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Do spillover effects between crude oil and natural gas markets disappear? Evidence from option markets

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ABSTRACT

This study investigates the volatility relationship between crude oil and natural gas markets from 2007 to 2015. Particularly, we focus on implied volatility and provide evidence from both call and put options. In general, we find that there are no volatility dependencies between these two markets after 2007, which is consistent with price independencies documented in Batten et al. (2017). However, we observe significant causality relations from oil to gas in put options in a minority of our sample. Further, the causalities can be decomposed into short-term and long-term relations, which might be explained by a series of influential events.

1. Introduction

There are ample evidences that the crude oil and natural gas markets are highly correlated when price and volatility spillover effects are considered (see Brown and Yücel, 2008; Hartley et al., 2008; Atil et al., 2014; Lin and Li, 2015; and references cited therein). However, with the help of futures prices and new empirical techniques including bivariate rolling VARs, Batten et al. (2017) demonstrate that there are no price spillover effects after 2007. This finding is striking in that it may indicate that there is a fundamental change in the relationship between the two energy markets. Thus, it is natural to ask whether volatility spillover effects also disappear when the new methods are employed, which is complementary to the price evidence in Batten et al. (2017).

In this paper, we try to answer this question by using implied volatility and the rolling VARs. As a matter of fact, Lin and Li (2015) find the volatility spillover effects of the oil market on the natural gas market and vice versa by using realized volatility of the spot markets. Nevertheless, as emphasized by Batten et al. (2017), futures prices are more efficient than spot prices in reflecting market information. Our option-implied volatility is forward-looking and a better measure of market expectation (Luo and Qin, 2017; Liu et al., 2013). Further, the rich data sets of option markets allow us to investigate volatility spillover effects in more detail.

Indeed, we obtain important findings when implied volatilities of both call and put options are employed. First, we find that the crude oil market is generally independent of the natural gas market after 2007, which is in line with price

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Table 1
Descriptive statistics of implied volatility indices.

	Mean	Max	Min	Std. Dev.	Skewness	Kurtosis	Jarque–Bera	ADF	PP	Obs
Panel A Levels										
Oil^{call}	33.773	96.696	12.733	14.267	1.601	3.347	1872.732***	−2.502	−2.424	2094
Gas^{call}	43.682	79.795	24.735	11.138	0.569	−0.483	133.142***	−3.721***	−3.619***	2094
Oil^{put}	34.887	99.698	12.609	14.457	1.550	3.219	1742.610***	−2.598*	−2.410	2094
Gas^{put}	44.402	94.156	26.178	11.407	0.704	−0.013	172.523***	−3.478***	−3.711***	2094
Panel B Log volatility changes										
Oil^{call}	0.0003	0.324	−0.159	0.052	1.024	4.072	1811.491***	−50.564***	−53.464***	2093
Gas^{call}	−0.0001	0.389	−0.207	0.043	0.539	6.110	3357.078***	−53.371***	−55.062***	2093
Oil^{put}	0.0003	0.331	−0.216	0.048	1.023	4.347	2012.802***	−50.220***	−52.554***	2093
Gas^{put}	−0.0001	0.340	−0.192	0.042	0.375	4.213	1596.568***	−54.945***	−55.175***	2093

Notes: This table reports summary statistics of the implied volatility indices in levels as well as in log changes. The sample period of daily implied volatility indices is from May 9, 2007 to August 31, 2015. Gas^{call} and Oil^{call} denote the implied volatility indices on the 30-day call options, Oil^{put} and Gas^{put} denote the implied volatility indices on the 30-day put options. The kurtosis has already subtracted 3. ADF is the Augmented Dickey–Fuller test and PP is the Phillips-Peron test for the unit root. *, **, *** represent significance at 10%, 5% and 1% levels, respectively.

Table 2
Correlations between the oil and gas implied volatility indices.

	Levels	Log volatility changes
Gas^{call} and **Oil**^{call}	0.6275***	0.1498***
Gas^{put} and **Oil**^{put}	0.6110***	0.1278***

Notes: This table reports the Pearson correlations between the oil and gas implied volatilities in levels as well as in log changes. The sample period of daily implied volatility indices is from May 9, 2007 to August 31, 2015. Gas^{call} and Oil^{call} denote the implied volatility indices on the 30-day call options, Oil^{put} and Gas^{put} denote the implied volatility indices on the 30-day put options. *, **, *** represent significance at 10%, 5% and 1% levels, respectively.

independencies documented in Batten et al. (2017). Second, we note significant causality from crude oil to natural gas in put options during periods between 2009 and 2011. This causality from oil to gas has also been detected by many other studies, e.g. Hartley et al. (2008) and Lin and Li (2015). Further, the causalities can be decomposed into short-term and long-term relations, which might be explained by a series of events.

2. Data and methodology

2.1. Data

To explore the dynamic linkages of volatilities between crude oil and natural gas, we use daily implied volatility indices derived from the at-the-money (ATM) call and put options on the United States Oil Fund (USO) and the United States Natural Gas Fund (UNG) in this study. Both USO and UNG are exchange-traded funds (ETFs), and the benchmarks of USO and UNG are the West Texas Intermediate (WTI) Light Sweet Crude Oil spot price and the Henry Hub Natural Gas spot price, respectively. We conduct our analysis using the implied volatilities of 30-day put and call options since the 30-day-to-maturity options are more liquid than others.[1] The sample period is between May 9, 2007 and August 31, 2015, yielding a total of 2094 observations. The data sets are obtained from the OptionMetrics database.

Table 1 reports summary statistics of the levels and the log changes of the implied volatility (IV) indices in panels A and B, respectively. We can see that the IV of oil has a higher level on average than the IV of gas, and the mean values of these log changes are close to zero. The standard deviations of the volatilities in levels as well as in log changes indicate that the IV of oil is more volatile than the IV of gas. As for the distributional properties, both the oil and gas implied volatility indices in levels are positively skewed; the IV of oil in levels is leptokurtic, while the IV of gas has a negative kurtosis, meaning it is clustered less around the mean and has shorter tails. However, the log changes of oil and gas implied volatility indices are both positively skewed and leptokurtic. Moreover, all the Jarque–Bera statistics reject the null hypothesis of normality at the significant level of 1%. The Augmented Dickey–Fuller (ADF) test and Phillips–Peron (PP) test are used for unit root tests. All the logarithmic first difference series are stationary, and we use them to conduct our further study.

Table 2 reports the Pearson correlations between the oil and gas implied volatilities in levels as well as in log changes. It shows that the implied volatilities of oil and gas options are significantly correlated (in both levels and logarithmic changes) and tend to change in the same direction.

[1] We also use the 60-day and 91-day implied volatility indices of put and call options as robust checks and obtain similar results. They are available upon request from the authors.