Dynamic Impact of the U.S. Monetary Policy on Oil Market Returns and Volatility

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Abstract

In this paper, we assess the dynamic impact of the U.S. monetary policy announcements on oil market futures returns and volatility. We use intra-day data together with a time-varying modeling approach to study the nature of this dynamic impact. In addition, we also control for macroeconomic news shocks and separately study the response of good and bad realized volatility. Evidence suggests that there is a significant time variation in the response of oil returns as well as its volatility to the Federal Reserve policy announcements. Furthermore, we find that higher (lower) uncertainty about Federal Reserve policy actions weakens (strengthens) the impact of the announcements on oil returns and volatility.

JEL Classifications: C32, E44, E52, G14, Q43

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1 Introduction

Oil market return and volatility are known to impact economic activity as well as inflation (see for example, Stock and Watson (2003), Hamilton (1983, 2008, 2009, 2013), Elder and Serletis (2010), Plakandaras et al., (2017), van Eyden (2019)). In addition, oil market movements are also found to have spillover effects on the financial, food and other commodity markets (see, Balcilar et al., (2013, 2017b) and Gupta and Yoon (2018) for detailed reviews in this regard). Given this leading role of oil movements, it is of paramount importance to policymakers, investors, and academicians to understand what factors drive the oil market, and in particular, its high-frequency movements.

While there exists a huge literature devoted to wide array of variables in predicting oil market movements (see Degiannakis and Filis (2017) and Gupta and Wohar (2017) for recent reviews on forecasting oil price returns and volatility), the role of monetary policy shocks in driving oil market movements has gathered attention more recently. Earlier research (for example, by Hamilton and Herrera (2004), Bodenstein et al., (2012), Hesary and Yoshino (2014), Yoshino and Hesary (2014)) used structural Vector Autoregressive (VAR)-type models to analyze the impact of monetary policy shocks on low-frequency monthly and quarterly movements of the oil market besides other macroeconomic shocks (Baumeister and Hamilton (forthcoming)).

However recent studies, borrowing from the literature on financial markets (see for example, Balcilar et al., (2017a) and Marfatia et al., (2017)), have identified monetary policy surprises on monetary policy committee (MPC) meeting dates from high-frequency (intraday and daily) data, as a possible predictor for commodity markets in general, which in turn has witnessed tremendous financialization in the recent years (Bahloul et al., 2018). Using regression-based methods studies have analyzed the impact of such shocks (Hayo et al., 2012; Rosa, 2014; Basistha and Kurov, 2015; Chebbi, 2018a, b; Gospodinov and Jamali, 2018; Kurov and Stan, 2018), along with macroeconomic news surprises

(Kilian and Vega, 2011; Chatrath et al., 2012, Bahloul and Gupta, 2018) on oil returns and volatility. Broadly, these studies tend to find that monetary policy plays a relatively more important role than macroeconomic news surprises. In this context, it important to note that the use of high-frequency data to identify monetary policy surprises "in a relatively cleaner manner" has been strongly advocated recently by Nakamura and Steinsson (2018a, b). Besides, given that oil market movements lead the macroeconomy, financial and commodity markets, it is indeed important to study the role of monetary policy on oil markets at high frequency to get an understanding of where the economy in general, and other markets are headed in the future.

The rationale for the key role of monetary policy (and macroeconomic news) surprises in driving the oil market is intuitively straight forward. Although the MPC meetings relate to monetary policy decisions, and dates for the release of macroeconomic data are pre-scheduled, the precise value of these factors can only be anticipated, most often based on consensus forecasts. The semi-strong form of the efficient market hypothesis implies that the forecasted values are already included in the pricing of an asset (oil) after the consensus data are published. However, the unexpected difference between the predicted and the announced data (the surprise component) will impact the asset pricing (in our case oil).

Given this, and against the backdrop of the recent growth in studies analyzing the impact of monetary (and macroeconomic news) surprises, we use futures market data on West Texas Intermediate (WTI) oil 16th of December, 1997 till 3rd of May, 2017 and aim to extend this line of research in the following ways. First, unlike the existing studies that use constant coefficient models, we for the first-time undertake a time-varying approach, rather than sub-samples, to analyze the impact of both conventional and unconventional monetary policy shocks (after controlling for macroeconomic news surprises) on both oil returns and volatility.[1] Following Cooley and Prescott (1976), the time-variation

[1] Both conventional and unconventional monetary policy stance is measured based on the behavior of same metric,

is modeled as a driftless random walk and is estimated using maximum likelihood via the Kalman filter.

