aggregates. Chatrath, Miao, and Ramchander (2012) extend Kilian and Vega's study to account for inventory changes. They are also unable to reject the null hypothesis of no response to macroeconomic news.

We examine the effect of monetary policy on energy prices. Our approach builds on a methodology originally developed by Faust, Swanson, and Wright (2004). Although our approach is similar to that used by Kilian and Vega (2011), there are several important differences. First, our measures of monetary policy news are derived from intraday changes in

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interest rate futures prices rather than from survey forecasts as in Kilian and Vega (2011). Rigobon and Sack (2008) show that noise in macroeconomic shocks derived from survey data biases estimated response coefficients in event study regressions toward zero. As a result, event study estimates based on survey expectations data may understate the effect of macroeconomic news on asset prices. Our measures of monetary shocks are less noisy than measures derived from survey-based expectations because the market expectations are incorporated in interest rate futures prices observed just before the announcement. Extracting monetary shocks from changes in interest rate futures prices also allows us to examine unscheduled meetings of the Federal Open Market Committee (FOMC). Survey-based expectations are unavailable for unscheduled meetings. Unscheduled FOMC meetings play a key role in our high-frequency event study estimates. Our approach based on futures prices is not without its own limitations, however, as discussed in Faust et al. (2004). Thus, our approach to measuring monetary shocks and the approach based on survey expectations data should be viewed as complementary.

Second, we use two measures of monetary policy news. Most studies looking at the effect of monetary policy on financial and commodity markets (e.g., Bernanke & Kuttner, 2005; Kilian & Vega, 2011) measure monetary policy shocks by estimating unexpected changes in the current federal funds target rate. Gürkaynak, Sack, and Swanson (2005) show, however, that two factors are required to capture the effect of monetary news on asset prices. The first factor (target surprise) captures unexpected changes in the Fed's current policy. The second factor (path surprise) contains two types of information. The first type of information reflects news about the future path of monetary policy communicated to the market through FOMC's policy statements. The second type of information captured by the path surprises relates to the fact that monetary policy statements convey the Fed's view of economic conditions.[1]

Third, we attempt to provide a link between the immediate response of energy futures to monetary news and the longer-term impact of such unexpected policy actions. To that end, we use intraday, daily, and monthly oil prices. Our initial tests are based on intraday energy futures market data. Focusing on an intraday event window around the news release allows estimating the immediate response of energy commodities to monetary news more accurately because it excludes the influence of most other price-moving events that occur on the same day. The results of the intraday analysis show a significant response of energy futures prices to monetary policy news. We also find that the unexpected changes in the fed funds target rate that occur at unscheduled FOMC meetings tend to have a larger immediate effect on energy futures prices than do the policy decisions made at scheduled FOMC meetings.

In further analysis, we examine the dynamic responses of daily energy futures prices to monetary news. Although the immediate effect of the target surprises on returns remains statistically significant for crude oil and gasoline, the estimates of the accumulated responses after 5 and 20 trading days are insignificant. Finally, we use a structural vector autoregressive (VAR) model with monthly data to examine whether monetary policy shocks have a significant effect on oil prices in a macroeconomic framework. The contemporaneous feedback from monetary policy to energy prices is identified using a subset of months with zero intraday target surprises. The VAR coefficient estimates show a small and statistically insignificant effect of monetary policy shocks on oil prices. Taken together, the results of this paper are consistent with the hypothesis that energy prices are predetermined with respect to monetary policy.

[1]Kohn and Sack (2004) show that movements of interest rates at the 1-year horizon observed after monetary policy statements are determined primarily by the Fed's assessment of economic outlook. Kurov (2012) provides similar evidence for the effect of monetary policy statements on the stock market.

2. RELATED LITERATURE

Barsky and Kilian (2002) and Frankel (2008) maintain that loose monetary policy leads to higher commodity prices through several channels. First, low interest rates increase the incentive for producers to postpone commodity extraction.[2] Second, low rates reduce the cost of carrying inventories, leading to lower supply of commodities and higher commodity prices. Third, low interest rates encourage speculators to invest in commodities in search of higher returns. However, Frankel (2008) finds no significant relation between real interest rates and real commodity prices in the period since 1980. Similarly, Frankel and Rose (2010) find no significant feedback from real interest rates to oil prices. Alquist, Kilian, and Vigfusson (2011) find no evidence of a predictive link between interest rates and oil prices. Moreover, Kilian and Murphy (2014) report finding no evidence that ex ante real interest rates Granger cause their VAR variables including the real price of oil.[3] Kilian and Lewis (2011) find no evidence of a response of U.S. monetary policy to oil price shocks since the late 1980s.

In a comprehensive study of the effect of macroeconomic news on energy prices, Kilian and Vega (2011) find no significant response of oil prices to monetary news. Finally, Anzuini, Lombardi, and Pagano (2012) identify monetary policy shocks using a standard VAR model and examine the relation between such shocks and commodity prices. They find that oil prices increase by only about 2% after a 100-basis-point cut in the fed funds rate.

A common issue in much of the empirical literature in this area is identification of monetary shocks. For example, Frankel (2008) uses monthly and annual data and relies on OLS regressions that do not account for endogeneity of monetary policy. However, a change in the interest rates in a given month could be due to a response of monetary policy to the change in commodity prices that occurred earlier in the same month. Commodity prices and monetary policy may also react simultaneously to economic developments. VAR-based identification schemes designed to account for endogeneity of energy prices and monetary policy often rely on strong identifying restrictions. Gürkaynak et al. (2005) argue that the problem of simultaneity of monetary policy and asset prices can be mitigated by using high-frequency data. We contribute to the literature by using monetary policy shocks measured from intraday changes in interest rate futures prices to estimate the effect of monetary policy on energy prices at intraday, daily, and monthly frequencies.

3. SAMPLE SELECTION AND KEY VARIABLES

3.1. Sample Selection

Our sample period extends from January 1994 to December 2008 and includes 129 FOMC announcements.[4] Nine of these announcements occurred after unscheduled FOMC meetings. Our sample period begins in 1994 for two reasons. First, in 1994 the FOMC began announcing policy decisions immediately after the meeting, whereas prior to 1994 such decisions were not explicitly announced and had to be inferred from the subsequent open market operations. Gürkaynak, Sack, and Swanson (2007) argue that after this change in the FOMC's disclosure policy the fed funds futures rate became a better predictor of the future target rate, allowing for more accurate estimation of monetary surprises. Second, in addition

[2]This argument follows the logic of Hotelling (1931).

[3]A related literature examines the effects of energy price shocks on macroeconomic performance. See, for example, Barsky and Kilian (2004) and Kilian (2008) for a detailed discussion of economic effects of oil price shocks.

