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OIL PRICE SHOCKS, STOCK MARKET BEHAVIOR, AND PORTFOLIO RISK MANAGEMENT: EVIDENCE FROM MAJOR OIL IMPORTING - EXPORTING MARKETS

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ABSTRACT

The paper reaches the impact of the oil crisis on stock market returns from Major Oil Importing - Exporting Markets and examines the utility of cross oil–stock market linkages in portfolio risk management. A VAR- BEKK- GARCH approach was employed to model the above hypothesis based on daily data from January 2000 to December 2017 from four selected countries: Saudi Arabia and Russia, known as the largest oil-exporting countries in the world and two oil-importing countries which are the United States and China. Results indicated that stock returns and the volatility spillover from crude oil return to oil-importing and oil-exporting stock market returns are significant in our data sample. Besides, after the petroleum crisis in 2014, this level of integration is increased with time for the dynamics correlations and however becomes less strong for the conditional variance.

Keywords: *Stock market returns; volatility spillovers; BEKK model; GARCH, oil shocks; oil export; oil import.*

INTRODUCTION[1]

Following the first oil crisis experienced in 1973, there is an ongoing debate about the complex connection between oil prices and stock market activity. A great deal of research, using various econometric techniques, has been focused on how oil price shocks affect economic activity and macroeconomic performance. Moreover, many researchers have researched the role of oil in hedging and managing risk equity portfolios. The impact of oil prices on the stock market differs from country to another based on whether the country is an oil-exporter or oil-importer. The best way to undeestand how shocks could affect stock market returns and volatility over time is beneficial for financial market participants and policy-makers.

Our project intends to:

- Firstly, explain the connection between oil and stock prices, and examines the stability of this relationship. Thus, we try to highlight any differences that may exist when the sample time-span period is sub-divided into two time-spans taking the recent 2014 petroleum crisis as a critical event point.
- Secondly, this project was conducted for four countries, U.S., Saudi Arabia, China, and Russia. To our knowledge, no other empirical investigations have examined these countries together, in the context we are interested

[1] Hint: In this article, the translations by Ayatollah Makarem Shirazi (May Allah keep his sublime shade continuing) have been utilized for the meanings of the Holy Quran's ĀYĀT.

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In this research, we propose three hypotheses to test:

Hypothesis 1. Oil price fluctuations affect differently stock returns from crude oil Exporting – Importing markets.

Hypothesis 2. The stock returns are impacted asymmetrically by the oil price fluctuations.

Hypothesis 3. Trading strategy using oil prices provides statistically significant profits for investors.

We briefly review the empirical studies conductedon oil price fluctuations on stock market returns.

Early literature such as Hamilton (1983) examined the influence of an increase of the oil price on the U.S. output and recognized oil price shocks as a factor causal to recession in the U.S. Similarly, Sadorsky (1999) suggested that U.S. real stock returns were depressed by positive shocks to oil prices. Conversely, Huang et al. (1996) showed that there was any correlation between oil futures returns and U.S. stock market returns. Chaudhuri and Daniel (1998) used both the cointegration and causality tests to examine the behavior of the US dollar real exchange rate and real oil prices. Their empirical results suggest that oil price shocks can have long-run effects on real exchange rates. Ciner (2001) used nonlinear causality tests and provided evidence that oil shocks affected U.S. stock index returns. Papapetrou (2001) tested the dynamic linkage between crude oil prices and employment in Greece using a cointegrated VAR model. Hammoudeh and Aleisa (2004) investigated the connection between oil prices and stock markets in GCC countries by applying the Johansen co-integration approach. Their empirical results suggested that only the Saudi market can be predicted by oil future prices. Likewise, Basher and Sadorsky (2006) discovered that oil price increases have a positive impact on excess stock market returns for daily and monthly data, in emerging markets, whereas for weekly and monthly data, oil price decreases have positive and significant impacts on emerging market returns. On the other hand, Park and Ratti (2008) found a negative response of oil price shocks on the stock markets in France, Germany, and Italy, a positive response in Norway, and no response in the United Kingdom. Hammoudeh and Li (2008) analyzed the impact of fluctuations in volatility based on the estimated persistence of volatility for five GCC stock markets. They concluded that GCC stock markets are more sensitive to major international factors than to local and regional factors. In a recent paper, Hammoudeh et al. (2009) investigated three sectors which are service, financial and industrial sectors of four GCC markets (Kuwait, Qatar, Saudi Arabia, and the UAE) by using multivariate VAR-GARCH models which allow for dynamic volatility and volatility transmission. Their findings show that past volatilities are more important than past shocks and that there are moderate volatility spillovers between the sectors within the individual countries, except for Qatar