This approach is appealing and a flexible way to uncover in time-varying responsiveness of oil market returns and volatility to monetary policy shocks of the U.S.. Thus, it not only allows for nonlinearity in the relationship but also detects precise time periods in which fundamental factors associated with the U.S. economy are more important than say, behavioral variables, in pricing the oil market (Drachal, 2016; Bonaccolto et al., 2018). In other words, unlike the constant parameter based studies used by existing studies, we do not rely on the presumption that the response of oil market returns and volatility to monetary shocks remain unchanged over time.

Second, realizing that market participants care not only about the nature of volatility but also of its level, with all traders making the distinction between good and bad volatilities (Caporin et al., 2016), we are the first paper to analyze the impact of monetary policy on volatility and its good and bad components.[2] Unlike existing studies which rely on conditional (unobserved) volatility, the measure and possibly the associated results of which is contingent on the Generalized Autoregressive Heteroskedastic (GARCH)-type models, we directly derive realized (observed) volatility which is the sum of non-overlapping squared high-frequency oil returns observed within a day from the intraday data.[3] Recent empirical evidence tends to suggest that the rich information contained in intraday data can produce more accurate estimates and forecasts of daily oil volatility (see, for example, Haugom et al. (2014), Sévi (2014), Prokopczuk et al. (2015)).

Finally, our study is the first attempt to analyze the time-varying impact of monetary policy shocks on oil market movements conditional on uncertainty surrounding monetary policy decisions. Kurov

i.e., the shadow short-term rates.

[2]In this regard, good volatility is directional, persistent and relatively easy to anticipate. Bad volatility, however, is jumpy and relatively difficult to foresee.

[3]Note that, earlier studies (like, Rosa (2014), Basistha and Kurov (2015), and Kurov and Stan (2018)) have used intraday data to analyze high-frequency impact of monetary policy shocks on oil market returns around narrow time-windows of the MPC meeting dates.

and Stan (2018) have used a similar approach but in a constant parameter framework. In sum, unlike current studies, our paper aims to provide a more complete picture of the oil market's response over time due to the conventional and unconventional monetary policy shocks, across monetary policy regimes, and in the presence of varying levels of uncertainty surrounding monetary policy decisions. Both the first and the second moment of oil market movements are analyzed. In addition, we also distinguish between good and bad volatilities.

Recall that oil market movements lead macroeconomic variables, financial and other commodity markets, and also recent financialization has resulted in increased participation of hedge funds, pension funds, and insurance companies in the market, to the extent that the oil market is now also considered as a profitable alternative investment in the portfolio decisions of financial institutions. Given this, our analysis has implications for policymakers, oil traders, and researchers.

The evidence clearly suggests that the impact of monetary policy announcements on the oil market movements, both for return and realized volatility has varied significantly over time. In particular, the impact of policy surprises is found to be mainly negative in the 1999-2003 period, whereas the volatility responded positively to monetary policy changes. This direction of impact reversed in and around the recent financial crisis period. These results are robust to the inclusion of macroeconomic news shocks in the estimation process. Further analyzing the time-varying response of oil markets to policy surprises, we find that the response of the oil market is significantly linked to monetary policy uncertainty. Evidence suggests that higher uncertainty around policy announcements tends to lower the impact of announcements on both the returns and volatility.

The remainder of the paper is organized as follows: Section 2 presents the methodology, while Section 3 discusses the data, Section 4 is devoted to the results, with Section 5 concluding the paper.

2 Methodology

In this section, we discuss the event study approach modeled with a state-space framework to study the time-varying impact of monetary policy on oil market movements.

Event-study approach

We study the time-varying impact of monetary policy on the movement of oil market return and volatility within the event study framework. The event study approach combined with intra-day data is one of the widely used approaches among researchers to control for the problem of endogeneity and the possible problems due to the joint response of the economic shocks and the stock markets to new information (Bernanke and Kuttner (2005)). Following the popular conventional Cook and Hahn (1989) style analysis, we estimate the impact of monetary policy on oil market return and its realized volatility. We also distinguish separately the impact on good and bad realized volatility due to monetary policy changes.

We are interested to study how the monetary policy announcements affect oil market movements. Hence, our event for analysis is the FOMC meetings and the announcements. We specify one day as the size of the window. This is following Bernanke and Kuttner (2005) and Hausman and Wongswan (2011). While there are some studies that use a much smaller window, our selection of window size has several merits. First, a one-day window is likely to crease out any keen-jerk reactions that possibly occur within a few minutes after the policy announcements. This occurs because markets may be relatively slow at incorporating the arrival of new information, at least for certain announcements. A one-day window, in contrast, is more likely to measure the true impact of policy on the oil market. Second, a one-day window is most appropriate in the present context as it is highly unlikely that the monetary policy announcements systematically coincides on exact dates with the possible confounding events and other market-wide news that may influence oil markets. Third, this modeling strategy is also supported by popular event studies like Bernanke and Kuttner (2005) and Hausman and Wongswan (2011).