[4]Similar to Bernanke and Kuttner (2005), we omit the target rate announcement made at the unscheduled FOMC meeting of September 17, 2001.

to target surprises, which capture unexpected changes in the fed funds target rate, we use path surprises representing news about the future direction of monetary policy. The path surprises correspond to changes in futures rates at the one-year horizon. Gürkaynak et al. (2005) show that the path surprises reflect information contained in FOMC statements. The FOMC started releasing policy statements immediately after the meeting in February 1994. Therefore, the path surprises have a clear economic interpretation in the post-1994 period.

In the period since December 2008, the fed funds target rate has remained near zero. With the conventional monetary policy tools unavailable to the Fed, the FOMC has attempted to reduce longer-term interest rates through large-scale purchases of long-term bonds, a policy commonly referred to as quantitative easing. In the post-2008 period, changes in interest rates and asset prices observed after FOMC announcements are likely to be driven primarily by news about the policy of quantitative easing. Since monetary policy at the zero bound is quite different from conventional monetary policy, we do not examine the post-2008 period.

3.2. Monetary Surprises

To compute the target surprises, we use the prices of fed funds futures in the intraday event window surrounding the FOMC announcement. The price of the fed funds futures contracts is based on the average fed funds rate during the contract's month, rather than the fed funds rate on the settlement date. Kuttner (2001) shows that the unexpected change in the federal funds target rate can be computed by scaling the futures price change to account for the timing of the announcement within a month. Following Kuttner (2001), we compute the target surprises as follows:[5]

$$\mathrm{TS}_t = \frac{D}{D-d}\left(f_t^0 - f_{t-1}^0\right), \qquad (1)$$

where f_t^0 is the fed funds rate implied in the price of the current-month fed funds futures contract after the policy announcement, d is the day of the current FOMC meeting, and D is the number of days in the month.

We compute the path surprises, denoted as PS_t, as the change in the one-year-ahead Eurodollar futures rate in an intraday event window around the FOMC announcement. Hausman and Wongswan (2011) use a similar measure of path surprises.[6] Our definition of the target and path surprises differs from the approach used by Gürkaynak et al. (2005) for several reasons.[7] First, the policy surprises that are measured directly from futures rates are easier to interpret than those obtained through principal component analysis.[8] Second, the target factor estimated by Gürkaynak et al. (2005) tends to exclude surprises in timing of policy decisions, that is, surprises that have no effect on rates beyond the current month. We find that such timing surprises move energy prices. Ignoring timing surprises would

[5]The scaling factor increases at the end of the month, amplifying the measurement error induced by discreteness of futures prices. To mitigate this problem, when the FOMC meeting occurs in the last 7 days of the month we use the change in the rate implied in next-month's contract as the measure of the target surprise.

[6]Alternatively, Wongswan (2009) measures the path surprises as the component of the change in the one-year-ahead Eurodollar futures rate that is uncorrelated with the target surprise. The results based on this measure are qualitatively similar to the reported results. These estimates are available upon request.

[7]The correlations of target and path surprises with the target and path factors estimated according to Gürkaynak et al. (2005) are about 0.95 and 0.88, respectively.

[8]Gürkaynak et al. (2005) estimate the target and path factor as the first two principal components of several short-term interest rate changes observed at the time of the policy announcement. The two principal components are linearly transformed and scaled so that the first factor moves the current target rate surprises one-for-one and the second factor moves the longer-term rate expectations.

understate the effect of monetary policy decisions. Finally, directly measuring the monetary surprises from futures prices allows us to avoid dealing with the generated regressor issue. Following Gürkaynak et al. (2005), we measure the target and path surprises in the event window from 10 minutes before to 20 minutes after the policy announcement. The target and path surprises in our sample are shown in Figure 1.

3.3. Energy Futures Returns

To examine the response of energy prices to monetary news, we use futures prices for WTI crude oil, gasoline, and heating oil.[9] Futures prices are used because intraday spot price data for energy commodities are unavailable. Energy futures markets are very liquid, and have been shown to dominate price discovery in energy commodities (e.g., Schwarz & Szakmary, 1994). Continuously compounded returns are computed in the same intraday event window as the monetary surprises using prices of the nearby futures contract. The nearby contract becomes relatively illiquid in its last few days of trading. Therefore, in the last 3 days of trading of the nearby contract we substitute prices of the next closest contract.[10] Fleming and Piazzesi (2005) show that Treasury yields continue to move in the direction of the monetary surprise for about 3 hours after unscheduled FOMC meetings. We find similar results for energy futures.[11] Therefore, for unscheduled meetings we measure energy futures returns in the event window from 10 minutes before to 3 hours after the announcement time. For comparison purposes, we also analyze the effect of monetary surprises on the S&P 500 index futures.

Summary statistics for monetary surprises and intraday futures returns are shown in Table I. As expected, the three energy futures returns are strongly positively correlated. The table also shows significant positive correlations between the energy futures returns after FOMC announcements and the S&P 500 futures returns. Both energy and S&P 500 futures returns in the event window are negatively correlated with the target surprises.

4. EMPIRICAL RESULTS

4.1. Response of Intraday Energy Futures Returns to FOMC Announcements

To examine the immediate effect of the monetary policy surprises on energy prices, we begin by estimating the following regressions for energy futures returns:

$$R_t = \alpha + \gamma \mathrm{TS}_t + \varepsilon_t, \tag{2}$$

and

$$R_t = \alpha + \gamma_1 \mathrm{TS}_t + \gamma_2 \mathrm{PS}_t + \varepsilon_t, \tag{3}$$

where R_t is the futures return in the intraday event window surrounding the FOMC announcement, and TS_t and PS_t are the target and path surprises, respectively.

The regression results are shown in Table II. In the single factor regression, the coefficient estimate of the target surprise ranges from −3.26 for crude oil to −2.53 for heating oil. When the path surprise is added to the model, its coefficient estimate is positive for all

[9]The futures market data are obtained from Genesis Financial Technologies.
[10]Andersen, Bollerslev, Diebold, and Vega (2007) use a similar approach to construct futures price series.
[11]These results are not reported in detail to save space but are available from the authors upon request.

