The response of oil market to US monetary policy surprises

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Abstract: The impact of monetary policy surprises from the USA on volatility of oil returns are examined over a period of instability from January 5, 2004 through December 31, 2008. Following Kuttner (2001), I use the change in the one-day current-month futures rate at a given date to measure monetary policy news. Using EGARCH model, my results suggest that these shocks are an important driver of the oil market. I find that the volatility reacts in a statistically significant and economically relevant fashion to surprise changes in the target rate. The estimated effect on the volatility is positive. Moreover, I show that the daily changes in federal funds futures rates don’t have any role in the dynamics of oil volatility during the sample period. Finally, I also show that all model parameters to be highly significant with higher volatility persistence.

Keywords: federal open market committee; FOMC; US monetary policy surprises; oil returns; conditional variance; EGARCH.

1 Introduction

Throughout the last decade, commodity markets have experienced an exceptional volatility and different phases of evolution. One possible explanation of the behaviour of commodity prices is the influence of monetary policy actions on commodity markets. In an early study, Frankel and Hardouvelis (1985) highlight a close link between news related to monetary policy and commodity prices. A related channel has been discussed by Frankel (1986), who shows in a theoretical model that monetary policy shocks have important effects on agricultural commodity prices. More recently, Barsky and Kilian (2002) document that the oil price increases appear to be strongly related to global...
monetary conditions. In other paper, Barsky and Kilian (2004) argue that monetary policy is a reliable predictor of commodity markets. As argued by Scrimgeour (2015), the fact that commodities and bonds are viewed as assets that can store value, then when Federal Reserve (Fed) decides to sell bonds to raise interest rates, this action, in turn, influences demand for commodities. In other words, a lower commodity prices in the spot market are closely associated with an increase on interest rates due to monetary intervention.

Taylor (2009) suggest that when the reduction of interest rates by the federal open market committee (FOMC) was responsible for accelerating the rise in commodity prices (oil prices) during the early stages of the recent financial crisis that flared up in August 2007. Furthermore, as documented by Frankel (2008), the commodity prices respond negatively to variations of interest rates. Such a link between interest rates and commodity prices would also be in line with the studies of Caballero et al. (2008a, 2008b) suggesting that in the 2000s, lower real interest rates are associated with higher commodity prices at the same time.

In the literature there are two main approaches explored to measure the impact of monetary policy actions on commodities and financial markets, for instance, bonds or stock markets. The first one is the event study approach as proposed by Kuttner (2001) and Bernanke and Kuttner (2005). The authors find evidence that US monetary policy is important in explaining the movements on US stock and bond markets. Nevertheless, and from technical point of view, an event study analysis would be expected to provide potentially biased estimates. The second approach is based on the identification-through-heteroskedasticity methodology as developed by Rigobon (2003) and Rigobon and Sack (2004). To correct the mentioned bias, Rigobon (2003) propose a model based on instrumental variables estimation. He used heteroscedasticity in the data to derive adequate instruments. Rigobon and Sack (2004) have analysed the effects of monetary policy surprises on US major stock indices and bond markets by using the identification through heteroscedasticity approach. In so doing, their paper finds supportive evidence of the earlier results of Bernanke and Kuttner (2005). There have been a few papers explicitly focused to compare the two methods. For example, a key finding of Rosa (2011) when analysing the reaction of asset prices in 51 countries to US monetary policy surprises is that the event study approach is to be preferred. Kholodilin et al. (2009) find that there is downward bias in the event study approach in the euro area context.

To now, the reaction of commodity markets to unexpected interest rate decisions on dates when the FOMC meets has attracted much less attention in the literature. For example, Kilian and Vega (2011) investigate via event study analysis the energy market response to US monetary policy news. The results illustrate that the influence of monetary policy actions appears insignificant for crude oil prices. Chatrath et al. (2012) and more recently Chan and Gray (2016) extend Kilian and Vega’s study and they find no significant impact of Scheduled macroeconomic announcements news.

