Oil News Sentiment and Volatility in Energy Market

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Abstract

This paper examines the effects of oil news sentiment on both of spot and future returns in energy commodity (crude oil, heating oil, gasoline, and natural gas) using weekly data from September 2006 to August 2016. Specifically, the asymmetric effects of sentiment (pessimism versus optimism) on volatility of spot and future returns in energy commodity are empirically investigated by GARCH (1,1) and DCC-MGARCH, repectively. Our empirical results indicate that based on the univariate GARCH (1,1) model, optimistic sentiment (positive sentiment change) significantly enhances both of spot and futures retunes while showing the robustness as the alternative measure of percentage change in oil news sentiment index. Moreover, the results of multivariate GARCH model using DCC-MGARCH indicates the similar finding that optimistic sentiment economically proliferates both of spot and futures retunes. Besides, optimistic sentiment change significantly mitigates the volatility for spot returns while pessimistic sentiment change only increases the volatility risk of crude oil. Moreover, optimistic sentiment change significantly decreases the volatility for futures return as pessimistic sentiment change conversely increases the volatility risk into crude oil and gasoline.

Keywords: News Sentiment; Volatility Spillover; Energy Market

1. Introduction

Considering that the nominal value of the energy commodity futures contracts traded on the New York Mercantile Exchange (NYMEX) amounts to between 1/3 and 1/2 of the market value of the stocks traded on the New York Stock Exchange (NYSE) and that energy related products are critically important to our economic system, understanding what drives the energy prices cannot be under emphasized. As a result the extreme behavior of energy spot and futures prices in recent years has captured the attention of hedgers, speculators, regulators and academics alike. Figure 1 presents the time series of weakly closing settlement prices for the spot energy commodity prices (crude oil, heating oil, gasoline, and natural gas), obtained from EIA (U.S. Energy Information Administration) and the corresponding time series of weekly changes in the log of the spot prices for the period September 2006 to August 2016. Figure 2 presents the time series of weekly futures prices and changes in the log of the futures prices. Noticeable in both figures are what appear to be jumps in the data, not to mention seasonal patterns, portrayed in Figure 3 and 4.

Futures markets are felt to be important aggregators of information about commodity prices ultimately contributing to the efficient allocation of commodity resources. Black (1976) goes so far as to argue that this price discovery role of futures markets dominates its role as a facilitator of risk sharing. Efficient price discovery however does not necessarily imply ‘smooth’ price changes. When news surprises occur efficient price discovery will manifest itself as price jumps in much the way Figures 1 and 2 portray. In addition, if price discovery occurs in the futures market (possibly due to low transactions costs) and is subsequently manifested in the spot market, we should observe jumps in spot prices but with a lag. Jumps in energy prices are an especially important element of the market and are an accepted phenomenon. Models of the dynamics of natural gas and oil prices generally have treated sharp moves in prices as a generalized jump process with a constant jump parameter (see Clelow and Strickland, 2000; Deng, 2000; Seppi, 2002; and Eydeland and Wolyniec, 2003, for examples and the references therein). Formal studies of the fundamental determinants of these jumps however are largely absent from the literature. Understanding how news about the fundamental determinants of energy prices influences price change shocks is an important element of understanding and modeling the dynamics of energy prices and jumps in the series. One of our main concerns is on how fundamental changes influence changes in the levels of the futures prices as well as the spot prices for four energy commodities : namely, crude oil, heating oil, gasoline, and natural gas.

Also, after studying the futures price data at Commodity Futures Traders Commission (CFTC), Haigh et al (2007) argued that speculators actually help the gas market by reducing volatility and increasing liquidity. It is the commercial market participants such as producers, brokers and trading companies that drive most of the energy price movements on the New York Mercantile Exchange (NYMEX) where energy futures contracts are traded. They further suggested that dealers and merchants (commercial traders or fundamental traders) change their positions first, prompting a change of positions from hedge funds (speculators) and hedge funds react to price but not cause it. Haigh et al's comments contradicted those of several others, who asserted that hedge funds (speculators) are responsible for increasing volatility in both the futures and cash markets (e.g., Stein, 1987; Hart and Kreps ;1986;Brunetti et al. 2011;Singleton ,2014; Ding et al. ,2014).

Haigh et al (2007) provided more detailed trader profile data for the gas and oil futures contract traded in NYMEX. Their conclusions mirror those in the above paragraph. Our proposed study intends to supplement the Haigh et al’s study in two major areas. Haigh et al used the futures and options data for the period of 8/4/2003 to 8/31/2004, a period that is about 1 year. There is a need to examine a longer time period since the market composition of the traders has changed substantially, with many hedge funds, institutional investors and others crowding into the energy markets in recent years. In addition and more importantly, we will incorporate fundamental variables in the study to aid our understanding of the behavior of the energy market. This is particularly important since it will enable us to determine the degree to which the market follows fundamentals or is driven by market sentiments or speculations.

Recently, a plethora of financial studies had addressed the importance of market sentiment in determining the asset returns (Riordan, Storkenmaier, Wagener, & Zhang, 2012; Tetlock, 2007, Tetlock, 2010 and Tetlock et al., 2008). Among the authors, Riordan et al. (2012) indicates that compared with positive news, negative news has more information contents and exerts substantial impact on asset prices and liquidity.

Different scholars also use a wide range of investor sentiment indices to carry out empirical research. Simon and Wiggins (2001) and Chen and Chang (2005) employed VIX、put-call ratio and TRIN；Sanders et al. (2003) used Consensus Bullish as a proxy and Kurov (2008) made use of Individual Investors Sentiment Indicators compiled from Investor Intelligence and American Association；lastly，Baker and Wurgler, (2006) and Baker and Wurgler (2007) created their indices based on the investor’ s belief of future asset price and risk. Lee et al. (2002) had found that Investors’ Intelligence sentiment is a significant factor in determining the stock price returns and fluctuation. The conclusion is similar to Bahloul and Bouri (2016), who investigated thirteen futures returns.

In line with market sentiment index, news sentiment, which refers to the dissemination of news that might shape sentiment, or beliefs of market participants about the state of the market, is proved to be a key indicator in different financial asset and commodity price determination (for example, Antweiler and Frank, 2004; Tetlock, 2007 Feuerriegel and Neumann 2013,; Zheng, 2014; Ratku, Feuerriegel, and Neumann, 2014; Feuerriegel, Heitzmann, and Neumann 2015; Borovkova and Mahakena, 2015). Among them, negative news sentiment is found by Feuerriegel and Neumann (2013) as a stronger driver in oil and gold market than positive news sentiment. This finding highlights an important implication that the asymmetric effect of news sentiment should be included in further examining the price dynamics. Zheng(2014) had successfully put this perspective into the linkage between stock market investor sentiment and commodity futures returns. Using VAR-GARCH-M, Zheng found the existence of the asymmetric response of prices to news.

Though directed toward a similar purpose, this study attempts to compliment Zheng’s work in three ways. 1) We consider energy commodity of spot and future returns while Zheng (2014) only focused on the commodity futures returns. 2) We use the weekly oil news sentiment index different form Zheng (2014) of monthly stock market investor sentiment, and then empirically and directly investigate sentimental asymmetry (pessimism versus optimism) on the energy commodity of spot and future returns. 3) Both of univariate and multivariate GARCH models, are employed for estimating the volatility clustering and spillovers among the energy markets.

This paper is expected to shed light on the role of news sentiment in price formation and volatility formation, which would lead to more efficient market regulation and oversight and efficiency improvement. In doing so, we intend to disentangle the puzzle of the news sentiment, and lastly, empirical evidence of cross market linkages is scarce in the co-movement correlation literature. This result, however, is warranted since there are implications for diversification benefits associated with it. We investigate four energy price return correlations using a multivariate setting.

2. Methodology and Data

To gauge the magnitude of the price change and volatilities, tabular account of the weekly price changes and volatility in the form of standard deviation (we will also perform an array of diagnoses of heterogeneity in the standard deviations, and if the conditional heterogeneity holds true, the GARCH model estimation of the volatility would be added,) and coefficient of variation will be provided. Week to week price change as well as weekly average price changes by year, season and for the whole sample period will be calculated to show the magnitudes of price fluctuations. Below delineates three basic specifications regarding our research questions.