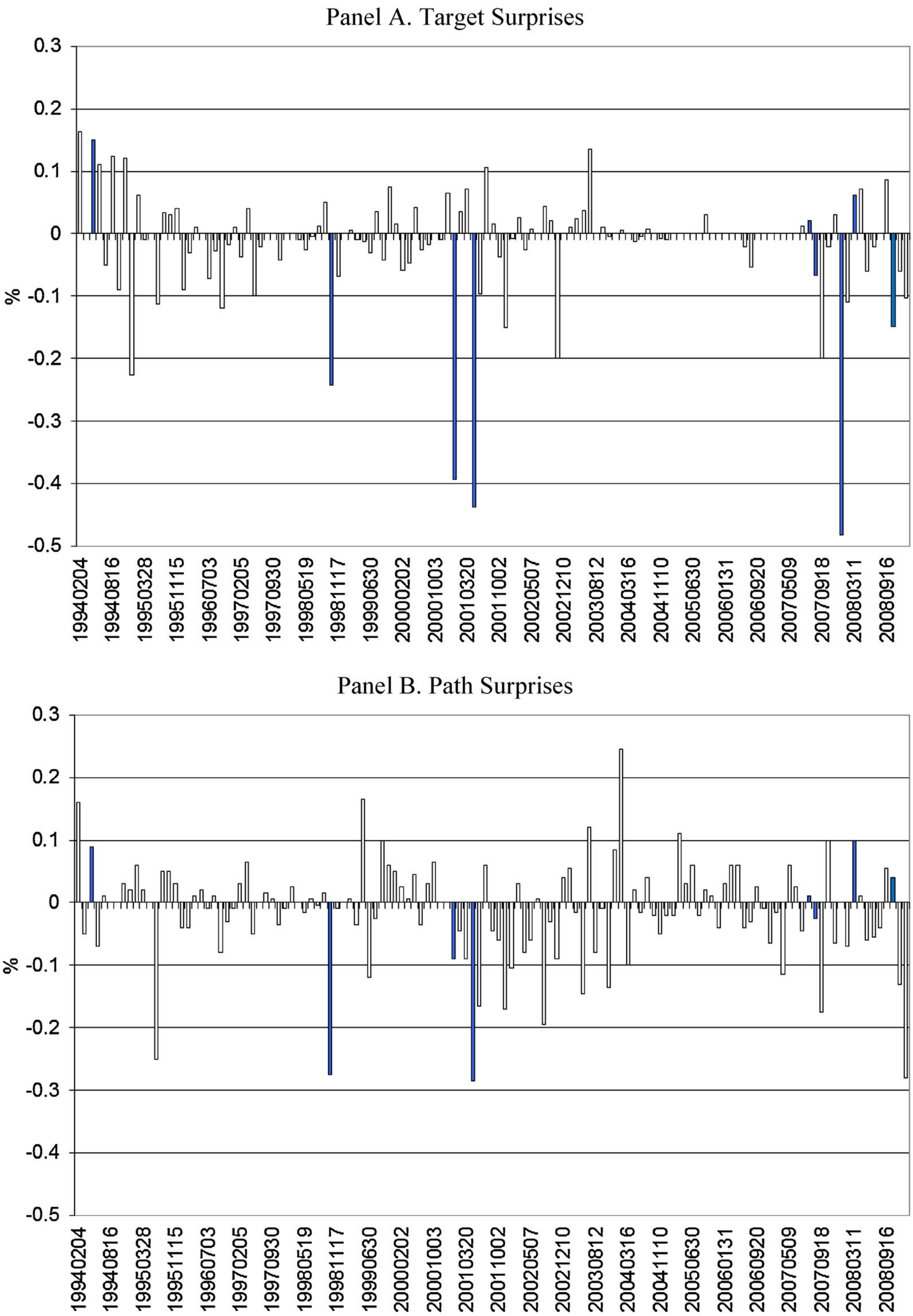

FIGURE 1

Monetary policy surprises. The path surprises are computed as the change in the four-quarter-ahead Eurodollar futures rate. Shaded bars represent unscheduled FOMC meetings. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

TABLE I
Summary Statistics for Intraday Futures Returns and Monetary Surprises

	Crude oil	*Gasoline*	*Heating oil*	*S&P 500*	*Target surprise*	*Path surprise*
Panel A: Summary statistics						
Mean	−0.01	0.08	0.01	0.02	−0.02	−0.01
Median	−0.05	0.04	−0.09	−0.10	0	0
SD	0.69	0.72	0.68	0.94	0.09	0.08
Skewness	1.15	0.84	0.70	2.40	−2.44	−0.76
Minimum	−1.76	−1.87	−1.52	−2.08	−0.48	−0.29
Maximum	3.25	2.69	2.26	4.68	0.16	0.25
Panel B: Correlations						
Gasoline	0.81***					
Heating oil	0.81***	0.75***				
S&P 500	0.45***	0.37***	0.39***			
Target surprise	−0.43***	−0.39***	−0.34***	−0.70***		
Path surprise	−0.05	−0.01	−0.03	−0.41***	0.46***	1

Note. The futures returns are computed in the intraday event window surrounding the FOMC announcement. For scheduled FOMC meetings, the event window is from 10 minutes before to 20 minutes after the announcement time. For unscheduled meetings, the event window is from 10 minutes before to 3 hours after the announcement time. The target and path surprises for all meetings are computed in event window from 10 minutes before to 20 minutes after the announcement time. The target surprises are computed from fed funds futures prices as in Kuttner (2001). The path surprises are computed as the change in the four-quarter-ahead Eurodollar futures rate. The sample period is from January 1994 through December 2008. The number of observations is 129. *, **, *** indicate significance at 10%, 5%, and 1% levels, respectively.

three energy futures, although it is statistically significant only for gasoline. Path surprises reflect news about the future path of monetary policy and information about the Fed's view of economic outlook. For example, a positive path surprise implies higher rates ahead, possibly due to FOMC's more optimistic assessment of the future economic conditions. The positive coefficient estimates of the path surprises indicate that information about the economy contained in monetary policy statements may be more important to energy futures traders than information about the future path of monetary policy.

With the path surprise added to the model, the estimates of the responses to the target surprises increase in magnitude, ranging from −3.94 for crude oil to −3.09 for heating oil. This implies that a hypothetical unexpected 100-basis-point cut in the fed funds target increases crude oil futures prices by about 4% during the intraday event window after the

TABLE II
Response of Intraday Energy and Equity Futures Prices to Monetary Surprises

	With target surprise		*With target and path surprises*		
	Target	R^2	*Target*	*Path*	R^2
Crude oil	−3.26 (0.98)***	0.189	−3.94 (1.07)***	1.64 (1.05)	0.219
Gasoline	−3.05 (0.76)***	0.153	−3.82 (0.82)***	1.88 (0.94)**	0.189
Heating oil	−2.53 (0.73)***	0.116	−3.09 (0.76)***	1.36 (0.87)	0.137
S&P 500 index	−7.19 (1.13)***	0.500	−6.69 (1.35)***	−1.20 (1.09)	0.505

Note. The table shows estimates for the following regressions:

$$R_t = \alpha + \gamma \mathrm{TS}_t + \varepsilon_t \text{ and } R_t = \alpha + \gamma_1 \mathrm{TS}_t + \gamma_2 \mathrm{PS}_t + \varepsilon_t$$

where R_t is the futures return in the intraday event window surrounding the FOMC announcement, and TS_t and PS_t are target and path surprises, respectively.The sample period is from January 1994 through December 2008. The number of observations is 129. The regression is estimated using OLS with the White (1980) heteroskedasticity consistent covariance matrix. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

announcement. These estimates are about one and a half times as large as the estimates in Anzuini, Lombardi, and Pagano (2012). The R^2 estimates for the two-factor regression range from about 14% for heating oil to about 22% for crude oil. In comparison, the R^2 for the S&P 500 futures is about 50%. In other words, monetary shocks explain about half of the variation in stock returns in the event window, but most of the variation in energy futures returns seems to be driven by other factors.[12] Nevertheless, the results in Table II provide initial empirical support for the notion that monetary policy influences energy prices. The finding that stock returns and energy futures returns respond in the same direction to target rate shocks is suggestive of a demand-driven transmission channel.

