Shock and Volatility Spillovers between Crude Oil Price and Stock Returns: Evidence for Thailand

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Abstract

This paper employs a bivariate BEKK-GARCH(1,1) model to examine shock and volatility spillovers between crude oil and stock markets by taking into account the impact of the 2008 global financial crisis. Daily data from crude oil market and the Thai stock market during February 6, 2004 and September 14, 2015 are used in the analyses. The whole sample is divided into the pre- and post-crisis periods. The results show that there are no spillover effects between oil price and stock returns in the pre-crisis period. In the post-crisis period, there are unilateral spillover effects from oil price to some equity sector returns. In the market level, there are unilateral spillovers of shock and volatility from oil price to stock market return. The findings in this paper are crucial for financial market participations to understand shock and volatility transmissions from oil to stock markets such that portfolio management should take into account the presence of oil price risk.

Keywords: Stock returns, oil price shock, volatility spillover, bivariate GARCH
JEL classification: G12, Q43

1. Introduction

In empirical studies, many researchers find that international oil prices can be one of the main factors that affect stock markets in both advanced and emerging market economies. There exists evidence indicating that there is nonlinear bidirectional causality between oil price shocks and stock returns in the US (Ciner, 2001). However, Huang et al. (1996) find no evidence of a linkage between the S&P 500 return and oil price change. Nonlinear effects of oil price shocks on stock returns are also found in the Gulf Corporation Council countries (Maghyeheh and AlKandari, 2007; Arouri and Fouquau, 2009). However, the linkages between oil price and stock indices might stem from sector indices and are time-varying (Arouri, 2011; and Degiannakis et al., 2013). The strength of linkages between oil shocks and stock returns can vary across equity sectors, and some sectors exhibit asymmetry in the reaction of stock returns to oil price shocks. For example, the correlations between European industrial sector indices and oil prices change over time and they are industry specific. Furthermore, both return and volatility can be correlated (Angelidis et al., 2015). Both oil price shocks and volatility can provide the predictive content of stock market returns, especially large stock markets in the US.

The issue concerning volatility transmissions among different markets has been recently explored. One of the main focuses is on volatility spillovers between oil and stock markets (Hassan and Malik, 2007; Malik and Hammoudeh, 2007; Malik and Ewing, 2009; and Arouri et al., 2011). Volatility spillovers from oil to stock markets are more pronounced than evidence of volatility spillovers from stock markets to oil market. In case of equity sectors and oil market, volatility transmissions are observed in only some of the equity sectors.

For less developed stock markets, empirical studies find the existence of shocks and volatility spillovers from oil to stock markets. This is the issue concerning unilateral spillovers from crude oil prices to stock market returns, which is contradictory to some previous studies that find bilateral spillovers between the two markets. Gomes and Chaibi (2014) find mixed results for 23 stock markets, but the spillovers run more often from oil to stock markets. Other recent studies find unilateral shock and volatility spillover from oil price to stock market returns (Anan et al., 2014; Bouri, 2015; Amed, 2017; Kurshid and Uludag, 2017; Uludag and Safarzadeh, 2018; and Chen et al., 2018). These studies find unilateral transmission for India, Lebanon, Egypt, some Balkan stock markets, and China. In addition, Anan et al. (2014) and Bouri (2015) find that unilateral volatility spillover from crude oil price to stock market return is stronger during the post crisis.

Most previous studies employ a multivariate vector autoregressive-generalized autoregressive conditional heteroskedasticity (MGARCH) models. In this paper, we examine shock and volatility transmissions between crude oil and the Thai stock markets using daily data from February 6, 2004 to September 14, 2015. Among various MGARCH models that can be used for an analysis of spillover effects, we opt to choose a bivariate VAR(1)-BEKK-GARCH(1,1) model to capture shock and volatility spillovers between each pair of time series. We treat international crude oil price as an external factor that influences stock returns and volatility. We first estimate the linkage between crude oil price and stock market return, followed by the estimate the linkage between crude oil price and each sectoral stock return. The overall results show the existence of unilateral spillovers from oil to the Thai stock market after the global financial crisis.

This paper is organized as the following. Section 2 presents data and methodology, and Section 3 reports empirical results. The last section concludes.