2.1 Univariate GARCH

This paper used the GARCH model to capture the volatility clustering in energ market, including contemporaneous shifts in oil news sentiment in the mean equation and lagged shifts in the magnitude of investor sentiment in the conditional volatility equation. Therefore, our model is specified as GARCH (1,1) with the following form:

$$RET_{i,t} = \alpha_0 + \alpha_1 \times \Delta Sent_t + \sum_{j=1}^{2} \beta_j \times RET_{i,t-j} + \sum_{k=1}^{3} \gamma_k \times SEA_t + \varepsilon_{i,t}, \quad \varepsilon_{i,t} \sim (0, h_{i,t}) \qquad (1)$$

$$h_{i,t} = \beta_0 + \beta_1 \varepsilon_{i,t-1}^2 + \beta_2 h_{i,t-1} + \beta_3 (\Delta Sent_{t-1})^2 \times D_{t-1}^{+} + \beta_4 (\Delta Sent_{t-1})^2 \times D_{t-1}^{-} \qquad (2)$$

where $RET_{i,t}$ is the weekly return on an energy commodity (crude oil, heating oil, gasoline, and natural gas), $Sent_t$ is a weekly measure of oil headline news index monitored by sentix (www.sentix.de), which is based on a survey-based index calculated from a market assessment of 5000 registered investors from Europe, the USA, and Japan. Specifically, two alternative measures of sentiment index are used in Equation (1). The first measure is calculated as the change in the oil news sentiment index, $\Delta Sent_t = Sent_t - Sent_{t-1}$; the second is measured as the percentage change in oil news sentiment index, $\%\Delta Sent_t = \Delta Sent_t / Sent_{t-1}$. SEA_t represents the month effect with higher returns for four energy commodity and the includes three seasonal dummies on February, March, and April. In Equation (2), $D^{+}_{t-1} = 1$ if $\Delta Sent_t > 0$; otherwise, $D^{-}_{t-1} = 0$ if $\Delta Sent_t \leq 0$.

2.2 Multivariate GARCH (DCC-MGARCH)

We estimate a dynamic conditional correlation (DCC-MGARCH) model, which is flexible enough to account for its own and cross-market volatility and persistence across the markets. In addition, the DCC model provides a dynamic conditional correlation matrix, which enables us to study whether the cross market interdependence is time-varying or not. Therefore, we model the price behavior as the following model:

$$RET_t = \beta_0 + \beta_1 \times \Delta Sent_t + \sum_{j=1}^{k} \gamma_j RET_{t-j} \sum_{k=1}^{3} \delta_k \times SEA_t + \varepsilon_t, \quad \varepsilon_t | I_{t-1} \sim (0, H_t) \tag{3}$$

where RET_t is a 4 × 1 vector of returns for crude oil, heating oil, gasoline and natural gas, β_0 is defined as a 4 × 1 vector of long-term drifts, β_j, with j = 1,.., k, are 4 × 4 parameter matrices, and ε_t is a 4 × 1 vector of forecast errors for the best linear predictor of RET_t. The forecast error is conditional on past information (I_{t-1}), and the error has a corresponding variance–covariance matrix H_t. The elements of β_j, j=1,.., k, provide measures of own- and cross-mean spillovers between markets as in a standard VAR representation.

We define the conditional variance-covariance matrix H_t as

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + G'H_{t-1}G + \pi_1(\Delta Sent_{t-1})^2 \times D^+_{t-1} + \pi_2(\Delta Sent_{t-1})^2 \times D^-_{t-1} \quad (4)$$

where C is a 4 × 4 upper triangular matrix of constants C_{ij}, A is a 4 × 4 matrix containing elements A_{ij} that measure the degree of innovation from market *i* to market *j*, and G is a 4 × 4 matrix whose elements G_{ij} show the persistence in conditional volatility between markets *i* and *j*. The conditional variance–covariance matrix as we defined in Eq. (4) allows us to study the volatility transmission across markets in terms of its persistence, direction and magnitude.

A DCC model assumes a time-dependent conditional correlation matrix $RET_t=(\rho_{ij,t})$, $i, j = 1, \ldots, 4$, and the conditional variance–covariance matrix H_t

$$H_t = D_t R_t D_t \quad (5)$$

where

$$D_t = diag\left(\sqrt{h_{11,t}}, \ldots\ldots, \sqrt{h_{33,t}}\right) \quad (6)$$

$h_{ii,t}$ is assumed to follow a GARCH(1,1) specification, i.e. $h_{ii,t} = \omega_i + \alpha_i \varepsilon^2_{i,t-1} + \beta_i h_{ii,t}$, i = 1,…, 4, and

$$RET_t = diag\left(q_{ii,t}^{-1/2}\right) Q_t diag\left(q_{ii,t}^{-1/2}\right) \quad (7)$$

with the 4 × 4 symmetric positive-definite matrix $Q_t = (q_{ij,t})$, i, j = 1,…, 4, given by

$$Q_t = (1 - \lambda_1 - \lambda_2)\overline{Q} + \lambda_1 u_{t-1} u'_{t-1} + \lambda_2 Q_{t-1} \quad (8)$$

and $u_{it} = \varepsilon_{it} / \sqrt{h_{ii,t}} \cdot \overline{Q}$ is the 4 × 4 unconditional variance matrix of u_t, and λ_1 and λ_2 are non-negative adjustment parameters satisfying $0 < \lambda_1 + \lambda_2 < 1$.

2.3 Data

The weekly measure on investor sentiment of oil headline news index is mainly collected from **Sentix** (www.sentix.de), based on a survey-based index calculated from a market assessment of 5000 registered investors from Europe, the USA, and Japan. Both of spot and future prices for energy commodities, including crude oil, heating oil, gasoline, and natural gas, are obtained from EIA (U.S. Energy Information Administration) (www.eia.gov). Our weekly data spans from September 2006 to August 2016.

3. Empirical Results

Both of spot and futures returns on energy commodity present the co-movement pattern with time (Figure 1 & 2). As shown in Figure 3 & 4, seasonal spot and futures returns in energy market exhibited higher averaged returns in three months of February, March, and April. Based on this observation, we control for seasonal fixed effect in our specification of mean equation.

3.1 The effects of change in oil news sentiment on spot and futures returns

Based on the univariate GARCH (1,1) model, optimistic sentiment (positive sentiment change) significantly enhances both of spot and futures retunes. This result also shows the robustness as the alternative measure of percentage change in oil news sentiment index. The results of multivariate GARCH model using DCC-MGARCH indicates the similar finding that optimistic sentiment economically proliferates both of spot and futures retunes.

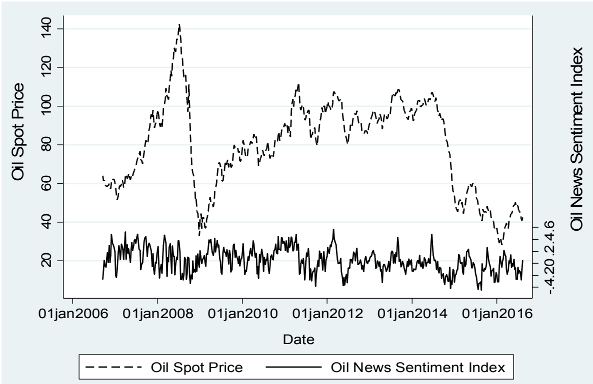
3.2 The asymmetric effects of change in oil news sentiment on spot and futures volatilities

First, based on univariate GARCH model, optimistic sentiment change significantly mitigates the volatility for spot returns while pessimistic sentiment change only increases the volatility risk of crude oil. Moreover, optimistic sentiment change significantly decreases the volatility for futures return as pessimistic sentiment change conversely increases the volatility risk into crude oil and gasoline. Second, based on the DCC-MGARCH, optimistic sentiment change maintains the positive influence on reducing volatilities for spot returns while this effect present consistent in futures returns for all commodities. We find the significance in volatility dynamics and spillovers cross market. The correlation among all commodities shows the significance in futures returns.

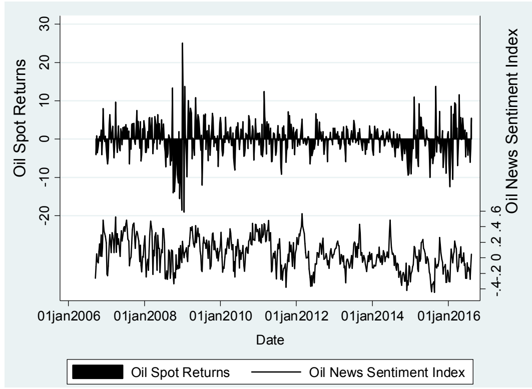
4. Conclusion

This paper discovers the asymmetrical impacts of news sentiment, the final results can aid investors to evaluate the timing of investment in order to avoid problems associated with irrational exuberance. Also, the government can utilize the news sentiment as a beacon for market stabilization policy and risk control. However, crude oil, heating oil, gasoline, and natural gas are four major energy substitute products, as we know. The cross market volatility spillover effect is found from the results of multivariate GARCH, the market participants can accordingly calculate the optimal hedge ratio and portfolio weight for the diversification.