Unscheduled FOMC meetings may contain a different type of surprise than do scheduled meetings. For example, Basistha and Kurov (2008) examine the effect of target rate surprises on stock returns using all FOMC meeting days and after dropping the unscheduled meetings. A scatterplot of intraday crude oil futures returns and target surprises is shown in Figure 2. Consistent with the regression results in Table II, the scatterplot shows a negative relation between target surprises and crude oil futures returns. However, the unscheduled meetings clearly play a key role in this relation.

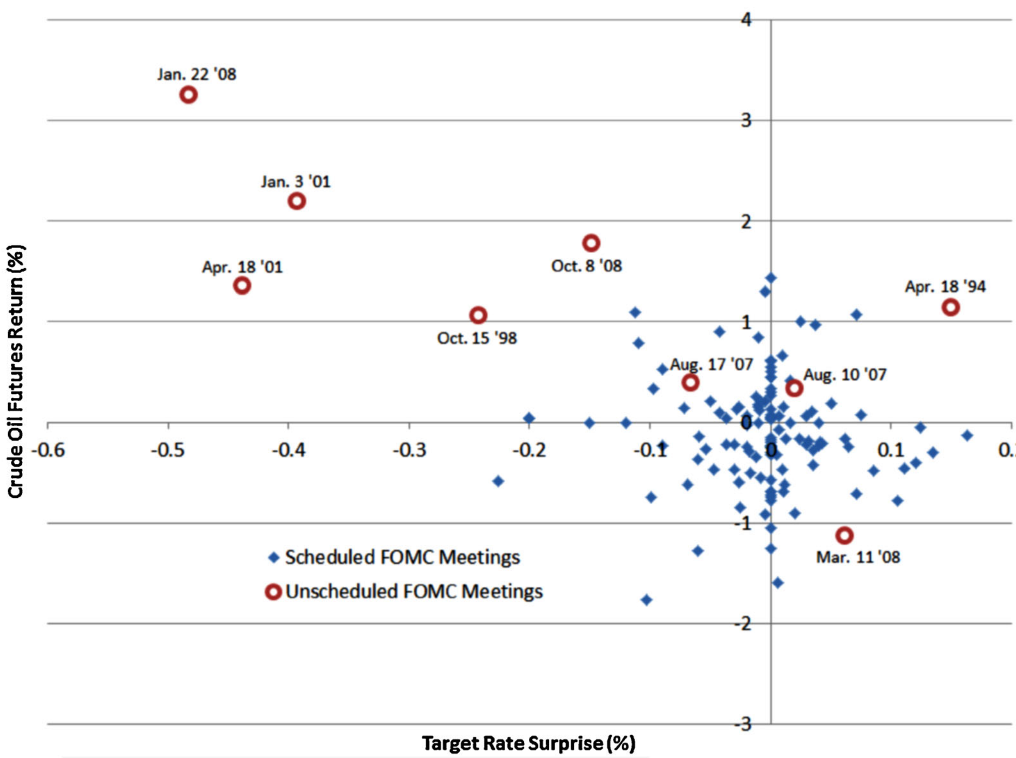

FIGURE 2

Scatterplot of intraday crude oil futures returns and target surprises. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

[12]It is possible that monetary news affects energy prices through its effects on the dollar exchange rate. To test for this alternative explanation of the results, we also estimated the regressions in Table II after including the contemporaneous returns on the U.S. Dollar Index futures as an additional explanatory variable. However, the dollar index return coefficient was insignificant and the coefficients of primary interest were not significantly affected. The results of this robustness check are not tabulated to save space but are available upon request.

To examine the effect of scheduled and unscheduled FOMC meetings on energy futures prices more formally, we estimate the following regression using intraday futures returns and monetary surprises:

$$R_t = \alpha + \gamma_1 \mathrm{TS}_t(1 - \mathit{Unsched}_t) + \gamma_2 \mathrm{TS}_t \mathit{Unsched}_t + \gamma_3 \mathrm{PS}_t + \varepsilon_t, \qquad (4)$$

where Unched_t is a dummy variable taking the value of one for unscheduled meetings. Coefficients γ_1 and γ_2, measure the market response to target surprises after scheduled and unscheduled FOMC meetings, respectively.

The results presented in Table III show that energy futures prices tend to react more strongly to target rate surprises after unscheduled FOMC meetings. For example, the estimate of the crude oil response coefficient for unscheduled meetings is about −5.61. In contrast, the corresponding coefficient estimate for scheduled FOMC meetings is about −0.88. There appears to be no statistically significant response of energy futures prices to target surprises following scheduled FOMC meetings.

4.2. Response of Daily Energy Futures Returns to FOMC Announcements

In this section, we extend the analysis of the intraday results to daily data using all return observations. This is a crucial intermediate step to understand how intraday estimates can be used in longer horizon empirical models like VARs with monthly data. We use both static and dynamic versions of the models with daily data. In both versions, we build on Equation (4) to incorporate four frequently used nonmonetary surprises that can potentially affect daily energy futures returns. The four nonmonetary surprises used as controls are unexpected changes in monthly industrial production, producer price index, nonfarm employment, and unemployment rate. These unexpected changes are computed using survey data collected by Money Market Services (MMS). As an additional control, we include the daily natural gas futures return. This variable controls for fundamental factors not included in the model that influence energy prices.[13]

$$R_t = \alpha + \gamma_1 \mathrm{TS}_t(1 - \mathit{Unsched}_t) + \gamma_2 \mathrm{TS}_t \mathit{Unsched}_t + \gamma_3 \mathrm{PS}_t + \sum_k \beta_k X_{k,t} + \varepsilon_t, \qquad (5)$$

TABLE III

Response of Intraday Energy and Equity Futures Prices to Monetary Surprises: Scheduled and Unscheduled FOMC Meetings

