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VOLATILITY SPILLOVER FROM THE GLOBAL OIL PRICE TO ASEAN STOCK MARKETS: A CROSS-QUANTILOGRAM ANALYSIS

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ABSTRACT

This paper investigates the link between the volatility of global oil prices and ASEAN stock market indices using the cross-quantilogram approach developed by Han et al. (2016). We find that a large and medium change in the global oil prices could result in persistent and robust volatility in the stock index of almost ASEAN markets. Moreover, Vietnam is a unique stock market sensitive to the slight change in global oil price, although it is not an instant response. This study offers strong implications for investors in optimising their portfolios. Besides, understanding the risk spillover from the global oil market to the stock market helps policymakers enact more appropriate policies to reduce equity volatility.

Keywords: cross-quantilogram, quantile, volatility spillover, global oil price, ASEAN stock markets

INTRODUCTION

A range of papers has extensively studied the stock market volatility because it plays a crucial role in risk management, portfolio optimisation, hedging, derivative price (Bašta & Molnár, 2018). Besides, Nikmanesh and Mohd Nor (2019) state that extreme fluctuations in the stock market can break the stability of the economic system. In the last few decades, volatility in emerging markets

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is of central importance in finance because of the young characteristic of these markets. Although emerging markets snowball and have vital roles in global financial markets, they remain vulnerable to external shocks such as changes from developed markets or global economic conditions (Dungey et al., 2007; Hanousek & Kočenda, 2011). Hence, exploring the sources of volatility in the developing stock markets is still a hot topic in financial literature.

Jones and Kaul (1996) state that oil price volatility can affect financial markets through the expected cash flow channel. Since crude oil is the most essential and indispensable input material for any economy, higher oil prices increase production, transport, and distribution costs, making goods and services more expensive. Rising oil prices generate inflationary pressures, economic recessions, and high unemployment, which have a spillover effect on financial markets (Mussa, 2000). Besides, crude oil has become an important investment for portfolio investors. Understanding the risk transmission between the stock and oil market helps the investors develop an optimal portfolio. For instance, if there is no volatility spillover, one can diversify his portfolio with oil and stocks.

The emerging economies are more energy-intensive than the developed ones, and then they are likely to be more adversely influenced by oil price shocks (Basher & Sadorsky, 2006). However, regarding oil and stock market volatility in developing countries, the results are not consistent. Hammoudeh and Choi (2006) confirm no long-run interaction between Gulf Cooperation Council markets and oil price changes. In contrast, Basher and Sadorsky (2006) ensure that variations in stock returns of 21 emerging markets have been affected by the oil price risk. Thus, offering extra insights into the relationship between the volatility of crude oil and the emerging market is necessary.

The Association of Southeast Asian Nations (ASEAN) is one of the fastest-growing trading regions in the last few decades. Being considered emerging and having significant growth in recent times, ASEAN stock markets have attracted more global investors because of higher returns and diversification benefits. The Southeast Asian stock markets are expected to bring tremendous benefits for both the region and the international investment community (Niblock et al., 2014). However, these markets often overreact to external shocks, and the excessive fluctuation in equity prices will affect investment strategy. Until now, studies concerning the ASEAN emerging markets are still restricted. This research contributes to the existing literature by focusing on the reaction of some ASEAN equity markets with shocks originating from the global oil price.

Notably, Reboredo and Ugolini (2016), Balcilar et al. (2019) find asymmetric effects in low and high quantiles of oil price volatility on stock markets. However, most influential studies typically have focused on the conditional mean of the stock volatility distributions and have not mentioned the heterogeneous volatility linkages between global crude oil and stock markets. The heterogeneous effect of oil price shocks on stock price volatility across different quantiles seems to be relatively limited in the literature.

We apply an approach called the cross-quantilogram, which is suggested by Han et al. (2016) on the daily data set spanning the period 2017 to 2020 to take account of the linkage in the volatility of the global oil market to emerging stock markets, in particular, the stock markets of ASEAN countries. This method has a quantile-based feature, which allows us to yield the directional predictability patterns in low, medium, and high quantiles to present different states of oil and stock markets. Unlike the ordinary correlogram requiring moment conditions, the cross-quantilogram is based on quantile hits. Hence, it can be applied well for heavy tail series, which characterised many financial time series (Demirer et al., 2020). Using this new technique in the context of ASEAN stock markets is another contribution of our study.