2. Data and Methodology

2.1 Data

This study employs daily data from January 6, 2004 to September 14, 2015 with 2,857 observations. World crude oil price is retrieved from the US Energy Information Agency while the market sectoral stock price indices are obtained from the website of the Stock Exchange of Thailand. All series are seasonally adjusted. Since daily data of prices are non-stationary, the changes in prices are used in the analysis of volatility models. The daily return of each series is calculated by:

$$R_{i,t} = \log \frac{P_{i,t}}{P_{i,t-1}} = \log P_{i,t} - \log P_{i,t-1}$$

where $P_{i,t}$ is daily closing price of each series.

Since the 2008 global financial crisis can affect the impact of volatility spillovers of crude oil price on sectoral stock returns in Thailand, the whole sample is divided into the pre- and post-crisis periods. The pre-crisis period covers the period from January 6, 2004 to May 30, 2008, and the post-crisis period covers the period from June 2, 2008 to September 14, 2015. The descriptive statistics of change in crude oil price, stock market return and eight sectoral stock returns are reported in Table 1.

For each series, the mean of return is almost equal to zero in both pre- and post- crisis periods. In addition, all stock return series are negatively skewed. However, the oil return series is negatively skewed in the pre-crisis period, but positively skewed in the post-crisis period. The large values of kurtosis in all series indicate that there are fat tails in the distributions of returns. Very large values of the Jarque-Bera statistics suggest that all series are not normally distributed. Non-normality of return distributions is suitable for the analysis of the GARCH model.

2.2 Empirical Methodology

The MGARCH models have been widely used in previous studies dealing with volatility transmissions among different time series. Among these models, the bivariate BEKK-GARCH(1,1) model is used in our analysis. We first specify the mean equations for the oil and stock return series as:

$$r_{1,t} = \mu_1 + \varphi_1 r_{1,t-1} + \varepsilon_{1,t} \qquad (1)$$

and

$$r_{2,t} = \mu_2 + \varphi_2 r_{2,t-1} + \varepsilon_{2,t} \qquad (2)$$

whrere r_1 and r_2 are the returns on oil price and stock price series, μ_1 and μ_2 are the long-term drift coefficients, and ε_1 and ε_2 are the error terms. Eqs. (1) and (2) are the classical first order autoregressive model.

For the conditional variance equations, we employ the BEKK model proposed by Baba et al. (1990) and Engle and Kroner (1995) is specified as:

$$H_t = C' + A_i' \varepsilon_{t-1}\varepsilon_{t-1}' A_i + B_j' H_{t-j} B_j \tag{3}$$

where C is a (2x2) upper triangular matrix, A_i and B_j are (2x2) parameter matrix. A_i measures the how conditional variance is related to past squared errors. B_j measures how conditional variance is related to past conditional variances. If all diagonal elements of C, A_{11}, and B_{11} are positive, the uniqueness of parameterization could be justified. More accurate structure of each parameter of Eq. (1) can be expressed as:

$$h_{11,t} = c_1 + a_{11}^2\varepsilon_{1,t-1}^2 + 2a_{11}a_{21}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{21}^2\varepsilon_{2,t-1}^2 + b_{11}^2 h_{11,t-1} + 2b_{11}b_{12}h_{21,t-1} + b_{21}^2 h_{22,t-1} \tag{4}$$

$$\begin{aligned} h_{21,t} &= c_{12} + a_{11}a_{12}\varepsilon_{1,t-1}^2 + (a_{21}a_{12} + a_{11}a_{22}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{21}a_{22}\varepsilon_{2,t-1}^2 + b_{11}b_{21}h_{11,t-1} \\ &+ (b_{21}b_{12} + b_{11}b_{22})h_{21,t-1} + b_{21}b_{22}h_{22,t-1} \end{aligned} \tag{5}$$

$$h_{22,t} = c_2 + a_{12}^2\varepsilon_{1,t-1}^2 + 2a_{12}a_{22}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{22}^2\varepsilon_{2,t-1}^2 + b_{12}^2 h_{11,t-1} + 2b_{12}b_{22}h_{21,t-1} + b_{22}^2 h_{22,t-1} \tag{6}$$

