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The impacts of the oil price fall on the exchange rates of ASEAN-5: Evidence from the 2014 oil price shock

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Abstract

In mid 2014, the crude oil price started to decrease significantly, and this sharp fall in the crude oil price had a considerable impact on the world economy and international trade. In this paper, we examined the impacts of the recent oil price fall on the exchange rates of the five biggest economies of the Association of Southeast Asian Nations (ASEAN-5). The derived results showed significant changes in dynamic conditional correlation and causality relationship among commodity and foreign exchange markets during the period of the crude oil price decrease.

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1. Introduction

In mid 2014, the crude oil price started to decrease significantly. The price for West Texas Intermediate (WTI), a grade of crude oil used as one of the most significant benchmarks in oil pricing, decreased from 106.2 US dollars per barrel in July 1, 2014 to 53.7 US dollars per barrel in December 31, 2014. For 2015 to 2016, WTI's price fluctuated between 27.6 to 60.7 US dollars per barrel[1].

In 2015, the world economic growth rate was 2.63%, 0.06% lower than the growth rate in 2014. World trade, as a share of the world GDP, decreased from 60.07% in 2014 to 58.32% in 2015. The biggest economies of the Association of Southeast Asian Nations—Indonesia, Malaysia, the Philippines, Singapore and Thailand (ASEAN-5)—also experienced vital changes during this period. Their GDP growth decreased from 5.0% in 2014 to 4.8% in 2015 for Indonesia, from 6.0% in 2014 to 5.0% in 2015 for Malaysia, from 6.2% in 2014 to 5.9% in 2015 for the Philippines and from 3.3% in 2014 to 2.0% in 2015 for Singapore. The only country that experienced increased growth rate in 2015 was Thailand, at 2.8% compared to 0.8% in 2014. Foreign trade, as a percentage of the GDP, decreased by 6.2% for Indonesia, 4.1% for Malaysia, 33.7% for Singapore and 5.2% for Thailand in 2015 compared to 2014. The Philippines' foreign trade as a percentage of GDP increased by 1.7% in 2015[2].

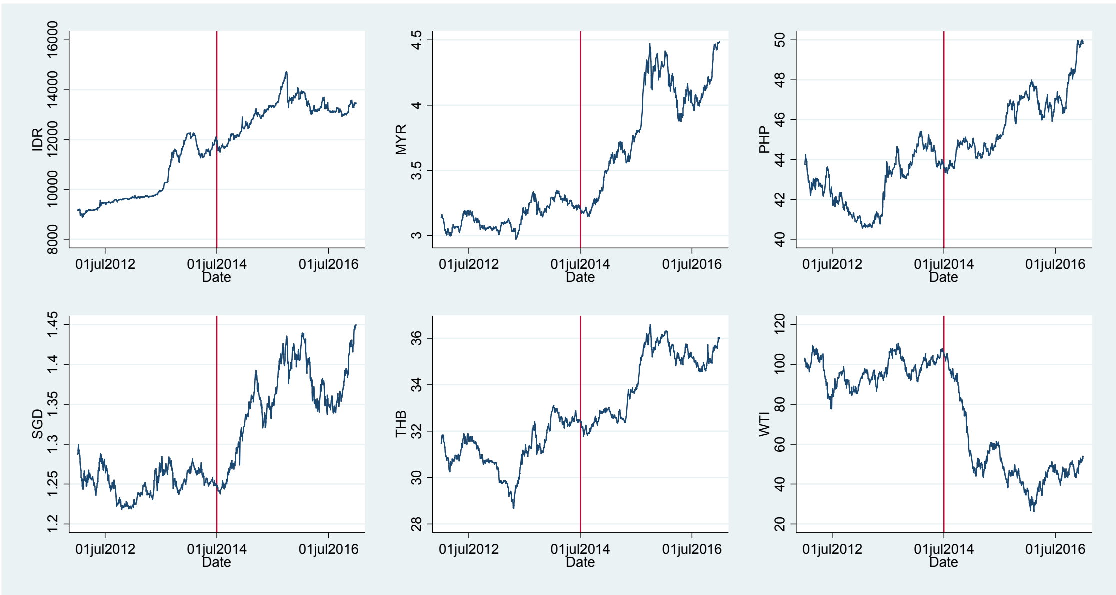

Figure 1. Daily exchange rates and crude oil price

One of the most sensitive macroeconomic variables to external shocks—the nominal exchange rate—depreciated by 1.5% to 8.9% in 6 months and by 3.2% to 17.9% within a year of the decrease in the crude oil price for ASEAN-5. Figure 1 displays the evolution of the nominal daily exchange rates and crude oil price. The vertical reference

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1 Petroleum and other liquids. Independent statistics and analysis. U.S. Energy Information Administration.