LITERATURE REVIEW

Many researchers provide evidence to support volatility spillover from oil price to stock market in the context of developed economies. For example, using a multivariate VAR analysis to estimate the effects of oil price shocks and oil price volatility on the real stock returns of the U.S. and 13 European countries, Park and Ratti (2008) find that an increase in oil price volatility statistically depresses stock returns in all European countries in the same month or within one month. Masih et al. (2011) reveal that after shocking oil prices, the stock market rises and then slows down, recovering to the long-run equilibrium level after a period of about nine months. Malik and Ewing (2009) use the BEKK-GARCH to test the transmission of volatility and shocks between oil prices and five U.S. major market sectors and conclude that the volatility of oil returns, directly and indirectly, affects the volatility of technology oil-consumer service, and healthcare sectors. Meanwhile, financial and industrial sectors have the least volatile response to oil price shocks.

About the emerging markets, the empirical studies show contrasting mixed results. Fang and You (2014) conclude that volatility in oil price has a remarkable effect on the volatility in the Indian stock index. Similarly, Uwubanmwen and Omorokunwa (2015) use the error correction mechanism and bi-variate GARCH to test whether there exists a relationship between oil price and stock price volatility in Nigeria and conclude that volatility in oil price stimulates volatility in stock prices. Contrary to the results mentioned above, Nandha and Hammoudeh (2007) reveal that the Philippines and South Korea are the only two stock markets in the Asian-Pacific region that are sensitive to oil price shocks in the short term. Similarly, oil price variations are not statistically significant for most Chinese stock market indices (Cong et al., 2008). Ramos and Veiga (2010) examine 43 stock markets, including developed and developing markets, and their study indicates that emerging equity markets are not sensitive to oil price volatility.

Specifically, it is perceived that most of these studies above apply the GARCH family models, which present the dependence of conditional expectation of the response variable on the covariates. More recently, a line of thinking has developed that no “one size fits all” type of linear relationship exists between oil and stock series (Çevik et al., 2018). Aloui et al. (2013) apply time-varying copula to detect the effect of the global oil on some Central and Eastern European stock markets and find that strong dependence is presented in the low tail and center, but it is absent in the upper tail. Sim and Zhou (2015) propose the quantile-on-quantile approach to reveal that adverse oil price shocks can affect the U.S. stock market positively, while the impact of positive oil price shock is weak. Reboredo and Ugolini (2016) test the hypothesis of equality between conditional and unconditional stock return to assess the oil price quantile and interquartile effects on stock return quantiles; and they find that after the financial crisis, large upward or downward in oil price changes have led to large upward or downward changes in stock return.

In the context of Asian equity markets, Akkoc and Civcir (2019) study the dynamic linkages between commodities and the stock market of Turkey. Bouri et al. (2017) investigate the cointegration among gold, oil, and Indian stock markets. Both studies mentioned that there is a presence of co-movement from oil return to stock return. Although various techniques are used to measure the correlation between oil and stock markets’ shocks, most of them are still in GARCH family. More recently, Bouri et al. (2018) apply the cross-quantilogram to examine the directional predictability of implied volatility from crude oil to some stock markets. When global crude is at high risk, the implied volatility of the stock market is significantly predictable for Japan, but no predictability is offered for India. Wang and Wang (2019) deal with the heterogeneity in crude oil and Chinese equity market spillover by creating a structural break dummy variable in volatility. To the best of my knowledge, there has been relatively little research addressing the volatility transmission between the ASEAN equity market and the global oil market.

DATA AND RESEARCH METHODOLOGY

Data

Our empirical analysis is based on a panel of countries in Southeast Asia, namely Vietnam, Thailand, the Philippines, Malaysia, Singapore and Indonesia. The four stock markets, including Myanmar, Brunei, Laos, Cambodia and Dong Timor, are excluded from our study due to the data availability. Our sample period is from 3 January 2017 to 31 January 2021. The used stock index for each market is detailed in Table 1. The data of the stock index of these markets are extracted from Datastream.