The time-varying parameter model

There is a significant anecdotal and formal evidence which suggests that the oil market is dynamic in nature and it responds differently across time to the monetary policy developments. To model this empirical reality, we adopt a time-varying parameter (TVP) framework. This framework is flexible in that it is able to aptly uncover the time-varying responses on the oil market to monetary policy. We cast the TVP model into the standard state-space form which in turn involves specifying two equations. First, a measurement equation which describes the relationship between observed variables (data) and unobserved state vector (time-varying coefficients). Second, a transition equation which describes the dynamics of the unobserved state vector.

In the present context, the measurement equation of the state-space model shows the unobserved time-varying response of oil returns and realized volatility to the U.S. monetary policy surprises. The measurement equation is then represented by equation 1a which has a straight forward state-space representation given by equation 1b.

$$Oil_t = X_t\theta_t + e_t \quad where, e_t \sim N(0, \sigma_e) \tag{1a}$$

$$Oil_t = \begin{bmatrix} c & surp \end{bmatrix} \begin{bmatrix} \alpha_t \\ \beta_t \end{bmatrix} + e_t \tag{1b}$$

Here, Oil_t represents the dependent variable, that is, oil market returns or its realized volatility. We also distinguish between good and bad realized volatility to uncover the effect of monetary policy shocks separately. In equation 1a, X_t is a vector of exogenous variables which includes a constant (c), the monetary policy surprise ($surp$). Apart from this specification, for robustness check, we also consider two other specifications, each controlling for macroeconomics news surprises and monetary policy uncertainty separately. The vector θ_t captures the corresponding unobserved time-varying parameters (α_t and β_t) of the model. Our parameter of interest in equation 1a is the coefficient β_t which captures the response of oil market returns/volatility to the monetary policy surprises.

In the next step, we specify the transition equation of the state-space system. Following the pioneering work of Cooley and Prescott (1976) the time variation is modeled as a driftless random walk process. The advantage of this specification is that it allows for the impact of the news to evolve gradually over time. The transition equation and its state-space form are then represented as follows:

$$\theta_t = F\theta_{t-1} + v_t \quad where, v_t \sim N(0, Q) \tag{2a}$$

$$\begin{bmatrix} \alpha_t \\ \beta_t \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \alpha_{t-1} \\ \beta_{t-1} \end{bmatrix} + \begin{bmatrix} v_{1t} \\ v_{2t} \end{bmatrix} \tag{2b}$$

where, Q represents the variance-covariance matrix of two uncorrelated disturbance terms v_{1t} and v_{2t}. This transition equation describes the time dynamics of the unobserved state vector θ_t which contains the time-varying parameters (α_t and β_t). The Kalman filter is applied to the above state-space model and the parameters are estimated using maximum likelihood.

3 Data

In this segment, we describe the data used with the discussion of the oil market data and our measure of monetary policy and macroeconomic news surprises. Based on data availability, the sample period of analysis is December 16, 1997 to May 3, 2017.

We use intra-day data on WTI oil futures that are traded at NYMEX over a 24 hour trading day (pit and electronic), to construct daily measures of standard realized volatility, and the corresponding good and bad variants, besides daily log-returns. The futures price data, in a continuous format, are obtained from www.disktrading.com and www.kibot.com. Close to the expiration of a contract, the position is rolled over to the next available contract, provided that activity has increased. Daily returns are computed as the end of the day (New York time) price difference (close to close). In the case of intra-day returns, 1-minute prices are obtained via last-tick interpolation (if the price is not available at the 1-minute stamp, the previously available price is imputed), and 5-minute returns are then computed by taking the log-differences of these prices.

Following Andersen and Bollerslev (1998), we consider the classical estimator of realized volatility (RV), i.e. the sum of squared intraday returns, expressed as: $RV_t = \sum_{i=1}^{T} r_{t,i}^2$, where $r_{t,i}$ denotes the intraday return i within day t and $i = 1, .., T$ denotes the number of intraday observations within a day. In addition, as developed by Barndorff-Nielsen et al. (2010), we also consider bad (RV_t^B) and good (RV_t^G) realized volatilities defined as: $RV_t^B = \sum_{i=1}^{T} r_{t,i}^2 \; I_{[(r_{t,i})<0]}$ and $RV_t^G = \sum_{i=1}^{T} r_{t,i}^2 \; I_{[(r_{t,i})>0]}$, where $I_{\{.\}}$ denotes the indicator function. Understandably, $RV^S = RV^B + RV^G$. We consider RV^B and RV^G in order to capture the sign asymmetry of the volatility process.