2 Comparisons are based on data from the World Bank national accounts.

line indicates July 1, 2014, as the beginning of the fall in the crude oil price. The fall in crude oil price in USD coincides with depreciation of exchange rates per 1 USD.

To the best of our knowledge, the effect of the recent fall in oil price on the foreign exchange markets of ASEAN has not been addressed in academic papers to date. New research, such as that by Kisswani (2016), Raghavan (2015), Razmi *et al.* (2015), Basnet and Upadhyaya (2015) and Vu and Nakata (2014), has used different monthly and quarterly data sets for the period before the recent oil price fall to analyse the effects of oil price fluctuations on major macroeconomic variables, partially on exchange rates, of selected ASEAN countries.

Kisswani (2016) investigated the long-term relationship between real oil prices and real exchange rates for selected ASEAN countries by utilizing quarterly data from the first quarter of 1973 to the fourth quarter of 2013. The research findings revealed a bidirectional causality between real oil prices and real exchange rates in the long term.

Raghavan (2015) used monthly data from January 2000 to December 2013 to assess the effects of oil shocks on the macroeconomic variables of ASEAN-5, including exchange rates. This study found a positive response of exchange rates to oil price shocks.

Razmi *et al.* (2015) used monthly data from 2002 to 2013 to examine the impact of oil price and monetary policy through the four known channels of the monetary transmission mechanism (interest rate, exchange rate, domestic credit and stock price) for four ASEAN countries. They found that the strong performance of the monetary transmission mechanism in Indonesia through interest rate, in Malaysia through domestic credit and the exchange rate and in the Philippines through interest rate and domestic credit reduced the impact of the oil price on variations in industrial production.

Basnet and Upadhyaya (2015) analysed the impact of oil price shocks on real output, inflation and the real exchange rate in five ASEAN countries. Their variance decomposition results stated that with a few exceptions, oil price shocks did not explain significant variations in any of the variables under consideration.

Vu and Nakata (2014) used a monthly dataset for the period January 1999 to July 2013 to analyse the effects of oil price fluctuations on the major macroeconomic variables, particularly the nominal exchange rate, of six ASEAN countries. The study showed that oil market–specific shocks explain a large percentage of the variances of the nominal exchange rate in Thailand and the Philippines, but not the nominal exchange rates in Singapore and Malaysia.

In this study, we have investigated information flow from the commodity market (i.e., the crude oil price) to ASEAN-5's foreign exchange markets (nominal exchange rates). We examined the extent to which exchange rates and their volatilities react to decreases and volatilities in the crude oil price. In particular, we estimated the coefficients of dynamic conditional correlation (DCC) between the daily logarithmic returns of WTI's price and the exchange rates of national currencies of ASEAN-5. Further, we estimated causality-in-mean and variance from the crude oil price to exchange rates using a cross-correlation function (CCF) approach for two subsets of data before and after July 1, 2014. The derived results highlight dynamic linkages and a causality relationship between the daily logarithmic returns of the crude oil price and nominal exchange rates of national currencies of ASEAN-5 before and during the recent oil price fall. The linkage between foreign exchange markets of ASEAN-5 was also examined.

Unlike existing studies, we used daily data and focused on the impact of the crude oil price only on the exchange rate. This enabled us to highlight many features of the dynamic linkage between crude oil price and exchange rates of ASEAN-5.

The next two sections describe the methodology and data used in our estimations. Section four presents the empirical findings from our estimations. The final section concludes the paper.

2. Methodology

First, we estimated the parameters of the DCC multivariate GARCH model. The conditional variances were modelled as a univariate GARCH model (Bollerslev, 1986). The conditional covariances were modelled as nonlinear functions of the conditional variances (Engle, 2002).

The mean equation of the model was

$$y_t = \omega + Cx_t + \varepsilon_t , \tag{1}$$

where y_t is a vector of the dependent variables, C is a matrix of the parameters and x_t is a vector of independent variables that may contain lags of the dependent variables, too.