where $h_{11,t}$ is the conditional variance of change in crude oil price at time t, and $h_{21,t}$ is conditional covariance between change in crude oil price and each series of stock return, and $h_{22,t}$ is conditional variance of each sectoral stock return. The parameters cij, aij, and bij are in matrices C, A and B. There are two hypotheses to be tested in analyzing spillover effects of crude oil price and each stock return series. Hypothesis 1: $a_{21} = b_{21} = 0$. And hypothesis 2: $a_{12} = b_{12} = 0$. The first hypothesis shows that there is no shock and volatility spillover effect of series 2 on series 1 while the second hypothesis shows that there is no shock and volatility spillover effect of series 1 on series 2. In our analysis, if the first hypothesis is rejected, there will be shock and volatility spillover effect from each stock return series on crude oil price change, and if the second hypothesis is rejected, there will be shock and volatility spillover effect from crude oil price change to a stock return.

According to Schreiber et al. (2012), a bivariate BEKK-GARCH model has more advantage than general MGARCH model due to a substantial decrease in number of estimated parameters. Furthermore, Chen et al. (2018) show that the BEKK model is the best when applied to the data compared with other versions of the models.

3. Empirical Results

Before estimating the bivariate BEKK-GARCH models, we perform unit root tests using the Augmented Dickey-Fuller test with constant to ensure that the return series are stationary. The results of unit root tests are reported in Table 2.

The results in Table 2 show that all return series are stationary because the null hypothesis of unit root is rejected at the 1% level of significance. Therefore, we proceed to estimate the bivariate BEKK-GARCH models.

The spillover effects of crude oil price to stock market return in the Stock Exchange of Thailand are obtained from the estimated bivariate BEKK-GARCH models. We focus on Eqs. (4) and (6) because these two equations will show transmissions of shock and volatility between oil price change and equity returns. The estimated coefficient of the ARCH term captures shock dependence while the estimated coefficient of the GARCH term captures volatility persistence of conditional variance or current volatility. The conditional variance of the stock market or equity sector return depends not only on its own past and innovations, but also on those of the oil price change. The same is true for conditional variance of oil price change. Therefore, shock and volatility spillovers between each pair of series can be analyzed. Table 3 shows how oil price volatility affects stock market return. By incorporating the AR(1) process in the conditional mean equation, the serial correlation problem is reduced when examined by system residual Portmantau tests for autocorrelations for most system equations.

It should be noted that the significance of estimated parameter a_{11} shows how past shock in oil return affects its volatility while a_{22} shows how past shock in equity return affects its volatility. Similarly, parameter b_{11} shows how previous volatility of oil price affects its current volatility while b_{22} shows how previous volatility of equity return affects its current volatility. Furthermore, the significance of a_{12} and b_{12} explains how past oil price shock and its past volatility affect current volatility of stock return. On the contrary, the significance of a_{21} and b_{21} explains how past shock in stock return and its past volatility affect current volatility of oil price change.

The results show that current oil price volatility is affected by its own past shock and volatility, and past shock and volatility of stock market return affect its own current volatility in both pre- and post-crisis periods. In the pre-crisis period, the coefficients a_{12} and b_{12} are not statistically significant, and thus crude oil price change does not have spillover effect on the stock market return. On the contrary, these coefficients are significantly positive in the post-crisis period, and thus there are shock and spillover effects from oil price to the stock market. However, the coefficients a_{21} and b_{21} are not significant in both the pre- and post-crisis periods. Therefore, it can be concluded that the Thai stock market return does not have shock and spillover effects on crude oil price change. It is reasonable that a small emerging stock market does not influence international oil market.

We proceed to estimate the BEKK-GARCH(1,1) model for oil and equity sector returns and the results are reported in Table 4. Again, the estimated parameters are obtained from Eqs. (4) and (6).