Based on standard VAR model, Anzuini et al. (2013) evaluated the impact of monetary policy shocks and commodity prices. Contrary to Kilian and Vega (2011), their results suggest that these shocks are an important driver of oil prices. In a more recent study, Scrimgeour (2015) apply the identification-through-heteroskedasticity approach as developed by Rigobon (2003) and Rigobon and Sack (2004) to estimate the effect of US monetary policy surprises on commodity prices. The author finds evidence that the response of commodity prices to Fed actions is statistically, and economically significant. Specifically, following ten basis-point surprise increased in interest rates, commodity
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prices decrease by approximately 0.6%. In a more recent paper, Basistha and Kurov (2015) investigate the empirical relationship between monetary policy surprises and energy markets at intraday, daily, and monthly frequencies. Two main findings can be marked. First, they show that energy prices react significantly to monetary shocks as measured by the surprise component of Fed funds rate futures within an intraday window. Second, the responses of energy prices to monetary policy surprises are statistically insignificant for the other frequencies.

My paper is closely related to the literature studying the factors affecting the movements on oil market, and more especially those related to US policy during the times of economic crisis. In this paper, I attempt to shed light on the effects of the US monetary policy surprises on the volatility of oil returns. This paper adds to the recent literature on the interactions between monetary policy shocks and commodity markets in several ways. First, I used an EGARCH model to specify the links between US monetary surprises and volatility. The response of oil market volatility to surprise changes in the target rate from US are less documented and understood. In a recent research, Hayo et al. (2012) employ GARCH model to investigate the US monetary policy surprise effect’s on the volatility of price commodities during the period 1998–2009. They found that target rate surprises increase the oil price volatility. More recently, Rosa (2014) documents that the volatility of crude oil futures prices and their trading volumes have experienced a substantial rise (higher than normal) after US monetary policy announcements by FOMC. Hence, we think that the effect of changes in the Fed’s target federal funds rate on commodity markets need not be limited to returns and can extend to volatility through a number of channels. What explains my choice? One possible explanation is that surprises on monetary policy or Fed actions can be considered as new information to investors, which can lead, in turn, to a rise of volatility through its effect on trading activity. This news obligates investors to rebalance their portfolios more intensively between assets thus spurring an increase in trading volume (Gospodinov and Jamali, 2015). As evidenced by the well-known positive relation between volatility and trading volume (Andersen, 1996; Karpoff, 1987, among others), the increase in trading volume could, in turn, translate into higher volatility. Another possible explanation, Ross (1989) attributes the increase in volatility in asset returns to information flow. Thus, it is important to take into account the eventual link between monetary policy surprises and volatility of commodity prices. Second, I employ the event study approach as set out by Kuttner (2001), commonly used in identifying the shocks to the federal funds rate and therefore the effects of monetary policy shocks. In particular, to extract monetary policy shocks, I use the one-day change in the current-month futures rate at a given date. Finally, I control the volatility returns and monetary policy shocks relationship by using the market participants’ expectations of the future level of the federal funds rate at daily level as captured by changes federal funds futures rates (Hamilton, 2009).

In this paper, interesting evidences emerge and are summarised as follows. The results present evidence that surprise changes in the target rate from US may have significant effects on the crude oil volatilities. My findings highlight the importance of US interest rate shocks. Finally, it is worth noting that all model parameters have been highly significant with higher volatility persistence.

The rest of my paper is organised as follows. Section 2 describes the model. Section 3 defines the data used in this study. Section 4 discusses the main empirical results. Section 5 concludes.
2 The model

In this section, I describe EGARCH model to accurately capture the underlying volatility dynamics. The empirical literature has reported that EGARCH specification allows for the implementation of several special features. It is suitable in explaining volatility asymmetry and allows negative volatility coefficients (Booth et al., 1997; Braun et al., 1995).

The ultimate goal of this paper is to measure the effect of US monetary policy surprises on oil price volatility. This study covers the period from January 5, 2004 through December 31, 2008. This period is characterised by an important number of Fed actions to stabilise the markets. I refer to Kuttner’s (2001) approach for assessing shocks from federal funds futures rates. As mentioned below with more details (Section 3), it is well known that Fed actions have been disclosed to the public at typically around 2:15 pm Eastern Time.

The commodity markets usually close before the announcement of FOMC statements of scheduled meetings during the period under study. Therefore, the monetary policy shocks from US only affect these markets on the subsequent business day, i.e. the day after a Fed announcement; and then they enter the model lagged one period.

The underlying common question is identifying the factors that can explain the volatility of oil prices over time, other than the monetary policy shock. The key contribution of this paper is the identification of the relationship among the oil market and monetary policy expectations. In other words, I assess whether future course of monetary policy has a significant effect on the volatility of oil market. Specifically, following Hamilton (2009), I measure market participants’ expectations of the future level of the federal funds rate at daily level as changes federal funds futures rates.