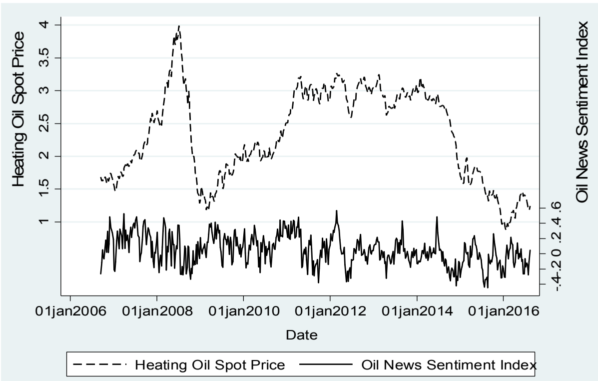
We show that based optimistic sentiment (positive sentiment change) significantly enhances both of spot and futures retunes while showing the robustness as the alternative measure of percentage change in oil news sentiment index. while multivariate model indicates the similar finding that optimistic sentiment economically proliferates both of spot and futures retunes. inaddition, optimistic sentiment change significantly mitigates the volatility for spot returns while pessimistic sentiment change only increases the volatility risk of crude oil. Finally, optimistic sentiment change significantly decreases the volatility for futures return as pessimistic sentiment change conversely increases the volatility risk into crude oil and gasoline.



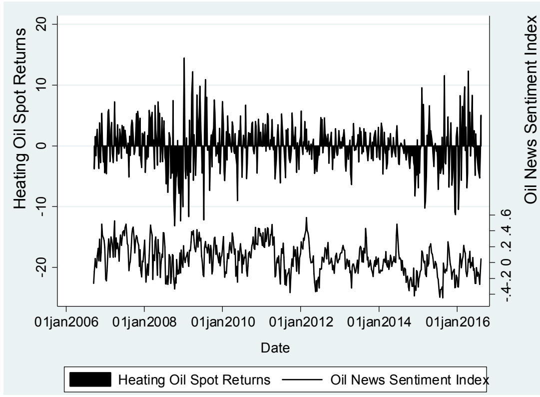
A1. Crude Oil Price



A2. Crude Oil Returns



B1. Heating Oil Price



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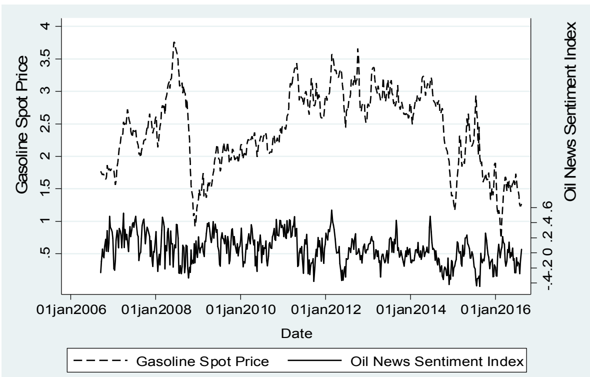
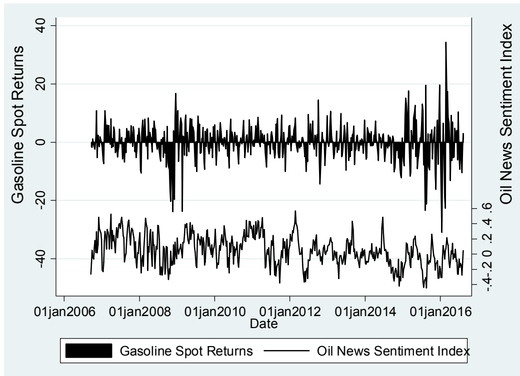
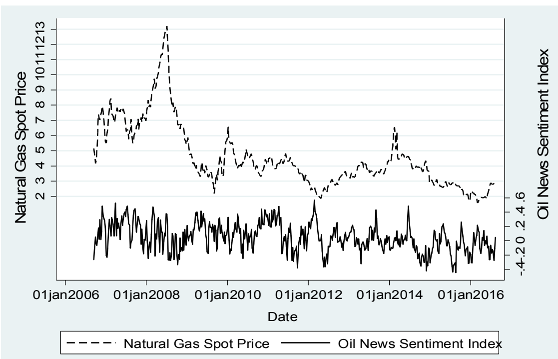


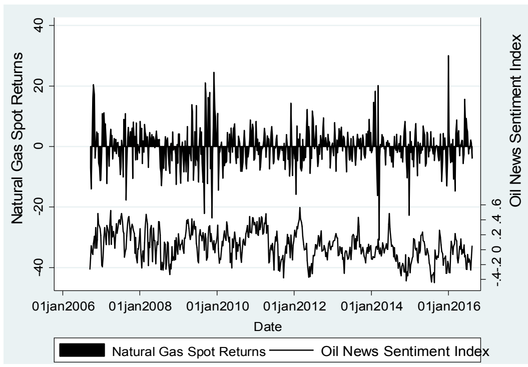
C1. Gasoline Price



C2. Gasoline Returns



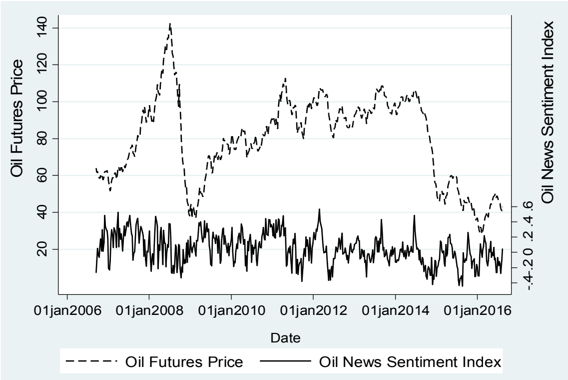
D1. Natural Gas Price



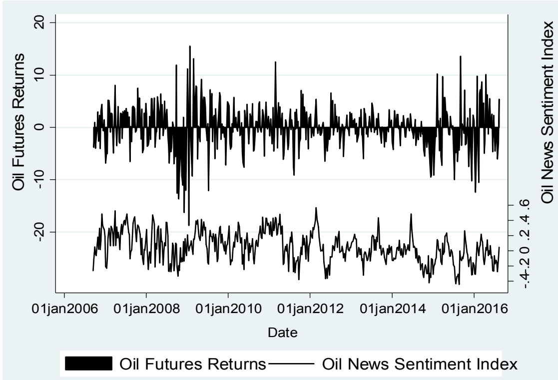
D2. Natural Gas Returns

Figure 1

Oil News Sentiment and Spot Price (Returns) of Energy Commodity



A1. Crude Oil Price



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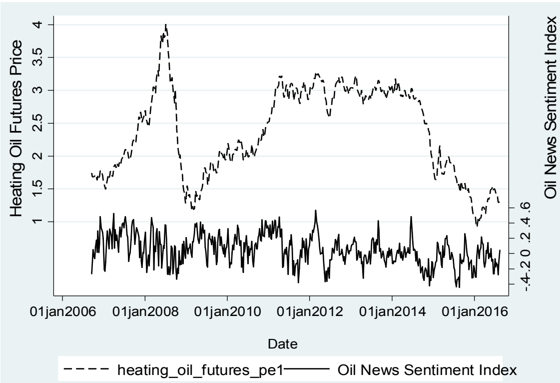
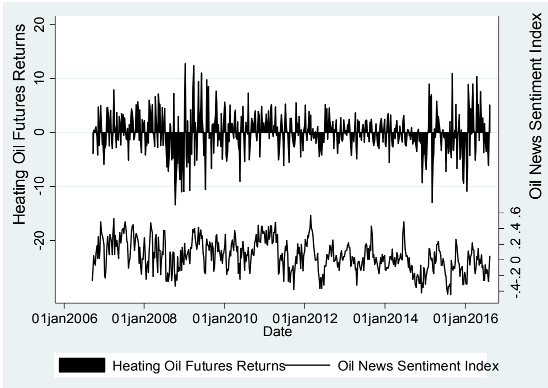
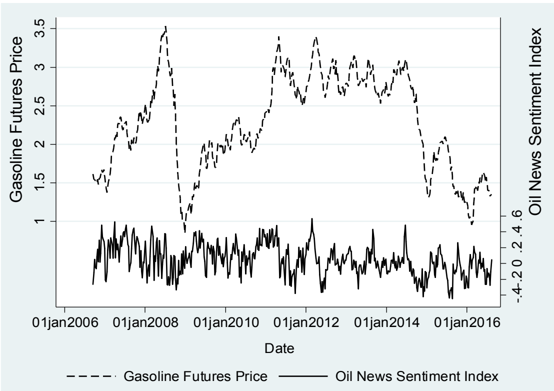