Table 1
List of stock index

Market	Stock market index
Thailand	Stock Exchange of Thailand Index (SET)
Vietnam	Vietnam Ho Chi Minh Stock Index (VN Index)
Singapore	The Straits Times Index (STI)
Indonesia	Jakarta Stock Price Index (JCI)
Philippines	Philippine Stock Exchange Composite Index (PSE)
Malaysia	The FTSE Bursa Malaysia KLCI Index (KLCI)

To calculate realised volatility, we adopt the method to take the ratio difference between the highest and lowest prices on day *t* to the average of these values, as shown in Equation (1). Although it is simple, Chun et al. (2019) confirm that this method often succeeds in estimating the daily volatility.

$$RV_t = \frac{P_{high} - P_{low}}{(P_{high} - P_{low})/2} \quad (1)$$

The summary key points of the realised volatility series are presented in Table 2. Augmented Dickey-Fuller and Phillips-Perron unit root test results suggest that all variables are stationary at 1% significant level. Malaysia and Singapore are the two least volatile markets because both the mean and the standard deviation of the two series are the smallest. The Philippines experiences the strongest fluctuation among the Southeast Asian stock markets. The oil price seems to fluctuate more highly compared to the stock index. This is because of the outlier in the oil price series, which occurs on 20 April 2020 when oil recorded negative prices for the first time in history. However, this does not affect the results because this study is related to the percentile, not the mean, of the realised volatility series.

Table 2
Descriptive statistics and unit root tests for realised volatility series

	Stock index						
	JCI	KLCI	PSE	STI	SET	VN	Oil price
Mean	0.0110	0.0078	0.0128	0.0089	0.0100	0.0117	0.0671
Median	0.0085	0.0062	0.0107	0.0076	0.0084	0.0093	0.0260
Maximum	0.1047	0.0665	0.1621	0.0578	0.0806	0.0631	21.25
Minimum	0.0000	0.0017	0.0018	0.0027	0.0027	0.0025	0.0032
S.D.	0.0090	0.0057	0.0096	0.0053	0.0068	0.0081	0.7584
ADF	–6.5239***	–7.6916***	–6.1476***	–5.4921***	–5.9086***	–7.2656***	–23.207***
PP	–15.883***	–21.485***	–23.292***	–19.553***	–18.883***	–17.939***	–22.099***

Notes: This table reports the main descriptive statistics, including the mean, median, minimum, maximum, standard deviation. The unit root test results based on Augmented Dickey-Fuller and Phillips-Perron method are also displayed. ***, **,* denote the 1%, 5% and 10% significance level, respectively.

METHODOLOGY

Let us define two continuous series $\{x_{i,t},\ t \in Z\}$ where index i equals to 1 and 2. The time series $x_{i,t}$ is assumed to be strictly stationary with the unconditional distribution function $F_i(\cdot)$ and the unconditional density function $f_i(\cdot)$. The α_i-quantile function of $x_{i,t}$ is $q_i(\alpha_i = \inf\{v\colon F_i(v) \geq \alpha_i\}$ for $\alpha_i \in (0, 1)$.

In the literature, $1[x_{i,t} \leq q_i(\alpha_i)]$ is called the quantile-hit or quantile – exceedance process, where $1(\cdot)$ denotes the indicator function. We consider a measure of serial dependence between two events $\{x_{1t} \leq q_{1t}(\alpha_1)\}$ and $\{x_{2,\,t-k} \leq q_{2,\,t-k}(\alpha_2)\}$ for an arbitrary pair of $\alpha = (\alpha_1;\ \alpha_2)$ and for an integer k. The cross-quantilogram is defined by Han et al. (2016) as the cross-correlation of the quantile-hit processes:

$$\rho_\alpha(k) = \frac{E\left[\psi_{\alpha_1}\left(x_{1,t} - q_{1,t}(\alpha_1)\right)\psi_{\alpha_2}\left(x_{2,\,t-k} - q_{2,\,t-k}(\alpha_2)\right)\right]}{\sqrt{E\left[\psi^2_{\alpha_1}\left(x_{1,t} - q_{1,t}(\alpha_1)\right)\right]}\ \sqrt{E\left[\psi^2_{\alpha_2}\left(x_{2,\,t-k} - q_{2,\,t-k}(\alpha_2)\right)\right]}} \tag{2}$$

where $\psi_a(u) = 1(u < 0) - a$.