Next, we turn our attention to the measure of monetary policy surprises. Given that the period of our analysis includes both conventional and unconventional monetary policy regimes, we use the shadow short rate (SSR) as our metric for monetary policy. The main advantage of the SSR is that it is not constrained by the zero lower bound (ZLB), and thus allows us to combine the data from the ZLB period with the data from the non-ZLB era. Moreover, this data is available at a daily frequency to match the oil prices. With the SSR not constrained by the ZLB, we can analyze the impact of both conventional and unconventional monetary policy decisions on the oil market movements using a uniform measure. The SSR used in this paper is developed by Krippner (2013), based on models of term-structure, at a daily frequency.[4]

The yield curve-based framework developed by Krippner (2013) essentially removes the effect that the option to invest in physical currency (at an interest rate of zero) has on yield curves. This results in a hypothetical "shadow yield curve" that would exist if the physical currency were not available. The process allows one to answer the question: "What policy rate would generate the observed yield curve if the policy rate could be taken as negative?" The shadow policy rate generated in this manner, therefore, provides a measure of the monetary policy stance after the actual policy rate reaches zero.

We use the changes in the SSR on the Federal Open Market Committee (FOMC) meeting dates, which happens to be a total of 200 cases during the period of investigation. As shown by Wu and Xia (2016), the SSR is a reasonable approximation of monetary policy shocks, hence, fully anticipated monetary policy announcements should have no immediate impact on the shadow short rate. As a result, a change in the shadow short rate on monetary policy event days should provide an accurate measure of monetary surprises.[5]

To check for the robustness of the impact of the monetary policy surprises, we also use a measure of macroeconomic surprises as proposed by proposed by Scotti (2016).[6] The surprise index summarizes recent macroeconomic surprises (industrial production, gross domestic product (GDP), employment, retail sales, personal income, and purchasing managers index (PMI)) and measures the degree of

[4]The data is downloadable from the Reserve Bank of New Zealand.

[5]In studies of our nature, as far as monetary shocks are considered, the Federal funds futures rate have received widespread attention, with it being considered a natural market-based proxy for the otherwise unobserved market expectations (Kishor and Marfatia, 2013). The main presumption behind using the futures price is that it embeds all the future expectations about interest rates at the current point in time. Hence, any change in the futures rate post-FOMC meeting is because the announced rate change (or no change) was unexpected before the FOMC meeting, thus leading to an impact on the oil returns and volatility. However, in the wake of the ZLB, trading in the Federal funds futures have been thin, and hence cannot be relied upon to compute monetary policy surprises corresponding to the unconventional monetary policy regime. We, however, repeated our analysis below with monetary policy shock data of Nakamura and Steinsson (2018a) derived from interest rate futures, and available till 19th of March, 2014, but found qualitatively similar results. These results are available upon request from the authors.

[6]The data is available for download from the following link: https://sites.google.com/site/chiarascottifrb/research?authuser=0.

optimism and pessimism of agents about the state of the economy. The macroeconomic surprises indexes are available daily and get updated every time new information becomes available. Therefore, if there are no new data, these indexes are equal by construction to their values on the previous day. Based on this, we will use the change in these indexes to capture the new information has been released.[7]

Finally, we also analyze whether the effectiveness of monetary policy in affecting oil market movements is compromised in the wake of uncertainty. In this regard, we use the monetary policy uncertainty indexes on days of the FOMC meetings developed by Husted et al., (2017). These are news-based index and captures the degree of uncertainty the public perceives about Federal Reserves policy actions and their consequences. Husted et al. (2017) construct two such measures by searching for keywords related to monetary policy uncertainty in the New York Times, Wall Street Journal, and Washington Post. The first index is called the 3-word (Fed) index , and is based on search articles containing the triple of "uncertainty" or "uncertain"; "monetary policy(ies)" or "interest rate(s)" or "Federal fund(s) rate" or "Fed fund(s) rate"; and "Federal Reserve" or "the Fed" or "Federal Open Market Committee" or "FOMC". In the 10-word proximity refinement, Husted et al. (2017) narrow the search of articles in which the word "uncertainty" or "uncertainties" is in close proximity (i.e., 10 words) to "Federal Reserve" or "monetary policy".[8] Note that, since these indexes are available up to the FOMC meeting on the 27th January of 2016, the effectiveness analysis of monetary policy conditional on uncertainty, also ends on this date.