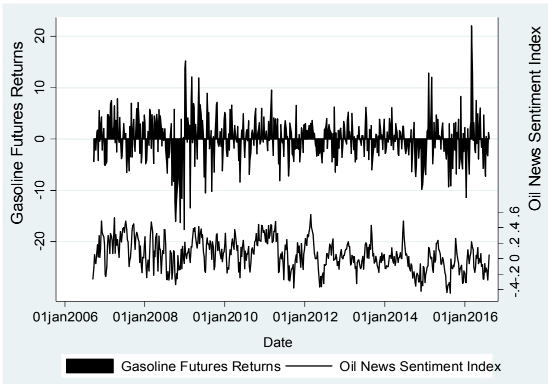
B1. Heating Oil Price



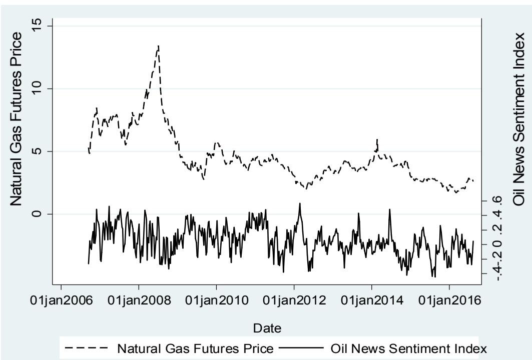
B2. Heating Oil Returns



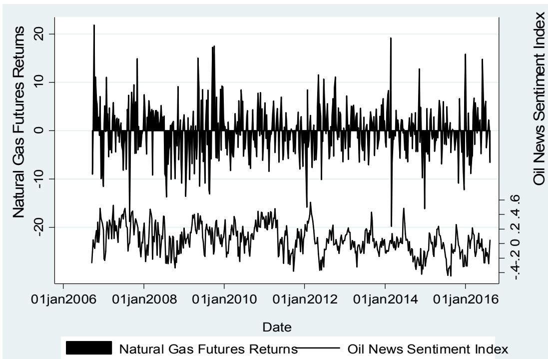
C1. Gasoline Price



C2. Gasoline Returns



D1. Natural Gas Price



D2. Natural Gas Returns

Figure 2

Oil News Sentiment and Futures Price (Returns) of Energy Commodity

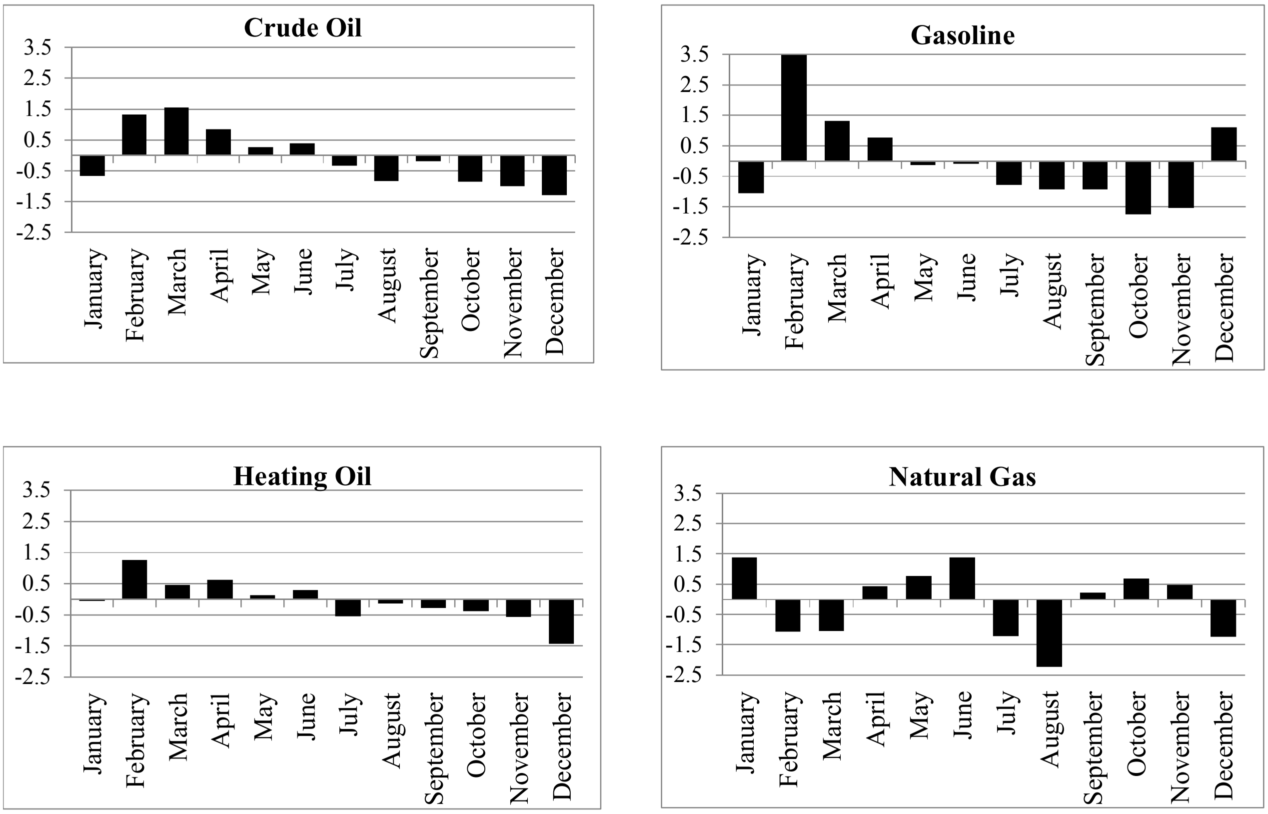


Figure 3
Seasonal Spot Returns in Energy Market

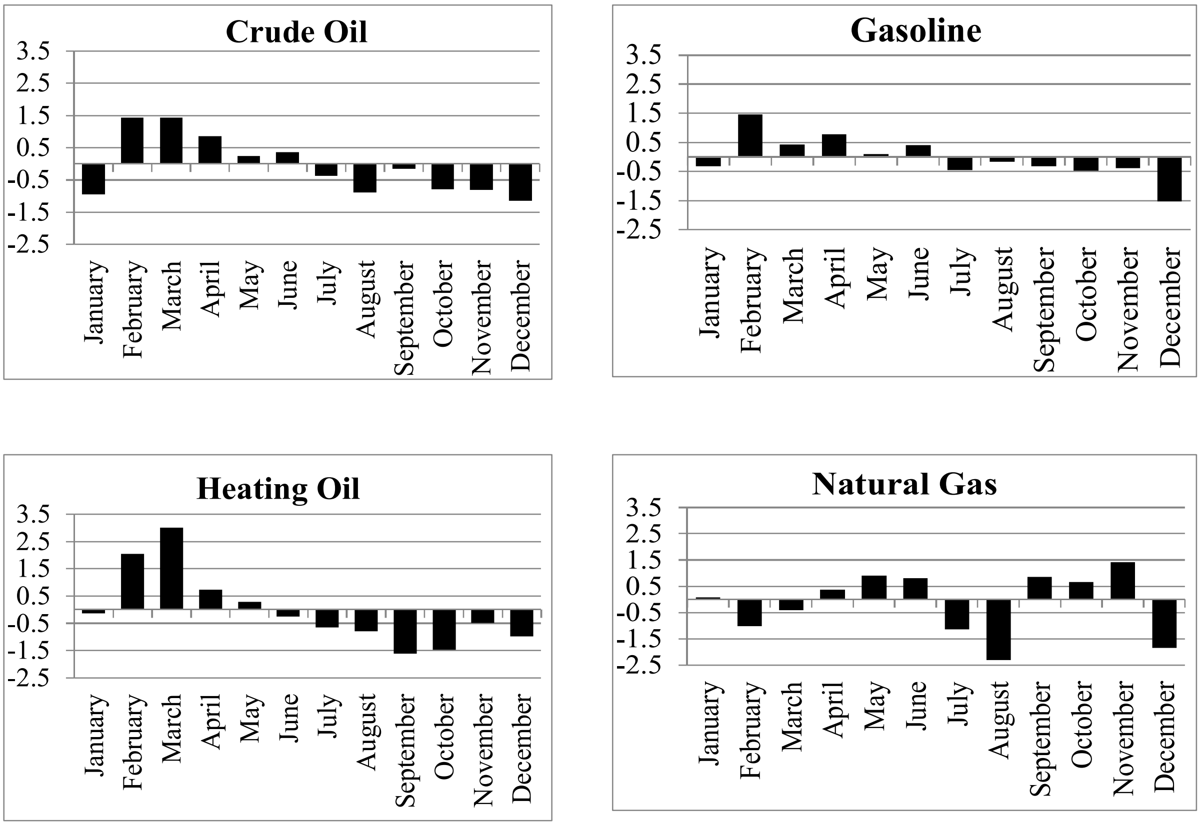


Figure 4
Seasonal Futures Returns in Energy Market

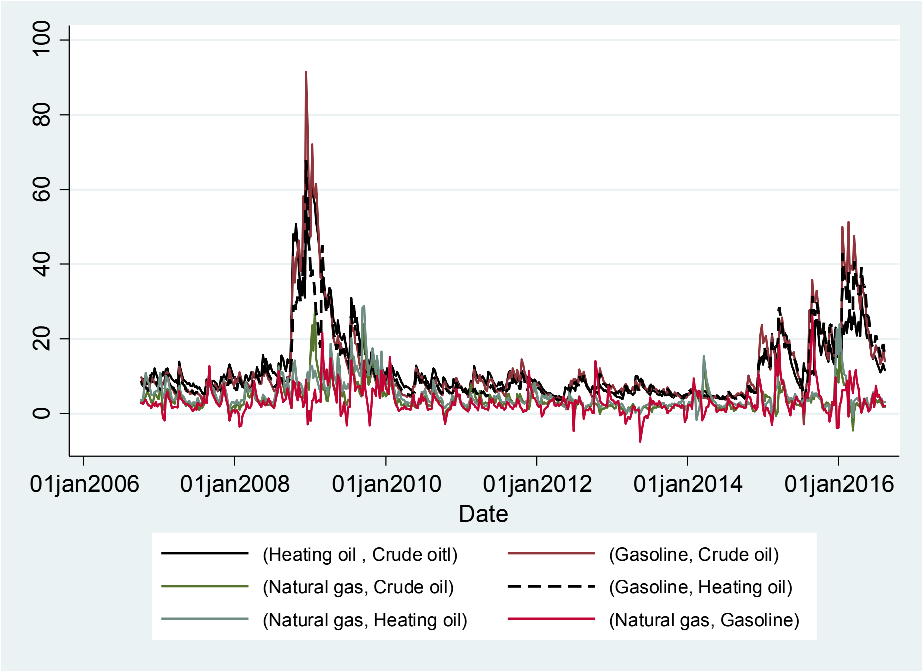


Figure 5
Dynamic Variance of Spot Returns in Energy Market

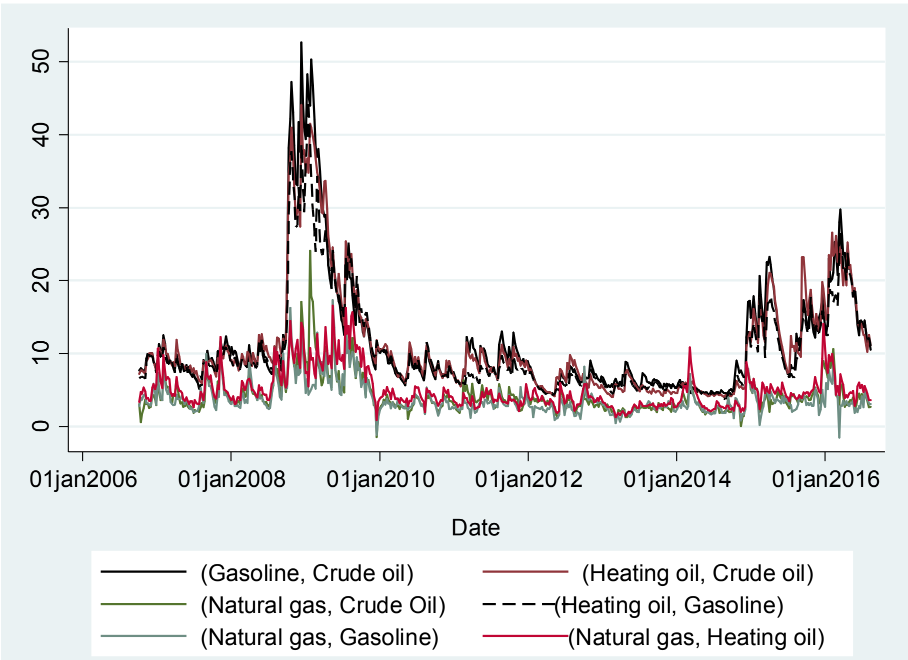


Figure 6
Dynamic Variance of Futures Returns in Energy Market

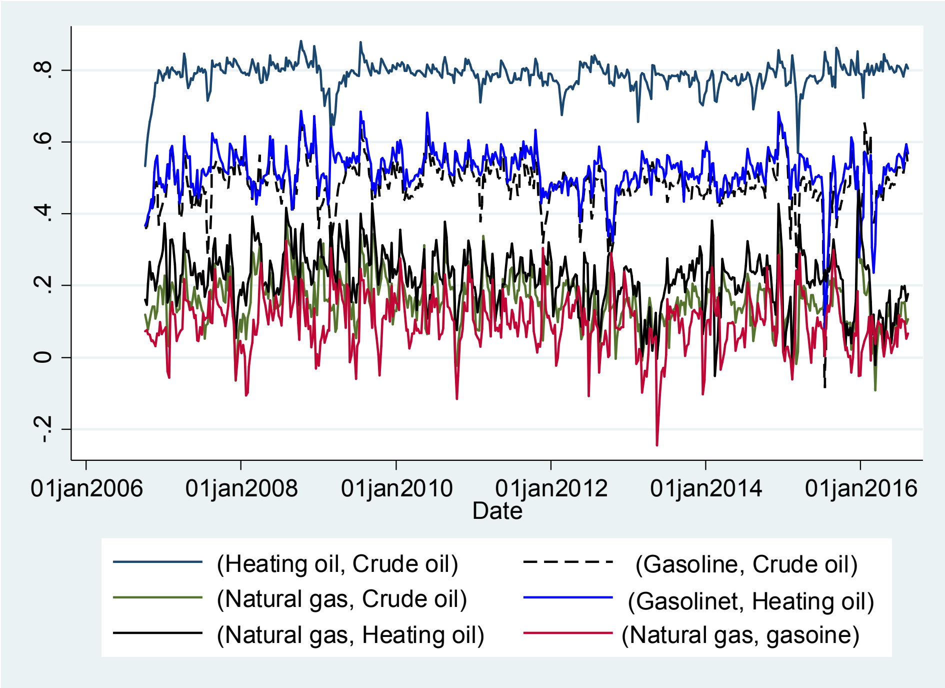


Figure 7
Dynamic Correlation of Spot Returns in Energy Market

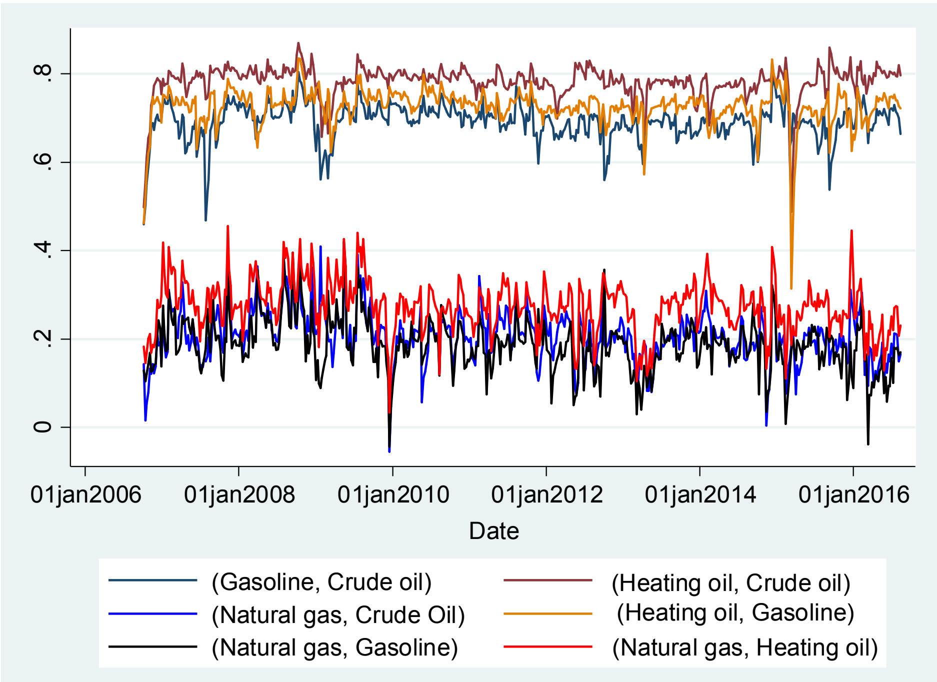


Figure 8
Dynamic Correlation of Ftures Returns in Energy Market

Table 1
Summary statistics of price, returns, and sentiment index