The inclusion of measure of market participants’ expectations, in the analysis of the conditional volatilities represents an original approach. This step not only enables us to quantify the effect of this important factor on the dynamics of oil prices, but it also mitigates the responses of oil market to surprise component and the daily expectations of the monetary policy.

I start this analysis by considering a baseline EGARCH model as shown in equation (1):

\[
\ln (\sigma_t^2) = \omega + \delta \ln(\sigma_{t-1}^2) + \alpha \left( \frac{\epsilon_{t-1}}{\sigma_{t-1}} \right) + \beta \frac{\epsilon_{t-1}}{\sigma_{t-1}} + \lambda_1 \text{SUR}_{t-1} + \lambda_2 \text{MEXP}_t
\]

where

- \(\sigma_t^2\) and \(\sigma_{t-1}^2\) denote the conditional variance of commodity price returns respectively at time \(t\) and \(t-1\) which depends upon the mean volatility level (\(\omega\))
- \(\text{SUR}_{t-1}\) gives the US monetary policy surprises at date \(t-1\)
- \(\text{MEXP}_t\) defines the market participants’ expectations at date \(t\)
- \(\delta\) measures the volatility persistence for a given shock in the conditional variance and the log transformation guarantees a positive variance.
Note that asymmetry take place if the coefficient $\beta \neq 0$, and when $\beta < 0$. One could interpret this as follow: following negative shocks, I observe a greater response in volatility than following positive shocks of the equal magnitude, and vice versa.

3 Data

The aim of this paper is to examine the relation between the effects of unexpected changes in policy interest rates by the FOMC on the volatility of oil price returns. We know that the FOMC meets eight times for each year since the early 1980s. Since 1994 FOMC statements are scheduled to be released to the public at or a few minutes after 2:15 pm Eastern Time following each meeting. Prior to 1994, the FOMC did not announce the decisions of scheduled meetings and, therefore, market participants had to infer these decisions from the size and type of open market operations OMOs in the days following each meeting (for more details see Lucca and Moench, 2015). The monetary surprise announcements are collected from the website of the Federal Reserve. The sample period includes 41 announcements of monetary policy surprises.

The measurement of US monetary policy shocks is different from that for the other central banks. In the literature, different methods exist which seeks to extract US monetary policy announcement surprises. For instance, Kuttner (2001) uses the change in the one-day current-month futures rate at a given date to measure monetary policy news. Gürkaynak et al. (2007), referred to changes in federal funds rate and Eurodollar futures. Hausman and Wongswan (2011) used the federal funds rate (target surprise) and the revision to the expected path of future monetary policy (path surprise). Poole and Rasche (2000) measure the daily monetary policy surprise in a simple way as an unscaled one-day change in the one-month-ahead futures rates. In other hand, and based on Federal funds futures data, Bernanke and Kuttner (2005) define the monthly monetary policy surprises as the difference between the average Fed funds target rate for a giving month $t$ and the one-month futures rate on the last day of month $t-1$. In this paper, I refer to Kuttner (2001) to obtain a measure of the surprise in the Fed target rate change.

To extract the surprise on an announcement occurred at day $d$, Kuttner’s (2001) proposed surprise component is given by the scaled version of the change in the one-day current-month futures rate. I obtain the surprise from the following formula:

$$S = \frac{D}{D-d}(f_d - f_{d-1}),$$

where $f_d$ denotes the current-month futures rate at the end of the announcement day $d$, $f_{d-1}$ is the current-month futures rate at day $(d-1)$ and $D$ is the number of days in the month with $d = 1, \ldots, D$.