[7]Note that, if macroeconomic announcements also affect the SSR on event days, then the change in the SSR will measure the monetary policy shocks-based index and captures the degree of uncertainty the public perceives with an error. Given this, regressing the oil price movements on the change in the SSR would lead to an omitted variable bias and inconsistent estimates of the impact of monetary policy shocks. Realizing this, we computed an alternative measure of monetary policy shock by regressing the changes in the SSR on the FOMC dates on the macroeconomic surprises and recovering the residuals from this regression as a measure of monetary policy surprise. However, our results, which are available upon request from the authors, were qualitatively similar to those obtained under the original measure of the monetary policy surprises.

[8]These two indexes can be downloaded from the Board of Governors of the Federal Reserve System.

4 Empirical results

4.1 *Time-varying response of oil market movement to policy changes*

The evidence suggests that the impact of monetary policy announcements on the oil market movements significantly varies across time (Fig. 1). We find that the impact of monetary policy announcements on oil returns in the 1999-2003 period was mostly negative but with an upward trend. This suggests that an unexpected rate hike meant a decline in the oil market returns. This highlights the classic channel of the impact of monetary policy on asset prices. Any unexpected interest rate hikes in this period possibly meant negative news for the asset markets, including the oil market returns.

What is further interesting is that in and around the period of the recent financial crisis, the Fed's policy announcements are found to impact oil market returns with a positive coefficient. Furthermore, the magnitude of impact peaked by end of 2008 and remained in the positive territory almost till the end of 2011. A rate cut (hike) signaled a weaker (stronger) economy, and this gets consequently reflected in a lower (higher) oil market returns. Even while oil and gold are historically considered as safe haven investments, the severity of the crisis was so high that in spite of the significant and sharp monetary policy easing, the asset markets including the oil market was a major plunge in the returns. This pattern around the crisis periods also provides some motivation to explore the linkages between the nature of time-varying impact and uncertainty, as visited in the next section.

These results highlight one of the main contributions of the paper that in evaluating the impact of monetary policy on energy prices it is important to model the time variations in the impact. Studies have found rather mixed evidence of the impact of monetary policy on energy prices. For example, Rosa (2014) finds that monetary policy news has highly significant effects on energy futures prices. Chebbi (2018a, b) also finds that monetary surprises led to significant increases in oil price. However, Basistha and Kurov (2015) find the dynamic responses of energy prices to monetary shocks are statistically imprecise. Our paper provides clarity to the underlying reasons for this mixed evidence found in the literature. Admittedly, the sample period and adopted methodologies in Rosa (2014); Basistha and Kurov (2015); Chebbi (2018a, b) differ across studies, and hence the results may not be directly comparable. But these differences in the sample period that lead to different results further strengths the main contribution of the paper, that is, the need to model time variations in assessing monetary policy's true underlying impact on the oil market.

The evidence of time-variation highlights the dynamic relationship between monetary policy and oil prices. This is not captured by approaches used by existing studies which use a fixed coefficient framework. This is despite the arguments made by Gospodinov and Jamali (2018). They find that the commodity price dynamics hinges on the sign of monetary policy shock, the level of monetary policy uncertainty and the state of the economy. Obviously, all of these factors change across time, and consequently, it becomes necessary to model time-variation in uncovering the true impact of monetary policy on oil markets.

The significant time variation is also found in the response of oil volatility to monetary policy announcements, and this is after controlling the impact of macroeconomic surprises. Figure 2 shows that in the pre-crisis period, the impact of monetary policy was negative in the early 2000s but was positive in the 2004-2008 period. However, after 2008 the impact on volatility remained negative and the magnitude increased steadily through 2011. This implies that in spite of the benign interest rate environment, there was significant volatility in oil prices in the post-2008 period. Note that the response of volatility to monetary policy shocks can be positive based on the classic asset price transmission channel or negative based on the signaling channel of monetary policy. The classic asset price transmission channel suggests an unexpected hike (cut) in the interest rate stirs (calms) market volatility, and the coefficient will be positive. On the other hand, the signaling channel of monetary policy suggests that a contractionary (expansionary) monetary policy signals a weaker (stronger) economy and consequently, higher (lower) volatility. This would be reflected by a negative coefficient, as in the post-2008 period.