In a recent paper, Ramos and Veiga (2010) examined the asymmetric effects of oil price fluctuations in international stock markets. Their results showed that the volatility of oil prices hurts the international stock market returns. Similarly, Ono (2011) used a VAR model to test the impact of oil prices on real stock returns for BRIC (Brazil, Russia, India, China) over the period 1999 to 2010. Their results showed the asymmetric effects of oil price shocks. In another recent study, Lee et al. (2012) analyzed the G7 economies context using collected monthly from 1991 to 2009 and tested the effects of changes in oil prices on different sector stock indices. They concluded that oil price shocks have a significant effect on some sector indices for some G7 countries. Yet in another study, Adaramola (2012) examined the long-run and short-run dynamic effects of oil price on stock returns in Nigeria and found a significant positive stock return to the oil price shock in the short-run and a significantly negative stock return to oil price shock in the long-run. Broadstock et al. (2012) considered the Chinese stock market and analyzed the time-varying connection between oil prices and energy-related stocks by applying a BEKK model. They concluded a sharp rise in correlation during the 2008 financial crisis, while Antonakakis and Filis (2013) used a DCC-GARCH model to identify the time-varying effects of oil price changes on stock market correlation. Ansar and Asghar (2013) analyzed the impact of oil prices on the consumer price index and stock market (KSE-100 Index). The study revealed the existence of a positive relationship among oil prices, CPI and KSE-100 Index but such a relationship is not much stronger. Abdalla (2013) inspected the impact of oil price fluctuations on stock market returns in Saudi Arabia. The empirical evidence from daily returns on the Saudi Stock market (Tadawul) Index and daily crude oil prices showed that stock market returns volatility increased because of crude oil price fluctuates during the period of study. Investigating the China and the US markets, Broadstock and Filis (2014) applied a Scalar-BEKK model to inspect the time-varying correlations between oil prices shocks of different types: supply-side, aggregate demand and oil-market specific demand and stock market returns. They found that correlations between oil price shocks and stock returns are time-varying. Further, China seems more resilient to oil price shocks than the US. In contrast, Fang and You (2014) considered the Chinese country and found that oil specific demand shocks hurts the Chinese stock market. However, in European countries' context, Cunado and de Gracia (2014) examined the impact of different types of oil shocks. Their results showed a negative response to oil price shocks on the aggregate stock markets in France, Germany, Italy, and the UK. In their study, Chkili et al. (2014) employ a DCC- FIAPARCH model to analyze the relationships between oil and the US stock market over the period 1988–2013. Their empirical findings revealed that the long memory and the asymmetric behavior characterize the conditional volatility of oil and stock market returns. Narayan and Gupta (2015) analyze the role of oil prices in predicting stock returns by using a predictive regression model. Their findings suggest that oil price predicts US stock returns and both positive and negative oil price changes are important in prediction of US stock returns, with negative changes relatively more important. Recently, Caporale et al. (2015) employed a GARCH (1, 1) model to analyze the impact of oil price volatility on stock prices in China over the period January 1997 to February 2014. Recently, Sanusi and Ahmad (2016) used a multi-factor asset pricing model to inspect the determinants of the oil and gas in the U.K. stock returns. Their empirical findings reveal that the oil and gas companies' stock returns have been affected by oil price shock. Besides, Diaz and Gracia (2017) analyze the impact of oil price shocks on stock returns of four oil and gas corporations listed on NYSE under the period 1974- 2015. Their findings show a significant positive impact of oil price shocks on stock returns in the short-run. Sharma (2017) inspect the impact of oil price shocks on twelve countries American Depositary Receipt returns. The empirical results suggest that oil price shocks have a positive and statistically significant impact on ADR returns in all twelve countries used in the sample. Killins et al (2017) used a structural vector autoregressive model to inspect the impact of oil price fluctuations on the macroeconomic environment. They find that the housing markets in Canada and the US react to oil price shocks and the reaction varies significantly based on country oil trading status and based on the change in oil prices is prompted by demand or supply shocks in the oil market. Mensi et al (2017) use a variational mode decomposition (VMD) method combined with a copula approach to investigate both short and long-run dependence between oil and four major regional stock markets (S & P500, stoxx600, DJPI, and TSX indexes). Their empirical findings reveal that there is a tail dependence between oil and all stock markets raw return series. Besides, they find strong evidence of up and down risk asymmetric spillovers from oil to stock markets and vice versa in the short-and long-run horizons. On the other hand, the dependence structure varies across market conditions.