	Target × scheduled	*Target × unscheduled*	*Path*	R^2
Crude oil	−0.88 (0.82)	−5.61 (0.86)***	1.27 (0.89)	0.315
Gasoline	−0.93 (0.89)	−5.40 (0.62)***	1.53 (0.78)*	0.269
Heating oil	−0.04 (0.05)	−4.36 (0.88)***	1.08 (0.79)	0.193
S&P 500 index	−2.12 (1.12)*	−9.19 (1.20)***	−1.75 (0.92)*	0.621

Note. The table shows estimates for the following regressions:

$$R_t = \alpha + \gamma_1 \mathrm{TS}_t(1 - \mathit{Unsched}_t) + \gamma_2 \mathrm{TS}_t \mathit{Unsched}_t + \gamma_3 \mathrm{PS}_t + \varepsilon_t$$

where R_t is the futures return in the intraday event window surrounding the FOMC announcement, TS_t and PS_t are target and path surprises, respectively, and $\mathit{Unsched}_t$ is a dummy variable equal to one for unscheduled FOMC meetings and zero otherwise.The sample period is from January 1994 through December 2008. The number of observations is 129, including nine unscheduled FOMC meetings. The regression is estimated using OLS with the White (1980) heteroskedasticity consistent covariance matrix. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

[13]Similarly, Mu (2007) includes the crude oil futures returns in a regression model for natural gas futures returns.

where R_t is the daily (close-to-close) futures return for all days in the sample, TS_t and PS_t are the intraday target and path surprises, respectively, and X_k are the control variables mentioned above.[14] The target and path surprises are set to zero on days with no FOMC meetings.

The regression results for Equation (5) are reported in Table IV. Both crude oil and gasoline returns are negatively affected by target surprises in the unscheduled meetings. The magnitudes of the responses are lower than those in the intraday results though still statistically significant. The responses to the target surprises at scheduled meetings are also negative though smaller in magnitude and statistically imprecise. Overall, the static daily results are quite similar to the results for intraday returns shown in Table III.

To conduct dynamic analysis of the target responses, we extend Equation (5) by allowing for distributed lags in target surprises at both scheduled and unscheduled meetings. We use lags of five and 20 trading days. The number of lags is denoted by T in Equation (6).

$$R_t = \alpha + \sum_{i=0}^{T} \gamma_{1i}\mathrm{TS}_{t-i}(1 - Unsched_{t-i}) + \sum_{j=0}^{T} \gamma_{2j}\mathrm{TS}_{t-j}Unsched_{t-j} + \gamma_3\mathrm{PS}_t + \sum_k \beta_k X_{k,t} + \varepsilon_t \tag{6}$$

The estimates for the model using five lags are presented in Table V, and the dynamic accumulated responses are shown in Figure 3. The immediate impact results for crude oil and gasoline closely mimic the daily results in Table IV. However, the accumulated responses after 5 trading days are often of the opposite sign with large standard errors. For unscheduled meetings, the estimates of the accumulated responses are small and imprecise.

The results for the model using 20 lags are presented in Table VI, and the dynamic responses are illustrated in Figure 4. As before, the immediate impact effects are very similar

TABLE IV

Response of Daily Energy and Equity Futures Prices to Monetary Surprises: Scheduled and Unscheduled FOMC Meetings

	Target × scheduled	*Target × unscheduled*	*Path*	R^2
Crude oil	−2.88 (3.22)	−3.82 (1.42)***	−0.20 (2.52)	0.079
Gasoline	−1.46 (3.54)	−3.07 (1.08)***	−0.29 (1.97)	0.081
Heating oil	−0.21 (2.95)	0.87 (1.80)	−2.46 (2.43)	0.120
S&P 500 index	−1.34 (2.18)	−3.66 (3.09)	−5.57 (2.15)***	0.011

Note. The table shows estimates for the following regressions:

$$R_t = \alpha + \gamma_1\mathrm{TS}_t(1 - Unsched_t) + \gamma_2\mathrm{TS}_t Unsched_t + \gamma_3\mathrm{PS}_t + \sum_k \beta_k X_{k,t} + \varepsilon_t$$

where R_t is the daily futures return for all days in the sample, TS_t and PS_t are target and path surprises, respectively, $Unsched_t$ is a dummy variable equal to one for unscheduled FOMC meetings and zero otherwise, and X_k are control variables that include unexpected changes in monthly industrial production, producer price index, nonfarm employment and unemployment rate, as well as the daily natural gas futures return.The sample period is from January 1994 through December 2008. The number of observations is 3759, including 120 scheduled and nine unscheduled FOMC meetings. The regression is estimated using OLS with the White (1980) heteroskedasticity consistent covariance matrix. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

[14]We also experimented with adding inventory surprises for crude oil, gasoline, and distillate fuel oil as additional controls. The survey expectations data used to compute such surprises are available beginning with July 2003. Petroleum inventory data are released in the Weekly Petroleum Status Report compiled by the Energy Information Administration (EIA). Sixteen out of 49 FOMC meetings in the period from July 2003 to December 2008 occurred on the days of release of the Weekly Petroleum Status Report. The results for regressions that included petroleum inventory surprises were similar to those reported in the paper.

TABLE V

Immediate Impact and Five-Day Accumulated Response of Energy and Equity Futures Prices to Monetary Surprises: Scheduled and Unscheduled FOMC Meetings

	Target × scheduled	*Target × unscheduled*	*Path*	R^2
Crude oil				
Immediate impact	−2.83 (3.23)	−3.83 (1.42)***	−0.21 (2.52)	0.085
Accumulated response	2.33 (7.87)	0.80 (6.02)		
Gasoline				
Immediate impact	−1.43 (3.55)	−3.07 (1.08)***	−0.29 (1.97)	0.083
Accumulated response	4.63 (8.79)	−1.04 (6.45)		
Heating oil				
Immediate impact	−0.14 (2.96)	0.86 (1.80)	−2.46 (2.43)	0.124
Accumulated response	4.70 (7.09)	8.14 (6.34)		
S&P 500 index				
Immediate impact	−1.35 (2.17)	−3.66 (3.09)	−5.57 (2.15)***	0.013
Accumulated response	−1.47 (4.42)	−2.43 (6.32)		

Note. The table shows estimates for the following regressions:

$$R_t = \alpha + \sum_{i=0}^{5} \gamma_{1i} \mathrm{TS}_{t-i}(1 - Unsched_{t-i}) + \sum_{j=0}^{5} \gamma_{2j} \mathrm{TS}_{t-j} Unsched_{t-j} + \gamma_3 \mathrm{PS}_t + \sum_k \beta_k X_{k,t} + \varepsilon_t$$

where R_t is the daily futures return for all days in the sample, TS_t and PS_t are target and path surprises, respectively, $Unsched_t$ is a dummy variable equal to one for unscheduled FOMC meetings and zero otherwise, and X_k are control variables that include unexpected changes in monthly industrial production, producer price index, nonfarm employment and unemployment rate, as well as the daily natural gas futures return. The sample period is from January 1994 through December 2008. The number of observations is 3759, including 120 scheduled and nine unscheduled FOMC meetings. The regression is estimated using OLS with the White (1980) heteroskedasticity consistent covariance matrix. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

to the results reported in Tables IV and V. The 20-day accumulated effect magnitudes for the unscheduled meetings have correct signs in most cases. However, they also have large standard errors. The results for target surprises on scheduled meetings are more mixed but still imprecise. Overall, the estimated dynamic responses do not show a pattern and are very imprecise. However, none of these estimates is close to their impact effects. This departure of accumulated responses suggests that it may be difficult to use intraday or daily event study results to identify structural VAR models.