In case of the response of good volatility (Fig. 4) and bad volatility (Fig. 4) to monetary policy surprises, we find interesting patterns of time variation as well. Figure 3 shows that the response of good volatility was positive in the 2003-2011 period. However, with the onset of the crisis, the magnitude of impact reduced and even turned negative in 2011, far after the end of the financial crisis. In contrast, bad realized volatility response turned negative with the onset of the crisis. In other words, the jumpy and relatively difficult to foresee component of volatility in oil prices (bad volatility) responded negatively right around the crisis period. However, monetary policy surprise impact on persistent and relatively easy to anticipate component of volatility (good volatility) did not turn negative only after the Fed's Operation Twist. This implies the degree of market anticipation, which is a function of the level of uncertainty, possibly plays an important role in determining the degree and nature of monetary policy impact on the oil market. We extend our analysis to gain further insights into this issue.

It is possible to argue that the movements in the oil markets respond to not only the monetary policy surprise but also the unexpected events that occur in the broader macroeconomy. As a result, it is the time-varying impact of monetary policy on oil markets may also pick up some of the impact that is channelized due to unexpected macroeconomic developments. To address this issue, we undertake a robustness check of our results by include macroeconomic surprises proposed by Scotti (2016) as a time-varying covariate in our model. The impact of monetary policy clearly shows no qualitative and even quantitative change to a large extent in our results. This is shown by a dotted line in Figures 1

- 4. Thus, the impact of monetary policy surprises on the oil market remains largely unchanged even after controlling for the macroeconomic surprises.

4.2 *Effects of policy uncertainty on its effectiveness*

The results convincingly show that the oil market movements in response to monetary policy announcements exhibit a significant time variation. The natural question then arises is, especially in the light of the time-varying pattern discussed above: how effective is the monetary policy in the presence of uncertainty? Apart from the time variations found in Figures 1-4, the idea is motivated by studies which find a close link between the degree of uncertainty in the markets and the monetary policy's impact on stock markets (Marfatia (2014)) and bond markets (Marfatia (2015)). Hence, it is pertinent to further study the possible relationship between monetary policy uncertainty and the time-varying response of the oil market to monetary policy announcements. To this end, we estimate the following regression with Newey-West Heteroskedastic and Autocorrelation corrected (HAC) standard errors:

$$oiltvp_t = c + \delta(unc_t) + \epsilon_t \tag{3}$$

where, $oiltvp_t$ represents the time-varying coefficient (β_t) and unc_t is a measure of monetary policy uncertainty prevailing at each point in time. As discussed earlier, we use the news-based monetary policy uncertainty indexes (3-word (Fed): MPUNC3, and 10-word (Fed): MPUNC10) of Husted et al., (2017), as our measures of uncertainty surrounding monetary policy decisions.

The coefficient of interest in the equation 3 is δ. It captures how the uncertainty around monetary policy announcements impacts the time-varying response of the oil markets to these announcements which the markets did not expect. From the Lucas island model's predictions, one would expect the sign of the coefficient δ to be negative. In the periods when the oil market participants are more uncertain about Federal Reserve policy actions and their consequences, the impact on the oil market will be negative to the policy announcements.

Results presented in Table 1 suggest that the extent of monetary policy's impact on the oil market movements significantly depends on the extent of uncertainty relating to monetary policy. Higher is the perceived uncertainty relating to monetary policy announcements, lower is the impact of these announcements on the oil market movements. The negative coefficient of uncertainty is true for time-varying effects on oil returns as well as the time-varying effects on the realized volatility, including good and bad realized volatility. The intuitive explanation of a negative coefficient could be that increased uncertainty makes the prediction of asset prices response to policy changes more difficult. This encourages herding behavior and consequently, reduces policy effectiveness.

This behavior of the oil market response to monetary policy is consistent with the behavior of broader asset class response to monetary policy. Both stock and bond markets response to monetary policy hinges on the level of uncertainty prevailing in the economy (Marfatia (2014, 2015)). In the case of commodity prices, Gospodinov and Jamali (2018) find that uncertainty associated with negative monetary policy shocks impacts commodity price changes negatively. Kurov and Stan (2018) find that higher policy uncertainty weakens the response of stock and crude oil markets to macroeconomic news, which is contrary to Treasury, interest rate, and foreign exchange markets' response.

The negative coefficient of uncertainty on the time-varying responses of the oil market has important policy implications. It does not mean that in time of high uncertainty the monetary policy is less effective in affecting the oil market movements. In fact, it means just the opposite. In order for policy actions to have an effective impact in the times of high uncertainty, even more aggressive policy actions may be required to move the market conditions.