Let $\hat{q}_{i,t}(\alpha_i)$ be the sample quantile of $x_{i,t}$. The sampled analog of the cross-quantilogram is

$$\rho_\alpha(k) = \frac{\sum_{t=k+1}^{T} \psi_{\alpha_1}\left(x_{1,t} - \hat{q}_{1,t}(\alpha_1)\right)\psi_{\alpha_2}\left(x_{2,\,t-k} - \hat{q}_{2,\,t-k}(\alpha_2)\right)\Big]}{\sqrt{\sum_{t=k+1}^{T} \psi_{\alpha_1}^2\left(x_{1,t} - \hat{q}_{1,t}(\alpha_1)\right)}\sqrt{\sum_{t=k+1}^{T} \psi_{\alpha_2}^2\left(x_{2,\,t-k} - \hat{q}_{2,\,t-k}(\alpha_2)\right)}} \tag{3}$$

for $k = 0, \pm 1, \pm 2$, etc.

To test for the directional predictability of events up to p lags ($x_{2,\ t-k} \leq q_{2,\ t-k}(\alpha_2)$: $k = 1, .., p$) for ($x_{1t} \leq q_{1t}(\alpha_1)$), the null and alternative hypothesis are given as follows:

$$H_0: \rho_\alpha(1) = \rho_\alpha(2) = ... = \rho_\alpha(p)$$

$$H_a: \rho_\alpha(1) \neq 0 \text{ for at least one } k$$

Han et al. (2016) recommend using the Ljung-Box version:

$$\breve{Q}_\alpha^{(p)} = \frac{T(T+2)\sum_{k=1}^{p} \hat{\rho}_\alpha^2(k)}{T-k} \tag{4}$$

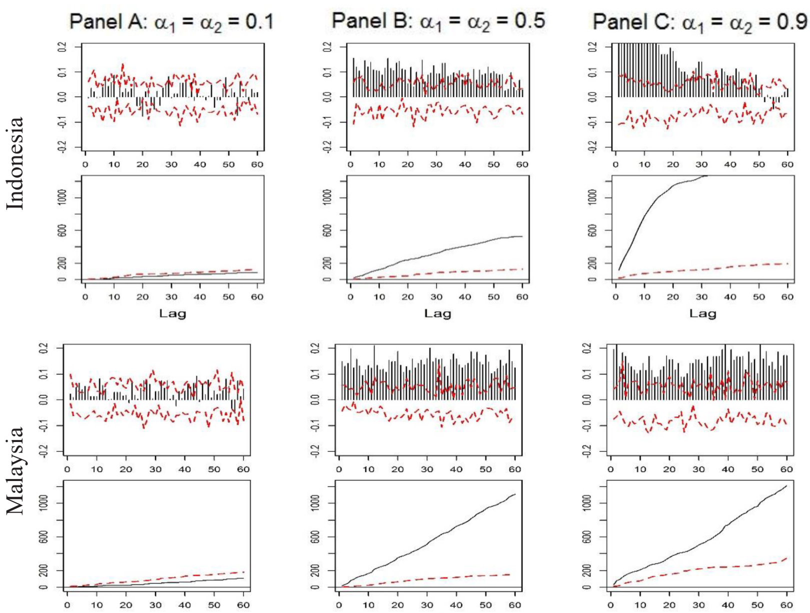
The critical values are obtained via the stationary bootstrap procedure of Politis and Romano (1994).

In this study, we measure the directional predictability from the volatility of the global oil price to volatility of the ASEAN stock indices by using $\rho_\alpha(k)$. When $\rho_\alpha(k)$ equals 0, there is no directional predictability, which means that oil volatility below or above the $q_{ov}(\alpha_{ov})$ quantile at time t is no helpful in predicting whether the volatility of stock index locates below or above the $q_{iv}(\alpha_{iv})$ quantile on the trading day $t + k$.