Ngene et al (2017) consider weekly returns of seven African stock markets to explore the impact of the exchange rate and inflation rate on long term dependency structure, over the period (2002-2014). Furthermore, they investigate the long-term dependency structure of stock returns and variance in the absence and the presence of structural breaks. Their results show that in the absence of structural breaks, there is evidence of long memory components in returns and variance. You et al. (2017) examine the impact of crude oil shocks and Chinese stock returns by employing the quantile regression technique. They suggest that oil price fluctuations have an asymmetric effect on stock returns. On the other hand, the impacts on stock markets are changes across periods used in their study. Maghyereh et al (2017) used a DCC-GARCH model to check the return and volatility spillovers between crude oil, gold, and equities for the Gulf Cooperation Council. They found significant spillovers from oil to equities. However, the spillovers of gold on the stock markets are insignificant. In their study, Xingguo and Shihua (2017) inspect the impact of oil price shocks and oil price volatility shocks on the Chinese stock market index and five sector returns. Their empirical reveal that that oil price shocks positively affect Chinese stock returns. Also, these results are more significant after the recent financial crisis. Kuttu (2017) explores the long memory dependence in the second moments of the return series in the equity markets of Ghana, Kenya, Nigeria, and South Africa. He finds the presence of long-range dependence in the conditional volatility in all the four countries' equity markets in the full sample. Charles and Darne (2017) compare several GARCH type models (GARCH, GJR-GARCH, and EGARCH) with the presence of jumps for Brent and WTI crude oil markets, over the period 1992- 2014. They conclude that Asymmetric models provide the best out-of-sample forecasts than GARCH models. Bai and Koong (2017) investigate the time-varying relationships among real oil prices, exchange rate changes and stock market returns in China and the U.S. over the period (1991 – 2015). They use both the diagonal BEKK model and the dynamic impulse response functions. Their empirical results suggest that oil prices respond positively and significantly to aggregate demand shocks and positive oil supply shocks adversely and significantly affect the Chinese stock market. Besides, a significant parallel inverse relation exists between the China stock market and the exchange rate and between the US stock market and the dollar. They find also that the Chinese stock market is more volatile and responsive to aggregate demand and oil price shocks than the US stock market in recent years.

This paper aims to contribute to the literature by understanding the issue of global spillover effects on the return transmissions and dynamic correlations between oil prices and stock market returns from oil-exporting and oil-importing countries. For this purpose, we consider Vector Autoregressive-BEKK GARCH (VAR-BEKK -GARCH) model to explore the joint evolution of conditional returns and volatility between Saudi Arabia, Russia, United States of America and China, in the last turbulent years.

Our study adds to and differs from the related literature in the following regards.

First, this study identifies two major oil-exporting countries and two major oil-importing countries from a list of the "The World Factbook[1]" in 2017 and other Sources. These four countries are selected based on the availability of data. The two-selected major crude oil-exporting countries are Saudi Arabia and Russia ranked number 1 and 2 in 2012 with 8,865,000 and 7,201,000 barrels per day exporting, respectively (Central Intelligence Agency, 2017). Likewise, the selected major oil-importing countries are the United States and China ranked numbers 1 and 2 with 9,080,000 in 2013 and 6,167,000 in 2014 barrels per day importing, respectively.

Second, in this study, we employ a recent robust quantity technique, namely the VAR-BEKK-GARCH model that allows most of the interaction between financial stock market volatility to be captured with flexibility and without parameter restrictions to assure the positivity of the conditional covariance matrix. Furthermost, we intend to model the stylized facts of returns to fully understand the international stock markets volatility dynamics. An advantage of the BEKK model is that the conditional-variance matrices are always positive definite. This is an important advantage in simulation studies. The specific aspect of this model allows us to observe the dynamic dependence between the volatility series.

Third, potential structural shifts in the sample oil-exporting and importing markets are investigated, since they may have an impact on the relationship between markets. In this regard, the sample dataset is sub-divided into two time-intervals, depicting the recent petroleum crisis (June 2014) as a critical structural shift point.

Fourth, the knowledge of cross oil–stock market linkages are useful for international investors seeking diversification benefits and investment protection against stock market losses. Thus, the oil price movement is an important barometer for investors to make necessary investment decisions and for policymakers to adopt appropriate policies in managing stock markets.

Finally, this research can contribute to Saudi Arabia's Vision 2030 as it compares the prices of oil production in the main importing and exporting countries: Saudi Arabia and Russia. Indeed, despite the plan focuses on rescuing Saudi Arabia from its dependence on oil, it appears that the active development of the oil sector will continue to maximize revenues from it in the long term. There is also no change, at least for the present, in the Saudi Arabian policy in the global oil market.

So far, to our knowledge, no other empirical studies have examined these countries together, in the context we are interested in.

This paper has been framed in such a way that, in Section 2, we present the data and descriptive statistics. Section 3 outlines the methodology used. Section 4 summarizes our results and section 5 concludes.

EMPIRICAL METHODS:

VAR model:

In the present study, we used a vector autoregression (VAR) framework introduced by Sims (1980) to examine the interrelationships between returns of crude oil price and oil-importing and oil-exporting markets.

The VAR(p) model used in this paper is given by:

$$X_{s.t}= C_1 + \mu^{S}_{1,1}X_{S(t-1)} + \mu^{S}_{1,2}X_{S(t-2)} + \dots\dots\dots\dots + \mu^{S}_{1,p}X_{S(t-p)} + \mu^{WTI}_{1,1}WTI_{(t-1)} + \mu^{WTI}_{1,2}WTI_{(t-2)} + \dots\dots\dots\dots + \mu^{WTI}_{1,P}WTI_{(t-P)} + \varepsilon_{s,t} \quad (1)$$

$$WTI_t= C_2 + \mu^{WTI}_{2,1}WTI_{(t-1)} + \mu^{WTI}_{2,2}WTI_{(t-2)} + \dots\dots\dots\dots + \mu^{WTI}_{2,P}WTI_{(t-P)} + \mu^{WTI}_{2,1}X_{S(t-1)} + \mu^{WTI}_{2,2}X_{S(t-2)} + \dots\dots\dots\dots + \mu^{WTI}_{2,P}X_{S(t-P)} + \varepsilon_{WTI,t} \quad (2)$$

Where $x_{s,t}$ and WTI_t represent the stock market and crude oil returns respectively.