4.3. Effect of Federal Funds Rate Shocks on Oil Prices in a Structural VAR

In this section, we use monthly data to estimate the contemporaneous effect of the federal funds rate shocks using a structural VAR framework. The model is specified as

$$A(L)y_t = u_t, \tag{7}$$

where $A(L)$ is the autoregressive lag polynomial, y_t is a vector of model variables, and u_t is a vector of structural shocks. The model structure closely follows the monthly five-variable VAR with 12 lags estimated by Kilian and Lewis (2011). We use the same five variables: the CRB spot index excluding the price of crude oil for commodity prices, the US composite refiner's acquisition cost of crude oil for oil prices, the three-month moving average of the Chicago Fed National Activity Index (CFNAI), the CPI inflation rate, and the federal funds rate, in that order. The commodity and oil prices are alternatively deflated by the CPI or core PCE to examine the sensitivity of our results to the choice of the price variable. The real prices are then used as log first differences (100×) in the VAR. Kilian and Lewis (2011)

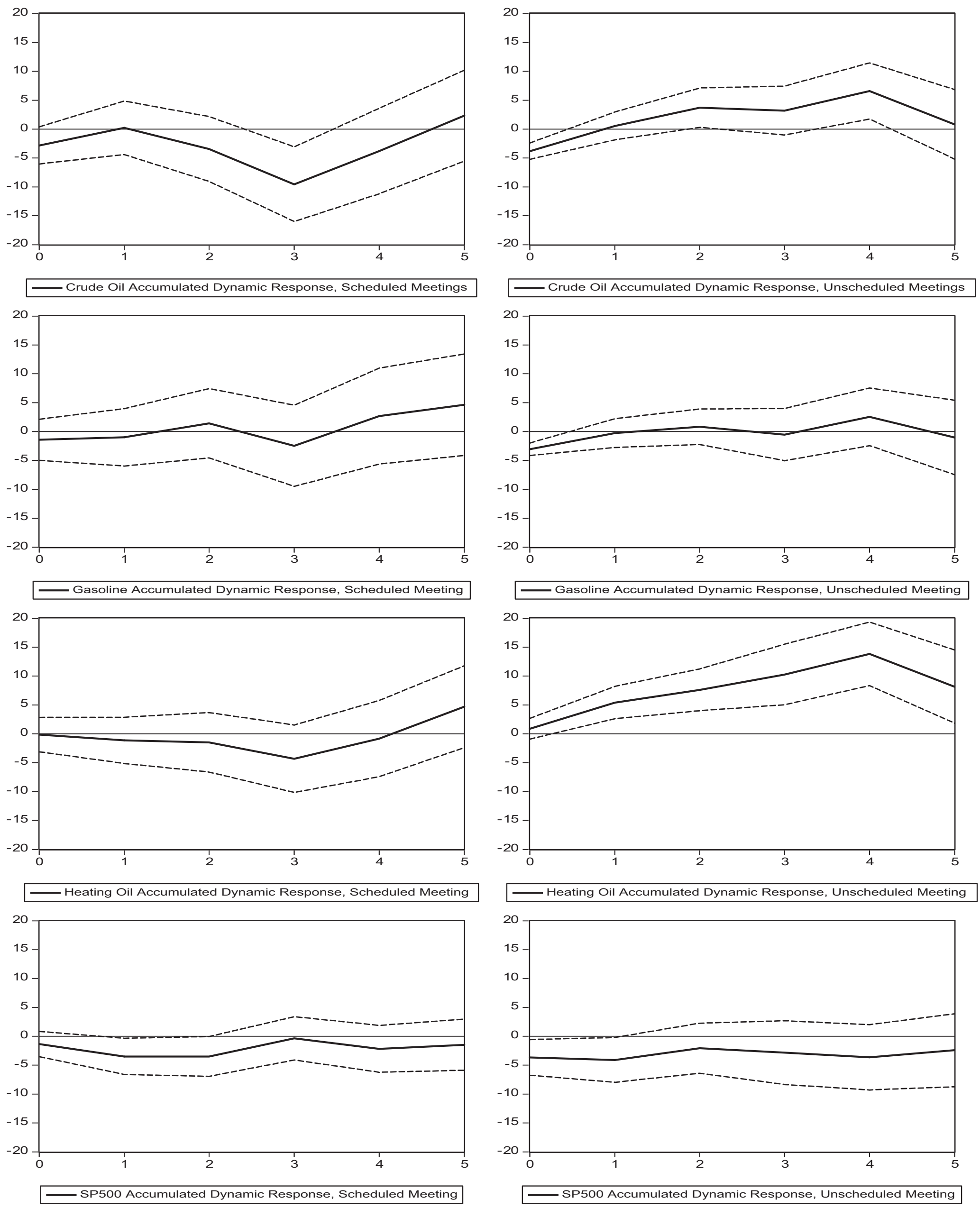

FIGURE 3
Accumulated dynamic responses to target surprises over a five-day period. Dashed lines show one-standard-error bounds.

use a recursive identification of structural shocks based on Choleski factorization. This identification scheme assumes that there is no contemporaneous effect of the federal funds rate shocks on oil prices.

Our primary departure from the Kilian and Lewis setup is in the use of the federal funds futures data to identify the contemporaneous effect of federal funds rate shocks on oil prices.