RESULTS AND DISCUSSION

Figure 1 presents the sample cross-quantilogram of daily volatility spillovers from oil price to six ASEAN stock markets. For each market, the results of the cross-quantilogram when oil volatility which is in the low (α_2 = 0.1), medium (α_2 = 0.5), and high (α_2 = 0.9) quantiles are reported in Panel A, Panel B and Panel C, respectively. The quantiles for the distribution of stock volatility are equal to the quantile of oil volatility in each case. The upper chart reveals the cross-quantilogram results for each stock market, while the lower chart reports the Ljung-Box test statistics. The red dashed lines represent the 95% bootstrapped confidence intervals for no directional predictability with 1,000 bootstrapped replicates. The lag k (k = 1, 2, …, 60) is on the horizontal axis.

In all these countries, when oil volatility is in high quantile (0.9), all the values of the cross-quantilogram are positive and significant. This implies that when the volatility of oil is high, it is more likely to have considerable fluctuations in all stock markets in the next day. Additionally, it takes about 40 days for the volatility of the Vietnamese stock market reaching to its peak once there exists large changes in global price. Meanwhile, it is over 60 days for the remaining ASEAN stock markets. It also indicates that the next-day effect is relatively weaker in Vietnam compared to any other country. The Indonesian stock market reacts the most strongly to oil price changes.



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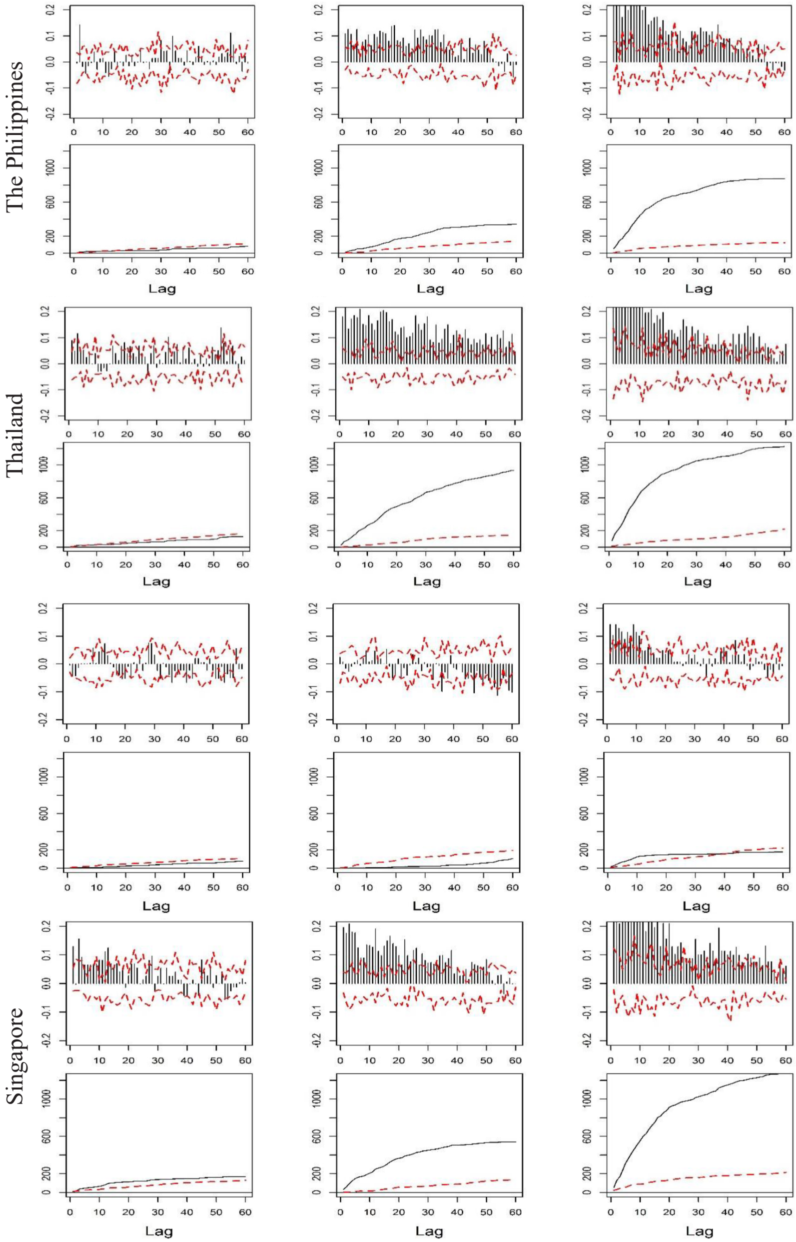

Figure 1. Directional causality in quantiles from oil price volatility to stock market index volatility

(*Note:* The upper panels report the cross-quantilogram from the low, medium and upper quantiles of oil price volatility to the high quantile in stock index volatility. The lower panels report the Ljung-Box type test statistics. Red-dashed lines represent the 5% critical values that are obtained via the procedure of 1,000 bootstrapped replicates).