$x_{s,t-i}$ and WTI_{t-i} where i=1,2, ……p are lagged dependent variables for stock and crude oil returns.

VAR models assume that series are stationary. In general, the macroeconomic and financial series are non-stationary. To differentiate them sufficiently allows the stationary riser. This operation, however, has limitations especially if the variables share one or more stable long-term relationships. In this case, a particular class of models is used: vector models with error correction (VECM).

To determine the optimal lag length (p) of the model, we use the Akaike's information criterion (AIC).

After estimating the VAR(p) model, we collected the residuals to model BEKK-GARCH.

BEKK-GARCH model:

The study of volatility interdependence between the crude oil and the oil-importing and oil-exporting markets is carried out by using the BEKK-GARCH model proposed by Engle and Kroner (1995).

The BEKK (p,p,k) model is defined as:

$$H_t = C^{*\prime}C^* + \sum_{K=1}^{K}\sum_{J=1}^{J} A^{*\prime}_{jK}\mu_{t-j}\,\mu'_{t-j}A^{*}_{jk} + \sum_{k=1}^{k}\sum_{i=1}^{p} G^{*\prime}_{ik}H_{t-1}\,G^{*}_{ik} \quad (3)$$

where C, A, and G are (N × N) matrices of parameters. The K element refers to the generality of the model and a higher K implies a more general process.

However, most of the practical applications of the BEKK (1,1, K) model set K = 1, which makes the process represented by:

$$H_t = C^{*\prime}C^* + A^{*\prime}_{11}\mu_{t-1}\,\mu'_{t-1}A^{*}_{11} + G^{*\prime}_{11}H_{t-1}\,G^{*}_{11} \quad (4)$$

Moreover, the model represents a direct multivariate generalization of the univariate GARCH model.If N = 1 and K = 1, the equation (3) reduces to the GARCH equation.

DATA AND DESCRIPTIVE STATISTICS:

In this study, we analyze the impact of oil prices on stock market returns of selected major oil-importing and exporting countries. we consider two emerging oil-exporting countries: Saudi Arabia and Russia, known as the largest oil-exporting countries in the world and are the main members of the Gulf Cooperation Council (GCC) and BRICS, respectively. Besides, two oil-importing countries those of the United States and China. Our analysis is based on the daily closing price data for the WTI (crude oil), TASI (Saudi Arabia), RTSI (Russia), S&P500 (United States) and SSEC (China).

Daily frequency is used because it it allows capturing the intensity of the dynamics of the relationship between variables. Crude oil prices expressed in USD per barrel for Brent spot prices to represent the international crude oil market.

The sample time-span period runs from January 2000 to December 2017 and is further sub-divided into two time-spans (January 2000 to June 2014; and, July 2014 to December 2017), taking the recent 2014 petroleum crisis as a critical event point. The data-series was initially converted into continuously compounded returns, $r_{i.t} = Ln\left(\frac{P_{i.t}}{P_{i.t-1}}\right)$, where $P_{i.t}$ represents the index price i at time t.

The data consist of 4484 daily stock market observations (excluding weekends and holidays) for SSEC COMPOSITE and TASI, and 4501 daily stock market observations for RTSI and WTI and 4527 daily stock market observations for S&P 500.

Data on crude oil prices are extracted from the US Energy Information Administration (EIA) database. While the closing value of the TASI, S&P 500, RTSI and SSEC index prices, are obtained from the Investing.com database.