Variables	Observations	Mean	Standard deviation	Minimum	Maximum
Panel A. Spot price					
Cride oil (WTC)	518	79.135	23.241	28.140	142.520
Heating oil	518	2.320	0.696	0.871	3.992
Gasoline	518	2.403	0.614	0.738	3.761
Natural gas	518	4.529	2.125	1.570	13.200
Crude oil returns	517	-0.076	4.449	-19.100	25.125
Heating oil returns	517	-0.059	3.813	-13.155	14.490
Gasoline returns	517	-0.065	6.393	-30.994	34.303
Natural gas returns	517	-0.120	6.502	-30.928	30.099
Panel B. Futures price					
Cride oil (WTC)	518	79.218	23.159	28.150	142.460
Heating oil	518	2.360	0.681	0.917	4.006
Gasoline	518	2.271	0.629	0.845	3.534
Natural gas	518	4.588	2.141	1.687	13.456
Crude oil returns	517	-0.076	4.239	-18.723	15.527
Heating oil returns	517	-0.049	3.737	-13.394	12.775
Gasoline returns	517	-0.035	4.354	-17.639	22.037
Natural gas returns	517	-0.137	5.349	-19.774	21.842
Panel C. Oil news sentiment index					
Changes in sentiment index	518	0.049	0.197	-0.443	0.565
% Changes in sentiment index	517	0.059	14.894	-55.720	44.800