Table 1 provides information regarding the summary statistics of daily return time series on oil prices, all monetary policy surprises based on all regularly scheduled Federal Open Market Committee meeting dates, Fed target rate change, and changes in market participants’ expectations. The sample period is from January 5, 2004 through December 31, 2008.
Table 1
Descriptive statistics for daily data

<table>
<thead>
<tr>
<th></th>
<th>Crude oil returns</th>
<th>Target rate change</th>
<th>Surprise change</th>
<th>Changes in market participants’ expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.047573</td>
<td>0.012500</td>
<td>-0.021541</td>
<td>-0.000674</td>
</tr>
<tr>
<td>Median</td>
<td>0.069716</td>
<td>0.000000</td>
<td>0.000000</td>
<td>0.000000</td>
</tr>
<tr>
<td>Maximum</td>
<td>12.15231</td>
<td>0.250000</td>
<td>0.237931</td>
<td>1.185000</td>
</tr>
<tr>
<td>Minimum</td>
<td>-15.49167</td>
<td>-0.750000</td>
<td>-0.740555</td>
<td>-1.185000</td>
</tr>
<tr>
<td>Std. dev.</td>
<td>2.300788</td>
<td>0.282786</td>
<td>0.129486</td>
<td>0.078850</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.044902</td>
<td>-1.282698</td>
<td>-4.280528</td>
<td>-1.742272</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>6.781457</td>
<td>3.912422</td>
<td>25.48638</td>
<td>145.6492</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>742.7969*</td>
<td>12.35629*</td>
<td>964.8813*</td>
<td>145.6492*</td>
</tr>
<tr>
<td>Probability</td>
<td>0.000000</td>
<td>0.002074</td>
<td>0.000000</td>
<td>0.000000</td>
</tr>
</tbody>
</table>

Notes: The table presents the main statistical features for the selected daily variables during the period January 5, 2004, until December 31, 2008. The sample includes oil price returns, target rate change by Fed, Fed monetary policy surprise and changes in market participants’ expectations. The monetary announcements surprises are collected from the website of the Fed. The sample period includes 41 announcements. I follow Kuttner (2001) and define the mentioned surprises by using the one-day change in the current-month futures rate. Also, I follow Hamilton (2009) and measure market participants’ expectations of the future level of the federal funds rate at daily level as changes federal funds futures rates. All retained variables are in percent.

The results in Table 1 indicate that the Fed monetary policy surprises are, on average, negative. Moreover, Table 1 also shows that these surprises exhibit a volatility of 0.129486.

Table 1 shows that the Fed funds target rate changes are, on average, positive and exhibit a volatility of 0.282786. Note that sample period is marked by changes of 0.25%, 0.50% or 0.75% in the Federal funds target rate.

Turning now to the main statistical features for the daily oil price return series employed in the empirical analysis for the period January 5, 2004, until December 31, 2008. As seen in Table 1, the average value of the returns is, on average, positive (about 0.05). When I study the standard deviation, the daily return series exhibits a daily volatility of about 2.30. The standard deviations as well the minimum and maximum values for each series illustrate the presence of significant time series variation in the oil returns.

The oil returns are found to exhibit negative skewness, (–0.044902) which imply that the distribution is asymmetrical right in a given time period. Concerning the kurtosis, I observe that the value is higher than three, the value for the normal distribution. In sum, the skewness and kurtosis results show that the daily returns are asymmetric, fat-tailed and high-peaked than the Gaussian distribution. These values give good reason for the reference to the GARCH class of models.
4 Empirical results

This section presents the empirical results. It shows the response of oil volatility to US monetary shocks, as measured by the surprise component of federal funds rate futures early proposed by Kuttner (2001). As a possible explanatory variable of volatility, I retain a measure of US monetary policy expectations captured by the daily level as changes federal funds futures rates (Hamilton, 2009). Note that the sample starts on January 5, 2004 and ends on December 31, 2008.

Results from the baseline EGARCH model are provided in Table 2. My main findings can be summarised as follows. The results from the model (1) suggest that US monetary policy shocks drive up the oil price volatility during the sample period retained in this study. In particular, the surprise component has a positive and statistically significant, at 10% level, effect on oil price volatility as a unit percentage change in the surprise tends to increase the change in volatility by 1.106405 percentage points. This indicates that the choice of US monetary policy surprise is appropriate for the energy market volatility. Furthermore, the influence of surprises on volatility of oil market returns evidenced in Table 2 is consistent with Ross’s (1989) findings which highlight that the increase in volatility in asset returns can be attributed to information flow. Interestingly, the fact that oil market has experienced large volatility in anticipation of Fed actions, this implies that while oil is viewed as asset which generates hard store value, but it cannot be necessarily a safe investment. Overall, the significant relationships that I find for the oil market and US monetary shocks corroborate a number of relatively recent papers linking the commodity markets with US monetary news (for example, Kilian and Vega, 2011; Hayo et al., 2012; Anzuini et al., 2013; Gospodinov and Jamali, 2013 and more recently Basistha and Kurov, 2015; Scrimgeour, 2015) and emphasise the importance of US interest rate shocks.