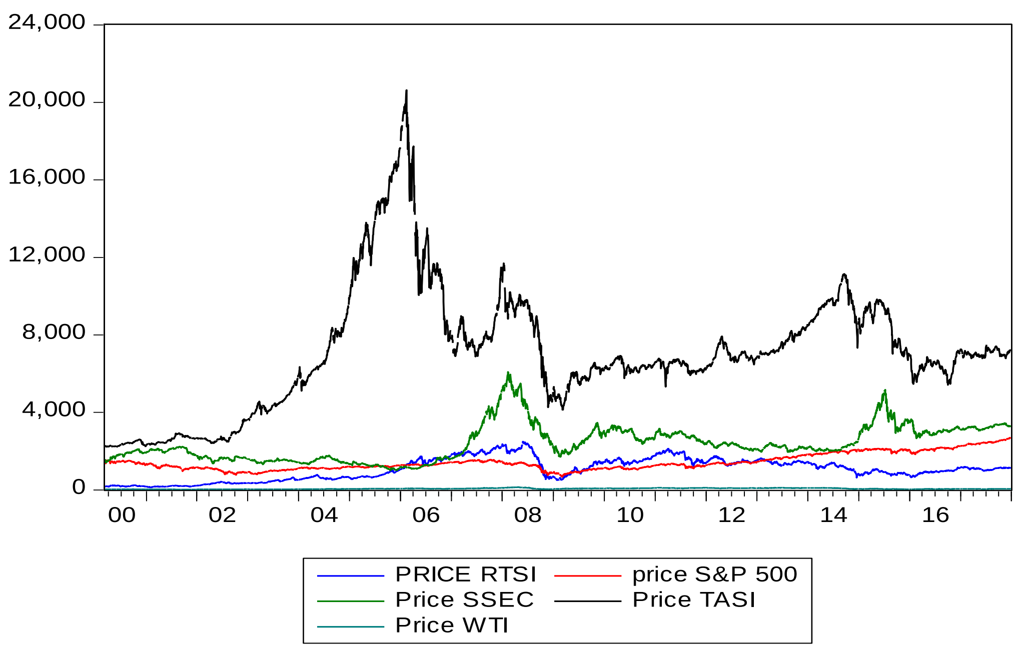


Figure 1: Dynamics of US, Saudi Arabia, China, Russia, and Crude oil stock prices over the period 1 January 2000 to 29 December 2017

Fig 1 illustrates the variation of stock prices in these five markets. From the graph, we can see how these markets are interrelated over the period 2000-2017. However, both China and the Saudi Arabia market indices commove together during all the period. Also, the financial Greek crisis in the period 2009-2010 was accompanied by decreases both in these markets. These decreases are dramatic for both Saudi Arabia and China.

The descriptive statistics for daily returns shown in **Table 1** suggest that all the data series are negatively skewed implying that these distributions are skewed to the left and have long left tails. Furthermore, the Kurtosis value of all returns is large than three times the value of Normal distribution. This means that all these financial returns have peaks relative to the normal distribution. Hence, these financial returns show the properties of asymmetry, leptokurtosis, and tail dependence; indicating that the normality assumption has been severely challenged. The Jarque-Bera statistics are highly significant for all return series and just confirm that an assumption of normality is unrealistic. Volatility is measured by the standard deviation and including the lowest value recorded on the American market (0.526154) however, the crude oil market seems to be the most volatile. Results from Augmented Dickey-Fuller (ADF) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests show that all return series are stationary, i.e. I(0), at significance levels.

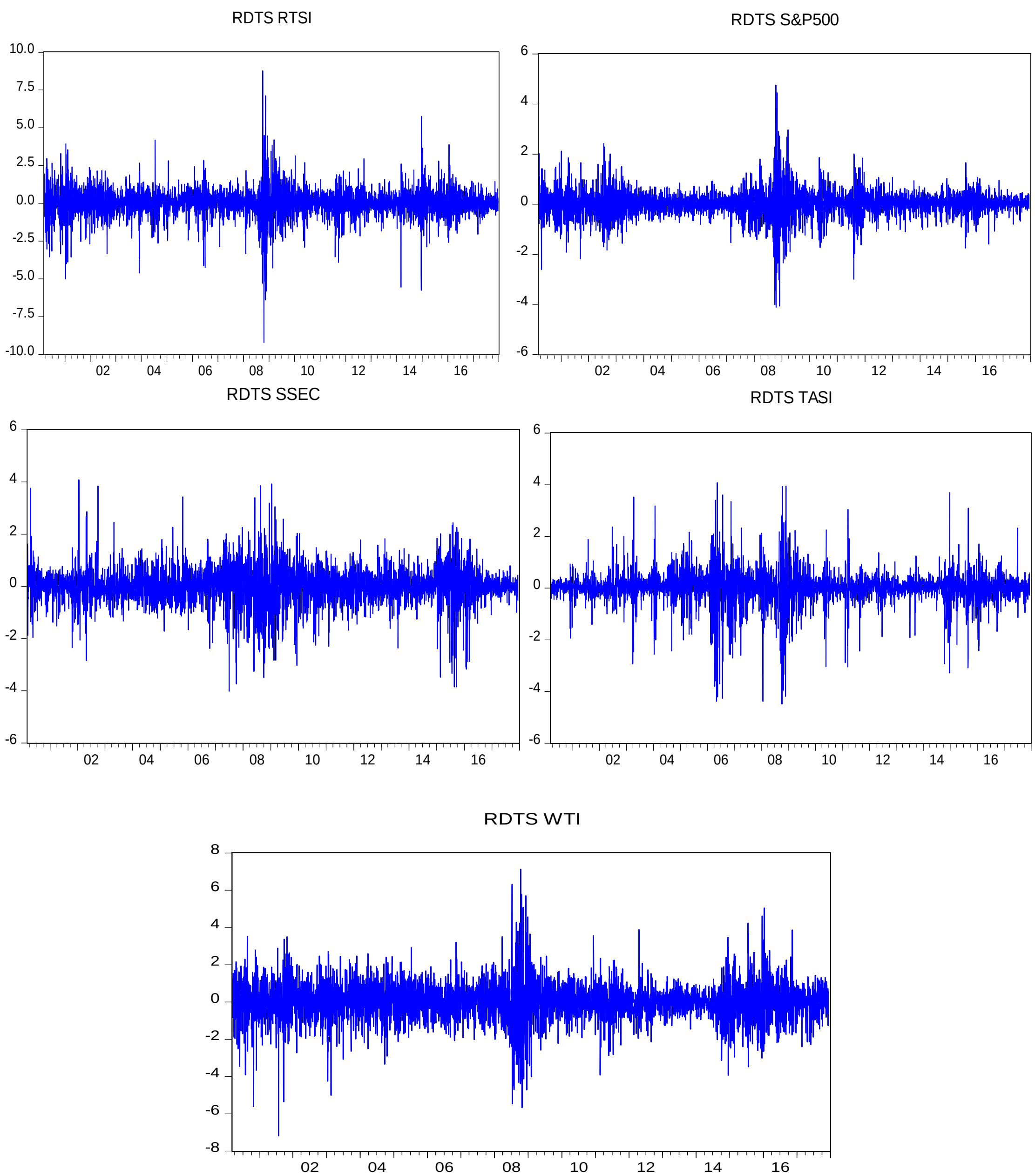
Table 1: Descriptive statistics for each daily return series