Table 2

The Effects of Oil News Setiment on Energy Spot Returns: GARCH

Variables	Baseline Model				Model 1				Model 2			
	Oil	Heating	Gasoline	NG	Oil	Heating	Gasoline	NG	Oil	Heating	Gasoline	NG
Panel A. Mean Equation												
Constant	-0.155	-0.049	-0.420*	-0.067	-0.656***	-0.441***	-0.948***	-0.084	0.072	0.082	-0.234	0.027
	(-0.839)	(-0.273)	(-1.687)	(-0.236)	(-3.548)	(-2.685)	(-4.163)	(-0.290)	(0.412)	(0.491)	(-1.031)	(0.092)
ΔSI					11.898***	9.514***	8.397***	1.780				
					(16.051)	(14.413)	(8.004)	(1.349)				
%SI									0.118***	0.085***	0.088***	0.026*
									(13.666)	(10.640)	(6.689)	(1.767)
FEB	1.664***	1.053**	4.355***	-1.099	0.460	-0.007	3.210***	-1.355	1.295***	0.866**	3.794***	-1.360
	(3.075)	(2.063)	(4.133)	(-1.021)	(0.941)	(-0.016)	(3.704)	(-1.242)	(3.200)	(1.985)	(4.212)	(-1.208)
MAR	0.906	-0.025	1.138	-0.443	-0.097	-1.110**	0.042	-0.700	0.731	0.288	0.955	-0.482
	(1.461)	(-0.041)	(1.266)	(-0.426)	(-0.183)	(-2.112)	(0.055)	(-0.668)	(1.290)	(0.631)	(1.076)	(-0.447)
APR	0.615	0.386	1.251	0.639	0.152	-0.101	0.357	0.410	0.554	0.531	1.278	0.581
	(0.839)	(0.638)	(1.239)	(0.516)	(0.256)	(-0.257)	(0.436)	(0.334)	(0.924)	(0.980)	(1.486)	(0.506)
AR(1)	0.201***	0.234***	0.206***	0.152***	0.155***	0.198***	0.194***	0.163***	0.180***	0.216***	0.207***	0.158***
	(4.004)	(4.908)	(4.290)	(2.911)	(2.988)	(4.147)	(4.259)	(3.065)	(3.425)	(4.360)	(4.342)	(2.946)
AR(2)	-0.084*	-0.086*	-0.126***	-0.033	0.063	-0.010	-0.135***	-0.034	-0.006	-0.059	-0.155***	-0.027
	(-1.770)	(-1.795)	(-2.643)	(-0.711)	(1.325)	(-0.231)	(-2.919)	(-0.693)	(-0.120)	(-1.212)	(-3.084)	(-0.576)
Panel B. Variance Equation												
Constant	0.349**	0.159*	1.038***	4.310***	-1.416***	-2.924***	-1.017*	1.141**	-0.170	-0.949*	-0.084	2.197***
	(2.056)	(1.786)	(2.740)	(2.807)	(-2.919)	(-3.176)	(-1.848)	(2.572)	(-0.580)	(-1.683)	(-0.118)	(6.125)
ARCH(1)	0.116***	0.084***	0.142***	0.225***	0.112***	0.079***	0.063***	0.206***	0.389***	0.153***	0.164***	0.233***
	(5.003)	(3.568)	(4.741)	(4.509)	(4.255)	(3.161)	(3.125)	(4.561)	(5.624)	(4.600)	(4.682)	(4.562)
GARCH(1)	0.867***	0.906***	0.829***	0.678***	0.808***	0.891***	0.885***	0.700***	0.449***	0.799***	0.799***	0.678***
	(34.888)	(38.222)	(26.786)	(9.713)	(23.043)	(31.276)	(38.280)	(10.835)	(7.690)	(22.018)	(23.360)	(10.858)
ΔSI^{+}_{t-1}					-9.170***	-10.947***	-10.991***	-2.632**				
$*D^{+}_{t-1}$					(-6.463)	(-4.338)	(-5.794)	(-2.021)				
ΔSI^{-}_{t-1}					3.491**	3.358	-1.657	0.746				
$*D-_{t-1}$					(2.177)	(0.886)	(-0.434)	(0.500)				
$\%SI^{+}$t-1									-0.084***	-0.064***	-0.054**	1.259
$*D^{+}_{t-1}$									(-5.716)	(-3.121)	(-2.207)	(0.471)
$\%SI^{-}_{t-1}$									0.053***	-2.494	-0.222	-0.014
$*D-_{t-1}$									(2.851)	(-0.140)	(-0.239)	(-0.572)
Obs	517	517	517	517	517	517	517	517	516	516	516	516
LL	-1412	-1352	-1580	-1648	-1307	-1256	-1532	-1647	-1333	-1293	-1549	-1640
χ^2	30.63***	31.08***	39.37***	9.77***	282.50***	226.61***	107.11***	12.84***	203.41***	127.51***	100.81***	11.89***

Note: The *t*-statistics are based on Newey and West's(1987) heteroscedasticity-consistent standard errors and are reported in parentheses. *, **, and ***indicatesd statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 3

The Effects of Oil News Setiment on Energy Futures Returns: GARCH

Variables	Baseline Model				Model 1				Model 2			
	Oil	Heating	Gasoline	NG	Oil	Heating	Gasoline	NG	Oil	Heating	Gasoline	NG
Panel A. Mean Equation												
Constant	-0.194	-0.067	-0.481**	-0.211	-0.646***	-0.434***	-0.814***	-0.226	0.020	0.048	-0.303	-0.167
	(-1.030)	(-0.383)	(-2.188)	(-0.770)	(-3.366)	(-2.839)	(-4.103)	(-0.801)	(0.119)	(0.305)	(-1.498)	(-0.596)
ΔSI					11.647***	8.852***	10.105***	2.826**				
					(15.970)	(13.675)	(12.267)	(2.154)				
%SI									0.118***	0.083***	0.098***	0.036**
									(14.435)	(10.153)	(10.069)	(2.450)
FEB	1.739***	1.171**	2.626***	-0.678	0.484	0.217	1.128*	-0.935	1.402***	0.998**	1.855***	-0.809
	(3.386)	(2.328)	(3.627)	(-0.857)	(1.031)	(0.497)	(1.943)	(-1.125)	(3.661)	(2.292)	(3.220)	(-0.808)
MAR	0.839	-0.074	2.909***	0.046	-0.125	-1.065**	1.657***	-0.346	0.615	0.347	2.985***	-0.018
	(1.283)	(-0.123)	(5.107)	(0.046)	(-0.234)	(-2.146)	(3.144)	(-0.322)	(1.037)	(0.819)	(6.242)	(-0.017)
APR	0.709	0.740	1.114	0.739	0.165	0.509	0.504	0.356	0.648	0.850*	1.087	0.616
	(0.972)	(1.306)	(1.465)	(0.652)	(0.289)	(1.268)	(0.775)	(0.295)	(1.044)	(1.654)	(1.413)	(0.552)
AR(1)	0.196***	0.205***	0.152***	0.157***	0.156***	0.161***	0.132***	0.161***	0.169***	0.181***	0.194***	0.151***
	(3.958)	(4.225)	(3.296)	(3.159)	(2.964)	(3.484)	(2.875)	(3.296)	(3.320)	(3.729)	(4.082)	(3.080)
AR(2)	-0.050	-0.102**	0.032	-0.015	0.091**	-0.030	0.061	0.002	0.029	-0.082	0.007	0.023
	(-1.065)	(-2.069)	(0.644)	(-0.302)	(2.055)	(-0.635)	(1.258)	(0.045)	(0.563)	(-1.609)	(0.136)	(0.462)
Panel B. Variance Equation												
Constant	0.287*	0.204**	0.427*	3.596**	-2.036***	-2.602***	-2.096***	1.135**	-0.365	-0.950*	-0.802	1.753***
	(1.933)	(2.429)	(1.724)	(2.348)	(-3.852)	(-3.371)	(-2.897)	(2.346)	(-1.154)	(-1.674)	(-1.619)	(5.397)
ARCH(1)	0.108***	0.082***	0.102***	0.133***	0.082***	0.089***	0.069***	0.123***	0.397***	0.163***	0.132***	0.124***
	(4.637)	(3.388)	(3.577)	(3.366)	(3.957)	(3.294)	(3.233)	(3.298)	(5.618)	(4.741)	(3.583)	(3.245)
GARCH(1)	0.877***	0.903***	0.874***	0.739***	0.858***	0.872***	0.887***	0.748***	0.461***	0.786***	0.820***	0.747***
	(36.057)	(33.805)	(24.247)	(9.313)	(33.813)	(27.269)	(32.890)	(9.396)	(7.882)	(22.013)	(21.032)	(10.153)
ΔSI^{+}_{t-1}					-10.289***	-10.303***	-9.855***	-0.689				
$*D^{+}_{t-1}$					(-6.367)	(-4.796)	(-4.202)	(-0.483)				
ΔSI^{-}_{t-1}					4.273**	3.692	4.037*	0.839				
$*D^{-}_{t-1}$					(2.461)	(1.261)	(1.772)	(0.692)				
$\%SI^{+}t-1$									-0.085***	-0.068***	-0.066***	0.297
$*D^{+}_{t-1}$									(-5.752)	(-3.396)	(-4.377)	(0.817)
$\%SI^{-}_{t-1}$									0.062***	-2.288	-0.703	0.003
$*D^{-}_{t-1}$									(3.497)	(-0.147)	(-0.154)	(0.183)
Obs	517	517	517	517	517	517	517	517	516	516	516	516
LL	-1400	-1345	-1417	-1580	-1293	-1250	-1340	-1577	-1320	-1287	-1357	-1572
χ^2	31.46***	27.84***	44.84***	11.62***	292.8***	206.4***	221.3***	16.55***	227.7***	115.2***	167.4***	15.10***