The results in Table 4 reveal that oil price change and each equity sector return behave in the same manner as oil and stock market return in that past shock and volatility significantly affect their own current volatility in both the pre- and post- crisis periods. In addition, shock and volatility spillovers for sectoral stock returns to oil price are not observed in both periods. In the pre-crisis period, shock and volatility spillovers from oil price to sectoral stock returns are also not observed. However, the results in the post-crisis period are different from the pre-crisis period. Both shock and volatility spillover effects from equity sector returns to oil price are evidenced in four sectors: agricultural business sector, industrial sector, and property and construction sector and resources sector. This is reasonable because firms in agricultural business, industrial, and property and construction sectors engage in energy-intensive economic activities while firms in resources sectors engage in energy-related activities. For the remaining four equity sectors, shock spillover effects from oil price to stock returns are evidenced in financial and service sectors while volatility spillover from oil price to stock return is observed in financial sector. Firms in financial sector are closely related to energy-intensive firms in terms of providing financial services. Only stock returns in technology sector are not affected by shock and volatility in the crude oil market since firms in this sector are not energy-intensive. The overall results suggest that there are unilateral shock and volatility spillovers from world crude oil market to the Thai stock market. The finding is in line with the finding by Anan et al. (2014), Bouri (2015), Amed (2017) and Uludag and Safarzadeh (2018). The results also indicate that the 2008 global financial crisis substantially influences shock and volatility spillover effects from oil to stock market.

4. Conclusions

This paper examines the impacts of shock and volatility spillovers between crude oil and stock market in Thailand using daily data from the January 2004 to September 2015. We employ a BEKK-GARCH(1,1) model that allows for analyzing both shock and spillover transmissions. Overall results point to the existence of significant shock and volatility spillovers running from oil to stock market after the post global financial crisis. The unidirectional spillovers can be expected to vary across different economic sectors. The results also show that the global financial crisis influences this unilateral linkage between oil and stock markets. Our sector analysis can be more informative and gives implications for portfolio management.

The findings on our study can offer some avenues for further research. More studies on emerging stock markets might produce the robustness of the issue pertaining to unilateral spillovers from crude oil to stock markets. This study has a limitation in that it does not analyze hedging effectiveness that can produce optimal weights and hedge ratios for oil-and-stock portfolio holdings.

TABLE

Table 1 Descriptive statistics for the return series.

Panel A: Pre-crisis period (1/06/2004 – 5/30/2008)					
Series	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
Oil	0.0014	0.0163	-0.0589	3.8183	30.7
SET	0.0002	0.0132	-0.7619	22.7801	17661.7
Agr	0.0003	0.0087	-0.8789	18.2043	19,364.3
Consump	-0.0001	0.0060	-0.5591	19.2196	11,872.6
Fin	0.0001	0.0156	-0.8379	20.7113	14,216.1
Indus	0.0001	0.1390	-0.2334	10.1075	2,278.8
Propc	-0.0003	0.0141	-0.6829	16.5686	8,353.2
Res	0.0007	0.0168	-0.2313	14.3841	5,830.7
Serv	0.0002	0.0105	-0.7735	17.9895	10,199.6

Tech	0.0001	0.0171	-0.5379	20.9619	14,543.5
Panel B: Post-crisis period (6/02/2008 – 9/14/2015)					
Series	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
Oil	-0.0004	0.0202	1.0083	19.0366	10,364.3
SET	0.0004	0.0135	-0.5588	9.8150	3535.3
Agr	0.0006	0.0118	-0.3476	5.6844	569.9
Consump	0.0004	0.0079	-0.6862	13.9808	9,077.5
Fin	0.0004	0.0164	-0.2379	8.9311	2,624.4
Indus	0.0002	0.0168	-0.2692	7.3037	1,394.5
Propc	0.0005	0.0142	-0.4332	7.5796	1,610.3
Res	0.0001	0.0175	-0.1763	8.8982	2,587.9
Serv	0.0007	0.0118	-0.8252	8.6903	2,602.1
Tech	0.0006	0.0153	-0.1972	6.9850	1,188.6

Note: Jarque-Bera statistic is used to test for normality of return distribution. Oil is change in crude oil price, SET is stock market return, Agr is agricultural business sector return, Consump is consumption product sector return, Fin is financial sector return, Indus is industrial sector return, Propc is property and construction sector return, Res is resources sector return, Serv is service sector return and Tech is technology sector return.