TABLE VI

Immediate Impact and Twenty-Day Accumulated Response of Energy and Equity Futures Prices to Monetary Surprises: Scheduled and Unscheduled FOMC Meetings

	Target × scheduled	*Target × unscheduled*	*Path*	R^2
Crude oil				
Immediate impact	−2.33 (3.27)	−3.63 (1.42)**	0.14 (2.55)	0.091
Accumulated response	0.59 (15.04)	−9.18 (10.62)		
Gasoline				
Immediate impact	−1.16 (3.62)	−2.87 (1.08)***	0.04 (2.00)	0.090
Accumulated response	−10.93 (16.46)	−2.09 (11.12)		
Heating oil				
Immediate impact	0.18 (2.99)	0.89 (1.86)	−2.18 (2.48)	0.128
Accumulated response	−3.14 (14.48)	4.93 (10.73)		
S&P 500 index				
Immediate Impact	−1.18 (2.21)	−3.74 (3.18)	−5.61 (2.20)**	0.020
Accumulated response	−6.59 (8.45)	−8.44 (8.45)		

Note. The table shows estimates for the following regressions:

$$R_t = \alpha + \sum_{i=0}^{20} \gamma_{1i} \mathrm{TS}_{t-i}(1 - Unsched_{t-i}) + \sum_{j=0}^{20} \gamma_{2j} \mathrm{TS}_{t-j} Unsched_{t-j} + \gamma_3 \mathrm{PS}_t + \sum_k \beta_k X_{k,t} + \varepsilon_t$$

where R_t is the daily futures return for all days in the sample, TS_t and PS_t are target and path surprises, respectively, $Unsched_t$ is a dummy variable equal to one for unscheduled FOMC meetings and zero otherwise, and X_k are control variables that include unexpected changes in monthly industrial production, producer price index, nonfarm employment and unemployment rate, as well as the daily natural gas futures return.The sample period is from January 1994 through December 2008. The number of observations is 3759, including 120 scheduled and nine unscheduled FOMC meetings. The regression is estimated using OLS with the White (1980) heteroskedasticity consistent covariance matrix. Standard errors are shown in parentheses. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

For each month from January 1990 to December 2008, we compute the sum of absolute values of target rate surprises measured in the 30-minute event window around the FOMC announcements that occurred in that month.[15] The results of this calculation show that over this period there were 112 months with no federal funds rate surprises. These months represent the zero federal funds shock regime. In other words, the FOMC's decisions regarding the fed funds rate in those months were fully anticipated by the market. Technically, this implies that for those months the mean, variance, and, therefore, the effects of federal funds rate shocks are all zero. However, all of the other contemporaneous impact parameters as specified by Kilian and Lewis (2011) are identified in those months.

This approach allows us to identify the effects of the federal funds rate shocks on the other variables in the model using the months where the futures data showed nonzero surprises. This identification scheme is very similar to the identification through heteroskedasticity approach of Rigobon (2003) and Rigobon and Sack (2003), which assumes the heteroskedasticity of the structural shocks can be described by two or more regimes.[16] The main assumption underlying our identification approach is that monetary policy shocks occur only around FOMC announcements. This assumption allows us to divide the sample period into two regimes: the zero fed funds shock regime and the nonzero fed funds shock regime.

[15]Prior to 1994, the FOMC's decisions regarding the fed funds target rate were not explicitly announced and became known to the markets at the time of the next open market operation. We thank Refet Gürkaynak for providing the intraday target rate surprises for the period between 1990 and 1994 used in Gürkaynak et al. (2005).

[16]Faust, Swanson, and Wright (2004) also use the federal funds futures data to identify the effects of monetary policy shocks in a VAR. However, we do not impose that the impulse responses in the monthly VAR match the responses estimated from the high-frequency futures data, as they do.

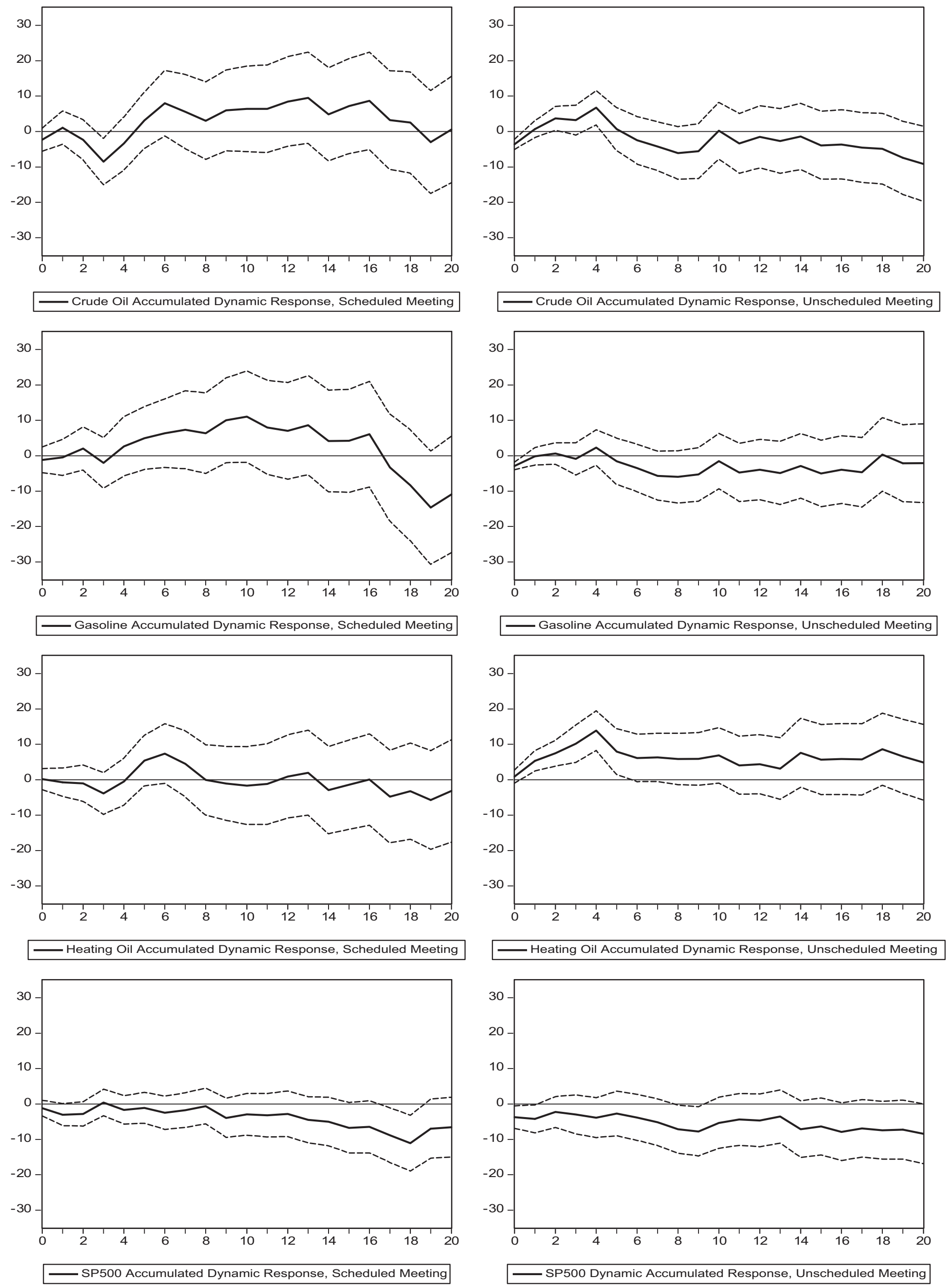

FIGURE 4
Accumulated dynamic responses to target surprises over a 20-day period. Dashed lines show one-standard-error bounds.