5 Conclusions

The objective of the paper is to uncover the possible time-varying impact of monetary policy on oil market futures and relates it the monetary policy uncertainty. We use an event study approach within a time-varying parameter framework to estimate the time-varying path of monetary policy impact on oil market futures returns and realized volatility. We further distinguish between good and bad realized volatility and uncover the impact on each of them in separate specifications. As a robustness exercise, we consider alternative model specification which controls for macroeconomic news shocks. Further, we explore the impact of monetary policy uncertainty on the time-varying response of the oil market.

The evidence clearly suggests significant time variation in the impact of monetary policy announcements on the oil market movements, both for futures return and realized volatility. The response of oil returns was mainly negative in the 1999-2003 period, whereas the volatility responded positively to monetary policy changes. However, this changed with the onset of the crisis, especially in the case of the response of volatility to policy announcements. These results are robust to the inclusion of macroeconomic news shocks in the estimation process. Our investigation further in the nature of the time-varying pattern, reveal that these time variation in the response of the oil market are significantly linked to monetary policy uncertainty. Evidence suggests that when there is significant uncertainty around policy announcements, the impact of the announcement is lower, on both the returns and volatility.

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Table 1: Impact of monetary policy uncertainty on time-varying response of oil market returns and its realized volatility.

This table shows the impact of monetary policy uncertainty on the time-varying response of the oil market to policy announcements. In particular, it shows the estimated impact the different measures of monetary policy uncertainty (MPUNC3 and MPUNC10) following Husted et. al. (2017) on the time-varying response of oil returns (TVPRET), realized volatility (TVPRV), good realized volatility (TVPRV^G), and bad realized volatility (TVPRV^B). For each regression, we report the estimated coefficient, standard error (Std. Error) and the p-values.

	Dependent Variables					
	TVPRET			TVPRV		
	Coefficient	Std. Error	P-Value	Coefficient	Std. Error	P-Value
C	0.001723	0.03603	0.9619	-0.00031	0.000238	0.1973
MPUNC3	-0.00054	0.000195	0.0066	-3.40E-06	1.40E-06	0.0165
C	-0.0504	0.034474	0.1455	-0.00055	0.000236	0.0216
MPUNC10	0.000108	0.000177	0.5426	-4.68E-07	1.67E-06	0.7798
	TVPRV^B			TVPRV^G		
	Coefficient	Std. Error	P-Value	Coefficient	Std. Error	P-Value
C	-0.00021	0.000136	0.1317	8.05E-05	9.39E-05	0.3922
MPUNC3	-6.3E-07	7.34E-07	0.3911	-2.4E-06	6.05E-07	0.0001
C	-0.00026	0.000139	0.0665	-8.9E-05	8.61E-05	0.3019
MPUNC10	-4E-09	8.17E-07	0.9961	-3E-07	7.07E-07	0.668

Figure 1: The time-varying impact of monetary policy on oil market returns.

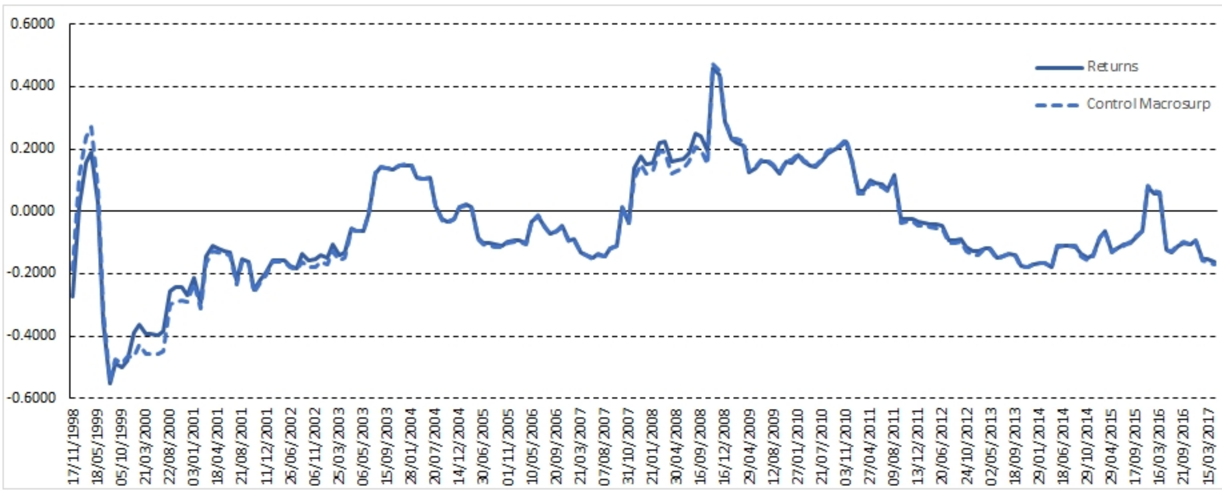

Figure 2: The time-varying impact of monetary policy on realized volatility.