The same conclusion is for the case of median quantile, except Vietnam. Evidence of dependence is found when both oil price and stock market risks are in the median quantile. Besides, we realise that the Vietnamese pattern is also different from other markets. The cross-quantilogram is negative at almost lags, while it is consistently positive for the other countries. It can be explained that when the oil volatility is below the median quantile, the Vietnamese stock market volatility will respond over the median quantile. However, Vietnamese cross-correlations are not significantly different from zero.

Moreover, if the volatility of oil price is in the low quantiles, no predictability in the stock market volatility is achieved using information from the oil market for all markets. In particular, the low oil volatility does not help predict whether volatility in ASEAN stock is above or below the 0.1 quantile. A remarkable point, in this case, is that there are different patterns in reacting to oil price changes in the Philippines and Vietnam. This evidence of negative predictability directs to a suspicion that maybe we skip the correlation when the oil volatility in the low quantile and these two markets' volatility in the median or high quantiles. Figures 2 and 3 present the result for the case of the Philippines and Vietnam when the oil volatility is low, respectively.

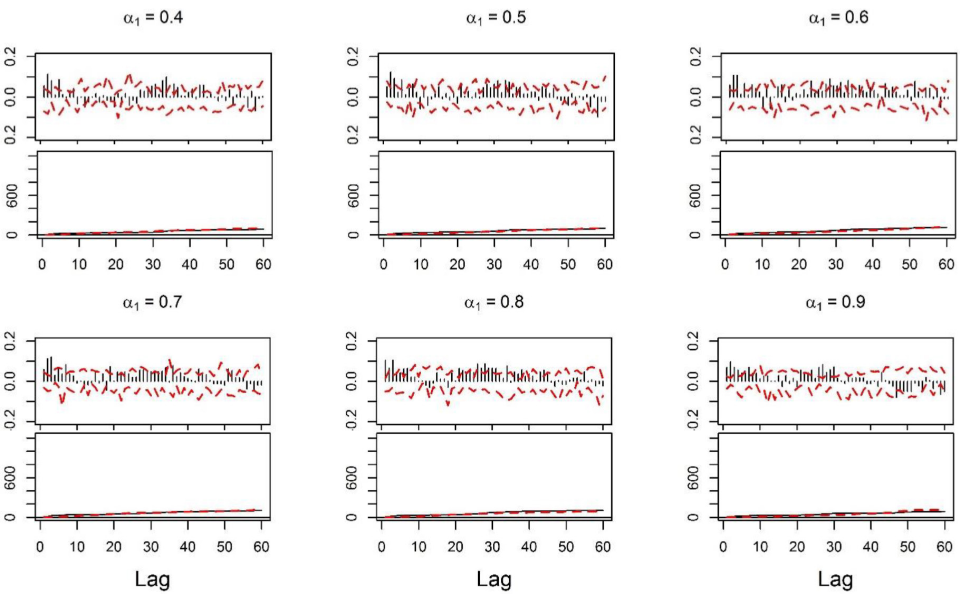

Figure 2. Response of the Philippines stock market when the oil volatility is in the low quantile ($\alpha_2 = 0.1$)

For the Philippines, unless it is in the 0.1 quantile, the cross-quantilogram of all quantiles is positive and insignificant. It is confirmed again that oil volatility directionally predicts the Philippine stock index only when it is at high risk. For the case of Vietnam, the cross-quantilogram for α_1 equals 0.5, 0.6, 0.7 and 0.8 are negative and significant from lags 30. When the oil volatility is below the 0.1 quantile, the Vietnamese stock market volatility is likely to be above the 0.8 quantile. This means that when the change in global is small, it is expected that the Vietnam stock market will experience a significant fluctuation. However, this response does not occur immediately, but after about one month, and it maintains until the next month.