	RDTS_WTI	RDTS_TASI	RDTS_SSEC	RDTS S&P500	RDTS_RTSI
Mean	0.007972	0.011167	0.007998	0.006477	0.018776
Median	0.033305	0.041234	0.016600	0.021874	0.053374
Maximum	7.126653	4.078343	4.082793	4.758650	8.774450
Minimum	-7.185191	-4.485589	-4.019868	-4.112558	-9.206793
Std. Dev.	1.036776	0.639504	0.682916	0.526154	0.944441
Skewness	-0.088216	-0.871927	-0.353599	-0.197117	-0.397849
Kurtosis	7.083448	12.76784	8.060105	11.82249	11.67986
Jarque-Bera	3117.697***	18373.56***	4871.806***	14555.21***	14178.47***
ADF test	-69.62***	-62.15***	-65.53***	-52.041***	-61.43***
KPSS test	0.1210	0.3401	0.0726	0.3066	0.3156
Obs.	4479	4479	4479	4479	4479

Note: ***, **, * represent a significance level of 1%, 5%, and 10%, respectively.

Figure 2 plots the daily stock market returns and volatilities for the sample of countries, showing increasing dynamics of returns and volatility series during and beyond financial crises. The financial Greek crisis in the period 2008-2010 shows the most profound impact on financial markets, with the biggest impact on Russia., followed by the U.S, crude oil, China and Saudi Arabia.

Panel A: Stock market returns



Panel B: Volatilities

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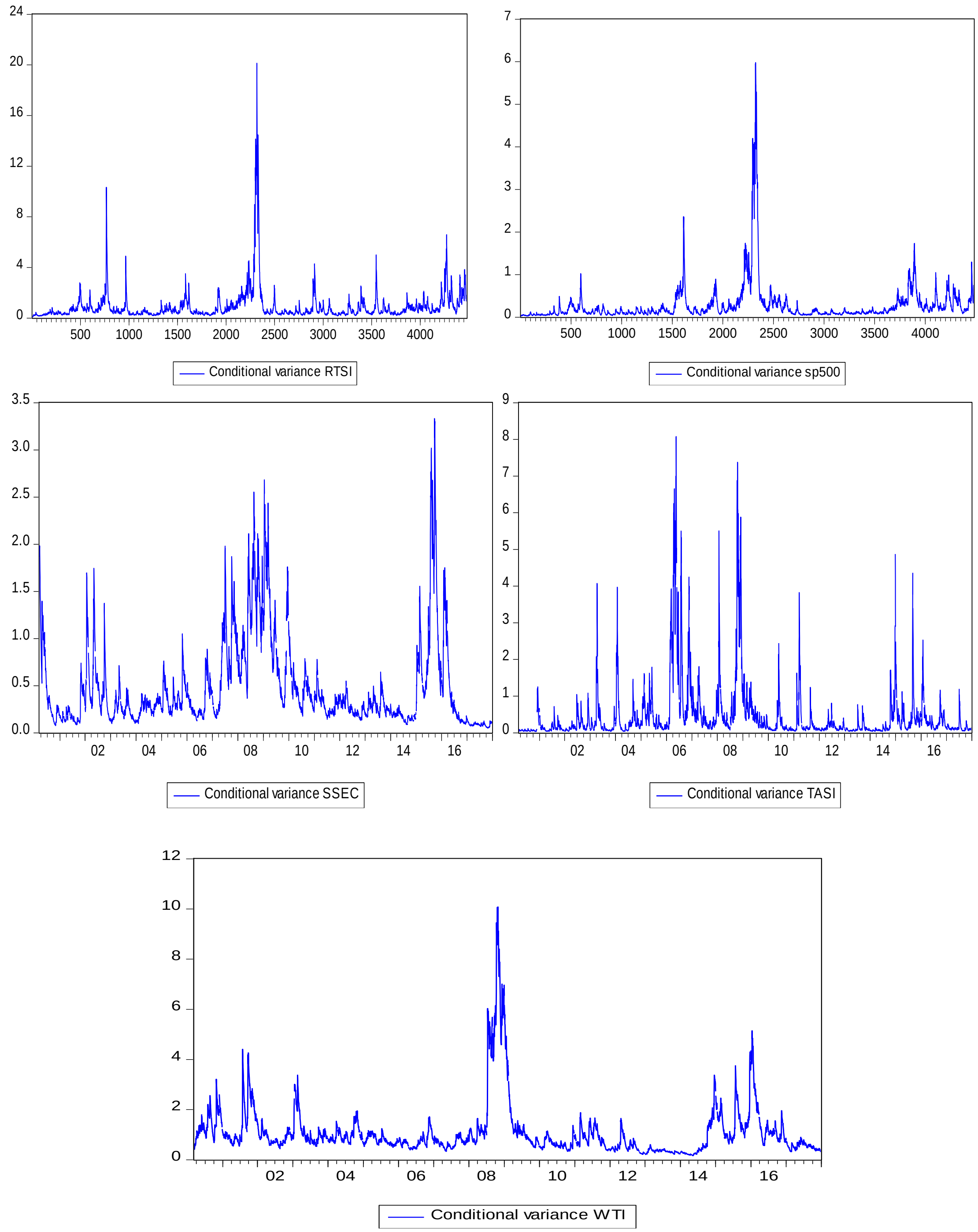