Note: The *t*-statistics are based on Newey and West's(1987) heteroscedasticity-consistent standard errors and are reported in parentheses. *, **, and ***indicatesd statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4

The Effects of Oil News Setiment on Energy Spot Returns: DCC-MGARCH

Variables	Baseline Model				Model 1				Model 2			
	Oil	Heating	Gasoline	NG	Oil	Heating	Gasoline	NG	Oil	Heating	Gasoline	NG
Panel A. Mean Equation												
Constant	0.061	0.148	-0.201	0.176	-0.631***	-0.417***	-0.799***	0.051	0.125	0.171	-0.124	0.247
	(0.361)	(0.996)	(-0.900)	(0.670)	(-4.385)	(-3.370)	(-3.905)	(0.203)	(0.894)	(1.437)	(-0.619)	(1.011)
Oil(t-1)	0.307***	0.238***	0.241**	0.089	0.142**	0.101*	0.070	0.052	0.424***	0.300***	0.282***	0.152
	(3.796)	(3.478)	(2.321)	(0.931)	(2.235)	(1.857)	(0.806)	(0.525)	(6.394)	(5.464)	(3.073)	(1.509)
Oil(t-2)	-0.156**	-0.110	-0.170*	0.043	-0.121*	-0.078	-0.097	0.043	-0.127**	-0.095*	-0.142	0.028
	(-1.974)	(-1.630)	(-1.662)	(0.486)	(-1.897)	(-1.414)	(-1.138)	(0.468)	(-2.085)	(-1.795)	(-1.597)	(0.329)
Heating Oil (t-1)	-0.128	0.007	-0.154	-0.045	-0.199***	-0.037	-0.167	-0.020	-0.034	0.116*	-0.038	-0.044
	(-1.531)	(0.086)	(-1.346)	(-0.385)	(-2.926)	(-0.579)	(-1.643)	(-0.168)	(-0.505)	(1.795)	(-0.355)	(-0.381)
Heating Oil (t-2)	0.106	0.014	0.213*	-0.178*	-0.033	-0.114*	0.062	-0.199*	0.135**	0.056	0.246**	-0.109
	(1.264)	(0.189)	(1.899)	(-1.673)	(-0.484)	(-1.839)	(0.618)	(-1.839)	(2.180)	(0.920)	(2.447)	(-1.056)
Gasoline (t-1)	0.022	-0.001	0.171***	0.089**	0.028	-0.002	0.173***	0.086**	0.005	-0.002	0.176***	0.120***
	(0.649)	(-0.047)	(3.141)	(2.112)	(1.021)	(-0.061)	(3.466)	(1.974)	(0.195)	(-0.063)	(3.570)	(2.921)
Gasoline (t-2)	-0.035	-0.015	-0.176***	0.060	-0.025	-0.001	-0.188***	0.063	-0.015	-0.006	-0.177***	0.043
	(-0.961)	(-0.457)	(-3.195)	(1.308)	(-0.878)	(-0.028)	(-3.667)	(1.334)	(-0.570)	(-0.248)	(-3.533)	(0.884)
NG (t-1)	-0.042*	-0.023	-0.047	0.127**	-0.015	-0.005	-0.039	0.123**	-0.030*	-0.019	-0.040	0.147***
	(-1.932)	(-1.112)	(-1.530)	(2.503)	(-0.810)	(-0.259)	(-1.368)	(2.373)	(-1.757)	(-1.092)	(-1.406)	(2.973)
NG (t-2)	0.023	-0.003	0.019	-0.015	0.050***	0.022	0.037	-0.015	0.024	0.004	0.023	-0.000
	(1.052)	(-0.153)	(0.615)	(-0.309)	(2.697)	(1.220)	(1.327)	(-0.306)	(1.413)	(0.255)	(0.805)	(-0.002)
FEB	1.137**	0.707	3.599***	-1.939**	0.237	-0.057	2.683***	-1.918**	0.531	0.313	2.935***	-2.286**
	(2.254)	(1.498)	(5.136)	(-2.115)	(0.523)	(-0.141)	(4.264)	(-2.010)	(1.353)	(0.817)	(4.884)	(-2.551)
MAR	0.447	-0.223	0.814	-1.154	-0.238	-0.945**	0.059	-1.267	0.676*	0.046	0.834	-0.991
	(0.867)	(-0.450)	(1.157)	(-1.245)	(-0.543)	(-2.322)	(0.100)	(-1.353)	(1.824)	(0.121)	(1.395)	(-1.189)
APR	0.521	0.275	0.929	0.145	0.145	-0.182	0.355	0.185	0.357	0.259	0.760	0.104
	(1.020)	(0.598)	(1.397)	(0.187)	(0.331)	(-0.472)	(0.534)	(0.232)	(0.911)	(0.753)	(1.279)	(0.148)
ΔSI					11.406***	9.246***	8.993***	1.531				
					(16.192)	(14.870)	(9.544)	(1.177)				
%SI									0.140***	0.118***	0.120***	0.058***
									(17.933)	(15.800)	(10.236)	(3.694)
Panel B. Variance Equation												
Constant	0.819***	0.433***	1.090**	4.301***	-0.804*	-1.798***	-0.470	1.323***	0.128	-0.635	-0.049	2.499***
	(2.862)	(2.764)	(2.574)	(3.014)	(-1.658)	(-3.262)	(-0.734)	(2.877)	(0.409)	(-1.423)	(-0.091)	(6.796)
ARCH(1)	0.134***	0.105***	0.161***	0.233***	0.114***	0.079***	0.077**	0.216***	0.284***	0.168***	0.179***	0.248***
	(5.293)	(4.442)	(5.083)	(4.397)	(4.059)	(3.307)	(2.185)	(4.156)	(4.304)	(4.623)	(4.884)	(4.600)
GARCH(1)	0.819***	0.863***	0.815***	0.674***	0.798***	0.875***	0.880***	0.689***	0.576***	0.775***	0.788***	0.673***
	(23.463)	(29.702)	(24.091)	(10.880)	(16.722)	(27.975)	(25.412)	(10.895)	(6.615)	(19.019)	(19.782)	(12.280)
$\Delta SI^{+}_{t-1}*D^{+}_{t-1}$					-6.604***	-7.772***	-8.996***	-1.037				
					(-4.603)	(-4.334)	(-3.755)	(-0.470)				
$\Delta SI^{-}_{t-1}*D^{-}_{t-1}$					1.033	0.665	-61.247	0.144				
					(0.721)	(0.301)	(-0.413)	(0.099)				
$\%SI^{+}_{t-1}*D^{+}_{t-1}$									-0.051***	-0.037*	-0.048***	0.980
									(-4.344)	(-1.719)	(-2.794)	(0.982)
$\%SI^{-}_{t-1}*D^{-}_{t-1}$									-0.021	-0.108	-0.157	-0.053
									(-0.258)	(-0.687)	(-0.598)	(-1.108)
corr(oil heating)	0.833***				0.753***				0.757***			
	(49.197)				(33.259)				(32.297)			
corr(oil gasoline)	0.574***				0.475***				0.468***			
	(15.428)				(11.905)				(11.062)			
corr(oil NG)	0.178***				0.178***				0.102**			
	(3.426)				(3.605)				(1.974)			
corr(heating gasoline)	0.588***				0.494***				0.485***			
	(16.232)				(12.710)				(11.853)			
corr(heating NG)	0.219***				0.226***				0.159***			
	(4.276)				(4.614)				(3.112)			
corr(gasoline NG)	0.149***				0.127**				0.076			
	(2.860)				(2.524)				(1.463)			
λ_1	0.068***				0.036**				0.090***			
	(3.176)				(2.149)				(3.570)			
λ_2	0.635***				0.710***				0.502***			
	(5.201)				(5.161)				(3.285)			
Observations	515				515				515			
LL	-5547				-5404				-5415			
χ^2	139.0***				465.4***				528.2***			