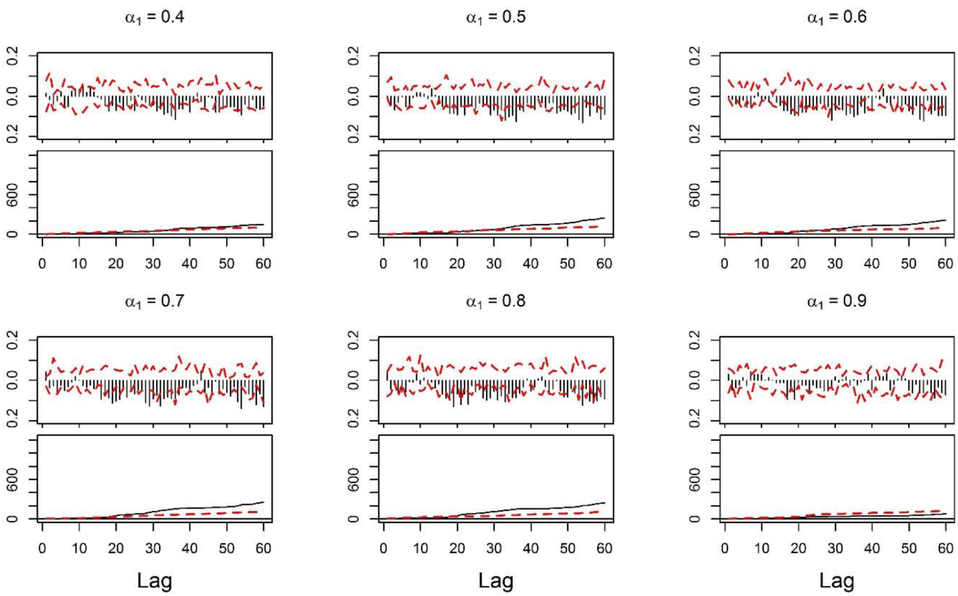

Figure 3. Response of Vietnamese stock market when the oil volatility is in the low quantile (α_2 = 0.1)

CONCLUSION

This study investigates the volatility spillovers from the global oil price to six emerging stock markets of ASEAN economies. This study contributes to the literature on the linkage in volatility between international oil prices and emerging stock markets by using the cross-quantilogram approach.

The research provides evidence that there is a long-term directional positive predictability from the oil price volatility to all ASEAN stock markets at a high level. The response period is about one month for Vietnam, while it is over 60 days for the others. Indonesia can be seen as the market which is most affected by the significant change in oil price. Five over six stock markets, except Vietnam, also react to the medium variation in oil price.

A notable is that Vietnam is a unique stock market reacting to the slight change in oil price. When the oil price volatility lies in the lowest quantile, Vietnam stock market index volatility may be above the 0.8 quantiles. Although this reaction does not happen immediately, it is still a long-term response starting a month after the oil shock and lasting over the next month.

The existing evidence on the volatility transmission from oil to stock markets in the ASEAN context is ambiguous. Koh (2015) applies the monthly SVAR model to examine the impact of oil price volatility on equity returns in five countries (Indonesia, Malaysia, the Philippines, Singapore and Thailand). The result indicates that stock price movements in these markets are mainly explained by oil price volatility. Mugableh (2017) examines the world oil price volatility on fluctuations in Southeast Asian stock returns, and the findings indicate that there are no significant effects of changes in global oil price on the mentioned Stock Exchange. However, Robiyanto (2018) argues that when investigating risk volatility, if the author applies the static approach, the result is unreliable. Along the same line, this study brings evidence about the nonlinear relationship between the volatility of global oil and ASEAN stock market indices.

This paper has strong practical relevance for investors. The analysis shows that the different magnitude of oil price volatility causes different consequences on the ASEAN stock markets. Investors should consider the quantile correlation between oil price and the stock market so that they can make the right strategic investment decisions. Since there is a long-term risk spillover from the oil market to ASEAN equity markets, the investors should be careful in constructing the oil-stock portfolios. Besides, they can apply the study to attain more accurate forecasts in compiling hedging strategies. This paper also contains policy implications. Policymakers need to understand how the stock market reacts to the weak or strong fluctuation of the oil market to design effective policies in looking for ways to decrease the markets' instability.

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