Figure 2. Dynamics of stock market return during and beyond the petroleum crisis

EMPIRICAL RESULTS:

As discussed above, our returns are first modeled by a bivariate VAR between Oil and stock market returns then the BEKK-GARCH model has been used to estimate the conditional covariance matrix for the four stock indices and to conclude about the volatility dynamics. The sample period runs from January 2000 to December 2017 and is further sub-divided into two time-spans (January 2000 to June 2014; and, July 2014 to December 2017), to investigate the impact of the recent 2014 petroleum crisis on returns and volatilities. The return transmissions are analyzed using a VAR(5) model for the pre-crisis and VAR (1) model for the post-crisis, where the lag length of five and one are selected by the Akaike's information criterion (AIC).

Table 2 presents the results of bivariate VAR modeling before and after the petroleum crisis. Overall, we found out that the crude oil returns had a substantial impact on the four countries in our data sample which depend significantly on past profitability of crude oil returns. This is in contradiction with the weak efficiency hypothesis developed by Fama (1965), which states that profitability series are characterized by a lack of memory and that the price instantly and completely reflects all the information available on the market. Consequently, we can predict the volatility of future returns of these markets from crude oil past returns.

Mostly, after the occurrence of the petroleum crisis in 2014, return spillovers from crude oil to the four countries have a reverse effect. Specifically, we observe that the stock return linkage between crude oil and Saudi Arabia and the United States stock markets seems to be negative during the post-crisis period.

Table 2: Bivariate VAR model

Panel A: Pre-crisis period:					
	WTI (crude oil)	**TASI (Saudi Arabia)**	**RTSI (Russia)**	**S&P500 (United States)**	**SSEC (China)**
WTI (-1)	-0.029384 (0.01673) [-1.75641]	0.006052 (0.01069) [0.56630]	0.001096 (0.01574) [0.06960]	0.007515 (0.00916) [0.82028]	-0.005586 (0.01104) [-0.50592]
WTI (-2)	-0.035495 (0.01671) [-2.12451]	-0.004514 (0.01067) [-0.42301]	0.031001 (0.01572) [1.97245]	-0.004615 (0.00916) [-0.50360]	0.013207 (0.01104) [1.19604]
WTI (-3)	0.033221 (0.01671) [1.98824]	0.009894 (0.01067) [0.92700]	0.068126 (0.01572) [4.33242]	0.002629 (0.00916) [0.28688]	0.030950 (0.01104) [2.80223]
WTI (-4)	-0.006829 (0.01671) [-0.40870]	-0.024442 (0.01067) [-2.28998]	0.035253 (0.01577) [2.23604]	-0.019248 (0.00916) [-2.10236]	0.033868 (0.01106) [3.06339]
WTI (-5)	-0.053924 (0.01671) [-3.22655]	-0.031371 (0.01068) [-2.93848]	0.007674 (0.01577) [0.48672]	-0.006063 (0.00915) [-0.66228]	0.000545 (0.01106) [0.04925]
C	0.014970 (0.01716) [0.87229]	0.014921 (0.01717) [0.86903]	0.020030 (0.01615) [1.24040]	0.005034 (0.00939) [0.53612]	0.002996 (0.01133) [0.26450]

Panel B: Post-crisis period					
	WTI (crude oil)	**TASI (Saudi Arabia)**	**RTSI (Russia)**	**S&P500 (United States)**	**SSEC (China)**
WTI (-1)	1.38E-16 (5.9E-17)	-0.006594 (0.01725)	0.021150 (0.02581)	-0.020549 (0.01032)	-0.034488 (0.02145)