Table 2 Base line EGARCH estimation

<table>
<thead>
<tr>
<th>$\omega$</th>
<th>$\delta$</th>
<th>$\alpha$</th>
<th>$\beta$</th>
<th>$\lambda_1$</th>
<th>$\lambda_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.030900</td>
<td>0.949811</td>
<td>0.058253</td>
<td>-0.107265</td>
<td>1.106405</td>
<td>-0.355880</td>
</tr>
<tr>
<td>(0.2218)</td>
<td>(0.0000)*</td>
<td>(0.0256)**</td>
<td>(0.0000)*</td>
<td>(0.0788)**</td>
<td>(0.1439)</td>
</tr>
</tbody>
</table>

Notes: Table 2 reports the estimation results from EGARCH model. To empirically test this model, I use daily return series of oil prices during a sample period that starts on January 5, 2004 and ends on December 31, 2008. The sample of monetary policy news can be divided on two categories the surprise and changes in market participants’ expectations about target rate change by the Fed. $\delta$ measures the volatility persistence. Statistical significance at the 1%, 5% and 10% levels is denoted by *, ** and ***, respectively. t-values are shown in parentheses.

Table 2 also reports the estimated coefficient of US monetary policy expectations which appears negative for this case study, but statistically insignificant effect on oil volatility. For example, a unit percentage change in the daily market participants’ expectations tends to decrease the volatility by about 0.356 percentage points.
Second, based on variance equation, I find that the estimated parameters to be highly significant, except for constant term. For example, the asymmetric component is highly significant at the 1% level. Furthermore, the lagged conditional variance term is significant indicating a high degree of persistence in volatility. Overall, my findings support the use of EGARCH model for capturing commodity market prices and their conditional variance.

In sum, the empirical results I obtain are in line with previous studies confirming the hypothesis that Federal funds rate surprises significantly affect the volatility of energy market. I note that the response of volatility to monetary policy expectations is not pronounced. Overall, it appears that only the surprise component of monetary policy stand help predicting oil price dynamics.

5 Summary and concluding remarks

Oil price developments have been one of the major sources of concern for policymakers in recent years. Understanding how oil prices incorporate information on changes in monetary policy is a key question in finance. However, to date, much existing literature did not explicitly tackle the response of oil market volatility to US monetary policy shocks. This article intends to fill this gap in the literature and attempts to measure the size of US monetary policy surprises’ effects on volatility by means of EGARCH model for daily data during a sample period that starts on January 5, 2004 and ends on December 31, 2008.

The main findings can be summarised as follows. First, US monetary policy shocks drive up the volatility of oil market during the sample period retained in this study. Specifically, I find that surprise changes in the target rate significantly increase conditional volatility. This significant and positive link highlights the importance of US interest rate shocks on influencing the volatility of oil market returns which, in turn, have an effect on consumer behaviour and consequently the performance of the overall economy. Second, I show that the changes in market participants’ expectations as measured by daily changes in federal funds futures rates do not play any role in determining the movement of oil markets. Third, my findings suggest that the significance levels of EGARCH model parameters are strongly higher. Furthermore, I find a higher persistence of volatility in oil series.

My paper uncovers important implications for investors and policymakers. First, investors would do well to pay attention to information flow from Fed actions regarding the US monetary policy. Second, the response of the volatility to monetary policy surprises is similar to that of bond and stock markets. This finding implies that when investors proceed to diversification to safeguard their portfolios against risk is not an appropriate decision. From a market perspective, for instance, oil price dynamics depend not only to oil supply, US macroeconomic fundamentals but also to US monetary policy actions. From a policy making point of view, given that volatility of commodity markets reacts in a statistically significant and economically relevant fashion to Fed actions, one may argue that the Fed might be able to influence market volatility by the ways of alternative actions or forward guidance. Indeed, a reliable analysis of the dynamics of oil prices can help policymakers by limiting their dramatic implications, for instance, as suggested by Bernanke (2008) the inflationary consequences and the adverse effect of oil price shocks on real economic activity.
References


Notes

1 In the literature researchers proposed also convenience yields (Gospodinov and Ng, 2013) and exchange rates (Chen et al., 2010) as determinants of the dynamics of spot commodity prices.