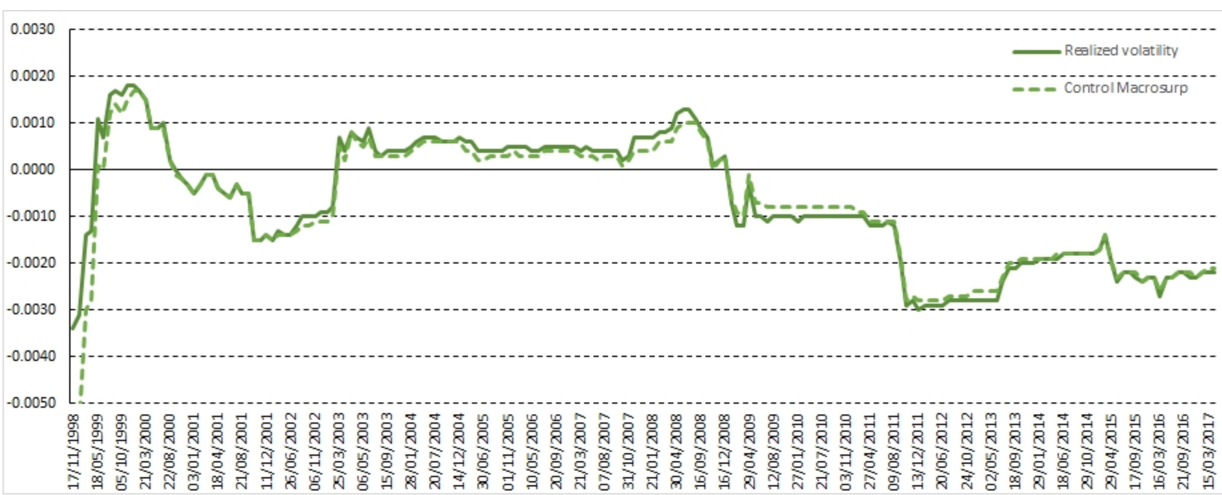

Figure 3: The time-varying impact of monetary policy on good realized volatility.

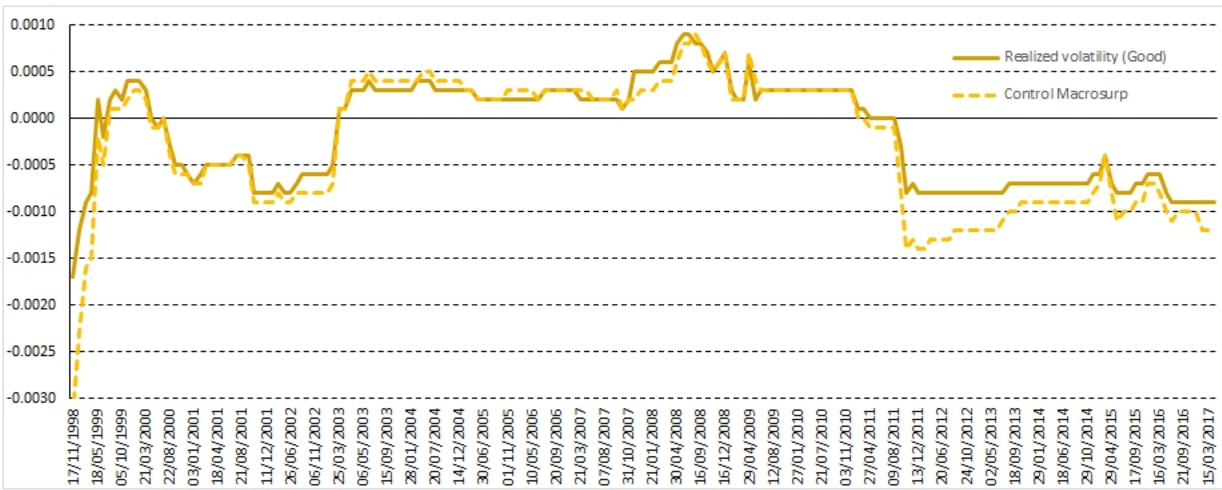

Figure 4: The time-varying impact of monetary policy on bad realized volatility.