Table 2 Results of stationarity tests

	Pre-crisis	Post-crisis
Variable	ADF statistic	ADF statistic
Oil	-29.345***	-7.221***
SET	-34.376***	-9.713***
Agr	-33.999***	-9.980***
Consump	-36.043***	-11.796***
Fin	-33.417***	-8.936***
Indus	-32.341***	-8.621***
Propc	-33.326***	-9.029***
Res	-16.116***	-10.510***
Serv	-34.708***	-9.342***
Tech	-35.891***	-10.727***

Note: Oil is change in crude oil price, SET is stock market return, Agr is agricultural business sector return, Consump is consumption product sector return, Fin is financial sector return, Indus is industrial sector return, Propc is property and construction sector return, Res is resources sector return, Serv is service sector return and Tech is technology sector return. ** indicates significance at the 1% level.

Table 3 Estimates of the BEKK-GARCH(1,1) model for oil price change and stock market return.

Parameter	Pre-crisis period	Post-crisis period
a_{11}	0.030***	0.055***
a_{12}	0.000	0.000***
a_{21}	0.001	0.000
a_{22}	0.129***	0.110***
b_{11}	0.949***	0.942***
b_{12}	0.025	0.052***
b_{21}	0.000	0.005

b_{22}	0.670***	0.110***

Note: *** indicates significance at the 1% level.

Table 4 Estimates of the BEKK-GARCH(1,1) model for oil price change and equity sector return.

Panel A: Oil and agricultural business sector returns		
Parameter	Pre-crisis period	Post-crisis period
a_{11}	0.031***	0.000***
a_{12}	0.000	0.000***
a_{21}	0.000	0.000
a_{22}	0.173***	0.100
b_{11}	0.941***	0.936***
b_{12}	-0.003	0.037***
b_{21}	0.000	0.008
b_{22}	0.173***	0.856***
Panel B: Oil and consumer product sector returns		
a_{11}	0.030***	0.061***
a_{12}	0.000	0.000
a_{21}	0.010	0.000
a_{22}	0.143	0.250***
b_{11}	0.949***	0.938***
b_{12}	-0.007	0.041***
b_{21}	0.002	0.001
b_{22}	0.736***	0.469***
Panel C: Oil and financial sector returns		
a_{11}	0.032***	0.056***
a_{12}	0.000*	0.000**
a_{21}	0.003	0.000
a_{22}	0.050***	0.100***
b_{11}	0.948***	0.941***
b_{12}	-0.035	0.025
b_{21}	0.003	0.001
b_{22}	0.817***	0.882***
Panel D: Oil and industrial sector returns		
a_{11}	0.029***	0.056***
a_{12}	0.000	0.000***
a_{21}	0.000	0.000
a_{22}	0.124***	0.106***
b_{11}	0.949***	0.941***
b_{12}	-0.008	0.087***
b_{21}	0.002	0.005
b_{22}	0.775***	0.093***
Panel E: Oil and property-construction sector returns		
a_{11}	0.029***	0.056***
a_{12}	0.000	0.000***
a_{21}	0.008	0.000
a_{22}	0.124***	0106***
b_{11}	0.949***	0.941***
b_{12}	-0.008	0.087***

b_{21}	0.000	0.001
b_{22}	0.775***	0.877***
Panel F:Oil and resources sector returns		
a_{11}	0.030***	0.052***
a_{12}	0.000	0.000***
a_{21}	0.005	0.008
a_{22}	0.185***	0.087***
b_{11}	0.948***	0.945***
b_{12}	0.158***	0.163***
b_{21}	0.001	0.000
b_{22}	0.686***	0.897***
Panel G: Oil and service sector returns		
a_{11}	0.032***	0.059***
a_{12}	0.000	0.000***
a_{21}	0.001	0.007
a_{22}	0.125***	0.127***
b_{11}	0.946***	0.939***
b_{12}	-0.034	0.004
b_{21}	0.002	0.001
b_{22}	0.755***	0.832***
Panel H: Oil and technology sector returns		
a_{11}	0.030***	0.064***
a_{12}	0.000	0.000
a_{21}	0.000	0.000
a_{22}	0.077***	0.122***
b_{11}	0.946***	0.934***
b_{12}	-0.057	-0.024
b_{21}	0.000	0.008
b_{22}	0.516***	0.795***

Note: ***, **, and * indicate significance at the 1%, 5% and 10%, respectively.

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