	[2.32070]	[-0.38227]	[0.81944]	[-1.99079]	[-1.60805]
C	-1.85E-17 (6.3E-17) [-0.29101]	-0.012890 (0.01851) [-0.69636]	-0.004557 (0.02771) [- 0.16443]	0.015503 (0.01110) [1.39721]	0.019800 (0.02299) [0.86119]

Note: Standard errors in ( ) & t-statistics in [ ]

Besides, own volatility and shock dependence, cross-market volatility and shock spillover for the Crude Oil and other stock markets are tested by the dynamic conditional BEKK-GARCH(1,1) model both for the pre-crisis and the post-crisis. The estimation results for the BEKK (1,1,1) models are reported in **Table 3** below.

Table 3: Parameters estimates of Diagonal BEKK model

Panel A: Oil exporting markets				
	Crude oil - Saudi Arabia		**Crude oil -China**	
	pre	**post**	**pre**	**post**
Conditional Means				
C1		0.000877	-0.000352	2.52E-13
C2		-0.000796	0.000367	-6.78E-13
Conditional Variance				
M (1,1)	0.015237*	0.095833*	0.015748*	0.032409*
M(1,2)	0.014773*	0.099356*	0.015281*	0.031670*
M(2,2)	0.014291*	0.102931*	0.014794*	0.030982*
A (1,1)	0.216565*	0.366033*	0.216317*	0.264281*
A(2,2)	0.205799*	0.373669*	0.205368*	0.254464*
B (1,1)	0.967231*	0.885228*	0.966978*	0.948989*
B (2,2)	0.970009*	0.878212*	0.969785*	0.952274*
Panel B: Oil importing markets				
	Crude oil -U.S.		**Crude oil - Russia**	
	pre	**post**	**pre**	**post**
Conditional Means				
C1	1.14E-12	-1.62E-11	-1.81E-08	1.28E-11
C2	-1.11E-13	1.50E-11	1.85E-08	-2.34E-11
Conditional Variance				
M (1,1)	0.008570*	0.023293*	0.012943*	0.023220*
M(1,2)	0.008302*	0.023206*	0.012821*	0.023260*
M(2,2)	0.008039*	0.023119*	0.012704*	0.023301*
A(1,1)	0.214954*	0.297987*	0.252105*	0.274231*
A(2,2)	0.207615*	0.297770*	0.251971*	0.274738*
B (1,1)	0.971878*	0.942911*	0.961065*	0.953319*
B(2,2)	0.973695*	0.943092*	0.961257*	0.953142*

Note: * represent a significance level of 1%.

Results indicate that volatility spillover from crude oil returns (WTI) to oil-importing and oil-exporting stock market returns used in this study are significant before and after the crisis.

Here A(i,i) and B(i,i) are the corresponding ARCH and GARCH parameters associated with market i.

The ARCH effects show that all diagonal elements A (1,1), A (2,2) are statistically significant for both sub-periods, signifying that each conditional variance depends on its own squared lagged innovations. This means that the volatility of crude oil stock market is strongly dependent on past its innovations and this level of interrelation is increased with time (ARCH effects) indicating a short-run persistence. Thus, the past shocks of the crude oil stock market affect the present volatility of stock returns of oil-importing and oil-exporting stock markets before and after the occurrence of petroleum crisis. Additionally, the small size of ARCH coefficient estimates indicates that conditional volatility has not been able to change dramatically under the impulsions of returns innovation (Xuan Vinh and Ellis, 2018).

Furthermore, the results of GARCH parameters B(1,1) and B(2,2) showed that the sensitivity to past own conditional volatility and cross-market volatility transmission are significant at the level of 1%, showing that future volatility can be predicted by both the past own conditional volatility in the long run and the cross-market volatility spillover. Besides, despite the maintenance of the effect of crude oil volatility on oil-importing volatilities and oil-exporting volatilities, this influence becomes less strong after the petroleum crisis in 2014.

In summary, we find that there is strong evidence of volatility spillovers from the Crude oil stock market to oil-exporting and oil-importing markets.

CONCLUSION:

This paper investigates the relationships in the returns conditional volatilities of two oil-importing and two oil-exporting markets using bivariate GARCH-BEKK model for the pre-and post-petroleum crisis.

Overall, the findings regarding the transmission of the return show that the crude oil stock market has a strong impact on the four markets in our data sample and the level of integration is increased with time. Moreover, in comparison with the pre-crisis period, the volatility spillover is less apparent after the petroleum crisis. The findings suggest that there exists significant unidirectional volatility spillover from the crude oil market to Saudi Arabia, the United States, China, and Russia when a shock occurs.

Our results have considerable implications for portfolio managers and investors in the evaluation of investment and asset allocation decisions and policymakers in the context of the stock market in crude oil and the oil-importing and oil-exporting markets.

Particularly, international portfolio managers can be better able to appreciate how the volatility linkage between stock markets interrelated overtime. This situation may offer them benefit in predicting the behavior of this market by capturing the other market information.

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