Note: The t-statistics are based on Newey and West's(1987) heteroscedasticity-consistent standard errors and are reported in parentheses. *, **, and ***indicatesd statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 5
The Effects of Oil News Setiment on Energy Futures Returns: DCC-MGARCH

Variables	Baseline Model				Model 1				Model 2			
	Oil	Heating	Gasoline	NG	Oil	Heating	Gasoline	NG	Oil	Heating	Gasoline	NG
Panel A. Mean Equation												
Constant	0.041	0.152	-0.175	0.011	-0.611***	-0.357***	-0.675***	-0.182	0.091	0.158	-0.177	0.017
	(0.244)	(1.039)	(-0.996)	(0.043)	(-4.239)	(-2.799)	(-4.333)	(-0.716)	(0.724)	(1.410)	(-1.234)	(0.069)
Oil(t-1)	0.293***	0.258***	0.262***	0.230***	0.148**	0.153***	0.190***	0.214**	0.397***	0.288***	0.309***	0.261***
	(3.595)	(3.675)	(3.098)	(2.647)	(2.268)	(2.616)	(2.647)	(2.488)	(5.942)	(5.225)	(4.464)	(3.122)
Oil(t-2)	-0.075	-0.031	-0.014	0.075	-0.090	-0.028	-0.027	0.068	-0.020	0.014	0.046	0.074
	(-0.920)	(-0.445)	(-0.169)	(0.822)	(-1.359)	(-0.477)	(-0.372)	(0.757)	(-0.317)	(0.258)	(0.675)	(0.838)
Heating Oil (t-1)	-0.167*	-0.043	-0.113	-0.194*	-0.213***	-0.085	-0.186**	-0.205*	-0.054	0.082	0.003	-0.156
	(-1.937)	(-0.548)	(-1.178)	(-1.779)	(-2.974)	(-1.267)	(-2.279)	(-1.897)	(-0.820)	(1.252)	(0.038)	(-1.452)
Heating Oil (t-2)	-0.015	-0.157**	0.020	-0.104	-0.049	-0.204***	-0.009	-0.116	0.071	-0.089	0.084	-0.041
	(-0.173)	(-2.095)	(0.226)	(-1.022)	(-0.697)	(-3.178)	(-0.121)	(-1.138)	(1.061)	(-1.406)	(1.154)	(-0.400)
Gasoline (t-1)	0.042	0.000	0.032	-0.041	0.002	-0.032	0.000	-0.058	0.043	0.032	0.083	-0.023
	(0.663)	(0.004)	(0.476)	(-0.497)	(0.045)	(-0.673)	(0.002)	(-0.718)	(0.869)	(0.751)	(1.474)	(-0.290)
Gasoline (t-2)	0.033	0.084	-0.019	-0.002	-0.012	0.049	-0.075	-0.000	-0.012	0.050	-0.068	-0.037
	(0.533)	(1.537)	(-0.281)	(-0.027)	(-0.221)	(1.027)	(-1.246)	(-0.004)	(-0.235)	(1.117)	(-1.169)	(-0.470)
NG (t-1)	-0.018	0.001	-0.047	0.153***	0.012	0.020	-0.029	0.150***	-0.013	-0.001	-0.044*	0.161***
	(-0.631)	(0.020)	(-1.567)	(3.033)	(0.512)	(0.929)	(-1.098)	(2.984)	(-0.617)	(-0.027)	(-1.789)	(3.267)
NG (t-2)	0.039	0.027	0.064**	0.012	0.056**	0.047**	0.082***	0.010	0.014	0.021	0.049**	0.024
	(1.407)	(1.076)	(2.093)	(0.249)	(2.445)	(2.203)	(3.128)	(0.212)	(0.665)	(1.040)	(2.001)	(0.494)
FEB	1.327**	0.930**	2.277***	-0.449	0.609	0.305	1.416***	-0.527	0.614*	0.483	1.424***	-0.718
	(2.547)	(1.962)	(4.073)	(-0.525)	(1.317)	(0.725)	(2.827)	(-0.599)	(1.664)	(1.318)	(3.128)	(-0.843)
MAR	0.222	-0.384	2.318***	-0.491	-0.099	-0.789*	1.731***	-0.468	0.562	0.052	2.509***	-0.175
	(0.407)	(-0.763)	(4.152)	(-0.580)	(-0.208)	(-1.749)	(3.417)	(-0.544)	(1.340)	(0.132)	(5.490)	(-0.217)
APR	0.462	0.471	0.573	0.330	0.298	0.156	-0.081	0.804	0.210	0.328	0.344	0.261
	(0.939)	(1.098)	(1.107)	(0.441)	(0.699)	(0.419)	(-0.173)	(1.050)	(0.522)	(0.898)	(0.779)	(0.367)
ΔSI					11.041***	8.979***	9.476***	2.322*				
					(15.844)	(14.538)	(12.538)	(1.871)				
%SI									0.140***	0.119***	0.132***	0.060***
									(17.407)	(15.054)	(14.519)	(3.960)
Panel B. Variance Equation												
Constant	0.742***	0.395***	0.649***	4.707**	-1.413***	-1.908***	-2.043***	1.465***	0.337	0.076	-0.784*	1.995***
	(3.030)	(2.929)	(2.794)	(2.134)	(-3.132)	(-3.520)	(-3.763)	(2.645)	(1.082)	(0.102)	(-1.784)	(5.585)
ARCH(1)	0.113***	0.097***	0.100***	0.153***	0.081***	0.079***	0.049***	0.149***	0.254***	0.189***	0.126***	0.156***
	(5.189)	(4.434)	(4.603)	(2.812)	(4.136)	(3.100)	(2.953)	(2.784)	(4.585)	(5.278)	(4.045)	(3.295)
GARCH(1)	0.840***	0.872***	0.862***	0.683***	0.850***	0.871***	0.902***	0.696***	0.632***	0.758***	0.818***	0.703***
	(27.100)	(31.977)	(30.560)	(6.271)	(27.960)	(25.071)	(44.328)	(6.745)	(9.751)	(22.268)	(19.713)	(9.508)
$\Delta SI^{+}_{t-1}*D^{+}_{t-1}$					-7.981***	-7.940***	-10.269***	0.755				
					(-5.537)	(-4.805)	(-5.704)	(0.370)				
$\Delta SI^{-}_{t-1}*D^{-}_{t-1}$					2.173	1.594	3.630**	0.312				
					(1.502)	(0.879)	(1.977)	(0.245)				
$\%SI^{+}_{t-1}*D^{+}_{t-1}$									-0.034**	0.011	-0.043**	0.231
									(-2.422)	(0.149)	(-2.066)	(1.278)
$\%SI^{-}_{t-1}*D^{-}_{t-1}$									-0.175	-0.785	0.006	-0.012
									(-1.264)	(-0.829)	(0.133)	(-0.470)
corr(oil heating)	0.835***				0.747***				0.765***			
	(50.282)				(31.887)				(32.827)			
corr(oil gasoline)	0.713***				0.613***				0.589***			
	(27.449)				(19.009)				(16.675)			
corr(oil NG)	0.219***				0.208***				0.164***			
	(4.476)				(4.299)				(3.182)			
corr(heating gasoline)	0.728***				0.629***				0.623***			
	(29.828)				(20.224)				(18.885)			
corr(heating NG)	0.273***				0.270***				0.230***			
	(5.660)				(5.627)				(4.520)			
corr(gasoline NG)	0.208***				0.180***				0.144***			
	(4.238)				(3.647)				(2.776)			
λ_1	0.055***				0.035**				0.051***			
	(3.220)				(2.378)				(3.232)			
λ_2	0.626***				0.696***				0.699***			
	(4.729)				(6.623)				(8.467)			
Observations	515				515				515			
LL	-5187				-5045				-5055			
χ^2	147.0***				454.6***				535.2***			

Note: The t-statistics are based on Newey and West's(1987) heteroscedasticity-consistent standard errors and are reported in parentheses. *, **, and *** indicatesd statistical significance at the 10%, 5%, and 1% levels, respectively.

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