We estimate the matrix of contemporaneous impact coefficients for the model shown in Equation (7) based on the following set of equations:

$$\begin{bmatrix} \varepsilon_t^c \\ \varepsilon_t^o \\ \varepsilon_t^{\text{CFNAI}} \\ \varepsilon_t^{\pi} \\ \varepsilon_t^{\text{FFR}} \end{bmatrix} = \begin{bmatrix} a_{11} & 0 & 0 & 0 & D_t{}^*a_{15} \\ a_{21} & a_{22} & 0 & 0 & D_t{}^*a_{25} \\ a_{31} & a_{32} & a_{33} & 0 & D_t{}^*a_{35} \\ a_{41} & a_{42} & a_{43} & a_{44} & D_t{}^*a_{45} \\ a_{51} & a_{52} & a_{53} & a_{54} & D_t{}^*a_{55} \end{bmatrix} \times \begin{bmatrix} u_t^c \\ u_t^o \\ u_t^{\text{CFNAI}} \\ u_t^{\pi} \\ u_t^{\text{FFR}} \end{bmatrix}, \tag{8}$$

where D_t is a dummy variable equal to zero if month t is in the set of months with no federal funds rate surprises and one otherwise, ε_t^idenote the reduced form residuals, and u_t^i denote the structural shocks in the price of commodities, crude oil, the CFNAI, the inflation rate, and the fed funds rate. The main parameter of interest is a_{25}, representing the contemporaneous effect of the federal funds rate shocks on oil prices.

We use equally weighted GMM to estimate the model parameters based on two regimes: the zero federal funds shock regime and the nonzero federal funds shock regime. The standard errors are computed using 1,000 regime-specific bootstrap replications following Rigobon (2003). Table VII shows estimates of the contemporaneous impact of a 100-basis-point unexpected increase in the federal funds rate on the other four variables in the model. All four impact estimates shown in Panel A are small and statistically insignificant. The estimates for oil prices are negative but very small, ranging from −0.04% to −0.13% depending on the price variable used. These estimates are much closer to zero than to the intraday results reported in Table II. These findings support the zero contemporaneous effect assumption in Kilian and Lewis (2011).

TABLE VII
Contemporaneous Effects of Federal Funds Rate Shocks: Evidence from a Monthly Structural VAR

	Commodity index	*Crude oil*	*CFNAI*	*Inflation*
Panel A: 112 months with zero federal funds rate surprises				
CPI	0.67 (0.84)	−0.04 (0.67)	0.00 (0.06)	0.10 (0.09)
Core PCE	0.92 (1.01)	−0.13 (0.78)	−0.00 (0.05)	0.02 (0.04)
Panel B: 145 months with zero federal funds rate surprises				
CPI	0.36 (0.76)	0.01 (0.56)	0.14 (0.08)*	0.04 (0.07)
Core PCE	0.65 (0.87)	−0.04 (0.81)	0.07 (0.07)	0.04 (0.04)
Panel C: 88 months with zero federal funds rate surprises, subsample 1994:01–2008:12				
CPI	0.43 (0.82)	−0.15 (0.89)	−0.09 (0.07)	0.19 (0.11)*
Core PCE	0.88 (0.99)	−0.23 (0.76)	−0.02 (0.06)	0.03 (0.04)

Note. The table shows contemporaneous effects of a 100-basis-point unexpected increase in the federal funds rate from a five-variable monthly structural VAR with 12 lags. The variables are the CRB spot commodity price index excluding the price of crude oil (percentage change after deflating by the overall price index), the composite price of crude oil (percentage change after deflating by the overall price index), the three-month moving average of the Chicago Fed National Activity Index (CFNAI), inflation (based on two overall price indices, CPI and core PCE), and the federal funds rate (in this order). In Panel A, we use 112 months with no federal funds rate shocks based on intraday federal funds futures data. In Panel B, we use 145 months with no federal funds rate shocks, defined as months with intraday fed funds rate surprises of up to two basis points. In Panel C, we use 88 months with no federal funds rate shocks based on intraday federal funds futures data.The primary sample period is from January 1990 through December 2008. The number of observations is 228. The subsample period is January 1994 to December 2008 with 180 observations. The estimates are computed using equally weighted GMM. Standard errors are shown in parentheses and are computed using 1000 bootstrap replications. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

A fair number of months show very small target rate shocks estimated using intraday fed funds futures data. These numbers may represent the bid-ask bounce in the fed funds futures prices rather than unexpected changes in the fed funds target rate.[17] Therefore, we additionally include futures surprises of up to two basis points in the set of zero federal funds rate shock months. This results in 145 months with zero fed funds rate surprises used for identification. The corresponding VAR results are shown in Panel B of Table VII. These results are qualitatively similar to the results shown in Panel A. Finally, in Panel C we redo our exercise in Panel A using monthly data from January 1994 to be consistent with our intraday sample. The results show a similar pattern. Overall, the contemporaneous impact estimates from the structural VAR do not resemble the intraday results. They also support Kilian and Lewis (2011) recursive identification scheme of Choleski factorization.

5. SUMMARY AND CONCLUSION

This study examines the effect of monetary policy surprises on energy prices at intraday, daily, and monthly horizons. We measure monetary policy shocks using intraday changes in interest rate futures prices that capture unexpected changes in the fed funds target rate and news about the future path of monetary policy. Using intraday energy futures data, we find an immediate response of energy prices to unexpected changes in the fed funds target rate. This result is driven primarily by several unscheduled FOMC meetings. When we use daily energy futures data to examine the dynamic response of energy prices to monetary policy shocks, we find that the accumulated responses after several days are statistically insignificant.

We also use intraday fed funds futures data to identify the contemporaneous effect of federal funds rate shocks on oil prices in a monthly structural VAR. The results show a small and statistically insignificant effect of federal funds rate shocks on oil prices. These results cast doubt on the validity of direct use of intraday estimates of asset price responses to monetary policy for structural VAR identification.[18] Instead, our findings provide support for the commonly used assumption of predetermined oil prices. Future research should examine the reasons behind the disparity between intraday and longer-term price impact estimates.

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[17]The minimum tick size of the fed funds futures in our data is one basis point. As mentioned above, the scaling factor used in computing the target surprises magnifies microstructure noise caused by price discreteness and bid-ask bounce.

[18]This identification approach is proposed by D'Amico and Farka (2011).

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