The variance equation of the model was

$$\sigma^2_{i,t} = \omega_i + \sum\nolimits_{j=1}^{p_i} a_j \varepsilon^2_{i,t-j} + \sum\nolimits_{j=1}^{q_i} \beta_j \sigma^2_{i,t-j} . \tag{2}$$

We used the log-likelihood ratio for the selection of the lag order and the definition of the parameters of GARCH. We applied Wald test to check the return series for the presence of an unknown structural break. If a structural break was present, we incorporated an additional dummy variable (D) that switches from zero to one at break point into the mean and variance equations. Variances and covariances derived from Equations 1 and 2 were used in the estimation of the DCC coefficients.

Next, we applied the CCF approach developed by Cheung and Ng (1996) to examine the causality-in-mean and variance between the variables. For that, we used an exponential GARCH (EGARCH) model (Nelson, 1991) to compute the conditional mean and conditional variance. The mean equation was

$$y_t = \omega + \sum_{i=1}^{k} a_i y_{t-i} + \varepsilon_t \quad (3)$$

The variance equation was

$$\ln(\sigma_t^2) = \omega + \sum_{i=1}^{p} (\gamma_i \varepsilon_{t-i} / \sigma_{t-i} + \alpha_i (| \varepsilon_{t-i} / \sigma_{t-i} | - (2/\pi)^{1/2})) + \sum_{i=1}^{q} \beta_i \ln(\sigma_{t-i}^2) \quad (4)$$

We selected the values of k, p and q based on the log-likelihood ratio. We used Wald test to check the return series for the presence of an unknown structural break. If a structural break was present in the time series, an additional dummy variable (D) for structural break was incorporated into mean and variance equations. We used the standardized residuals and their squared values derived from EGARCH model in CCF to test the causality-in-mean and causality-in-variance. A generalized version of Cheung and Ng's (1996) chi-square test statistic (Hong, 2001) was used to test the hypothesis of no causality from lag 1 to a given lag of k in the cross-correlation coefficients.

3. Data

All estimations were based on the nominal daily crude oil price and exchange rates. The crude oil price is in units of USD per barrel. The exchange rates are defined as numbers of national currency per a unit of USD. The exchange rates were the representative exchange rates as reported by the Monetary Authority of Singapore; the Bank of Thailand; and the central banks of Indonesia, Malaysia and the Philippines. The source of the data for the WTI price was Thomson Reuters. These data are available on the website of the U.S. Energy Information Administration (EIA).

Table 1. Daily logarithmic returns, January 4, 2012 to December 29, 2016

Variables	Obs.	Mean	Std. Dev.	Skewness	Kurtosis	Jarque–Bera	ADF
IDR	1041	0.0004	0.0051	-0.0509	9.2540	1697.0***	-6.4640***
MYR	1041	0.0003	0.0056	-0.1647	5.7093	323.10***	-6.6630***
PHP	1041	0.0001	0.0029	0.2441	4.4286	98.860***	-7.4040***
SGD	1041	0.0001	0.0037	0.0512	7.9440	1061.0***	-6.4910***
THB	1041	0.0001	0.0033	-0.1630	9.2118	1678.0***	-6.0890***
WTI	1041	-0.0006	0.0246	0.0878	6.5508	548.2 0***	-5.8880***

Note: *** in the Jarque–Bera test indicates that the null hypothesis of "normal distribution" was rejected at the 1% significance level. The maximum number of lags for the ADF test selected by the Schwarz information criterion (SIC) was 21. For the ADF test, *** means smaller than the critical value at the 1% significance level.

Table 1 shows descriptive statistics of the logarithmic returns for the period of January 4, 2012, to December 29, 2016. The mean values demonstrate that the exchange rates depreciated when the crude oil price decreased. The depreciation rate of the Indonesian rupiah (IDR) and the Malaysian ringgit (MYR) was relatively higher as compared to other exchange rates. Standard deviations show that WTI had high volatility. IDR and MYR were more volatile than the other exchange rates. Skewness values showed some lack of symmetry. The distribution for the Philippine peso (PHP), the Singapore dollar (SGD) and WTI was skewed on the right, demonstrating longer tails on higher returns. For IDR, MYR and Thai baht (THB), the distribution was skewed on the left, demonstrating longer tails on lower returns. The kurtosis values are higher than a standard normal distribution. That is, data set tend to have heavy tails or outliers. The Jarque–Bera test rejects the null hypothesis of "normal distribution" at the 1% significance level. The standard Augmented Dickey–Fuller (ADF) test statistics (Dickey and Fuller, 1979, 1981) reject the null hypothesis of presence of a unit root at the 1% significance level. Data description validates the application of GARCH-type models.

Table 2. Daily logarithmic returns, January 4, 2012 to June 30, 2014

Variables	Obs.	Mean	Std. Dev.	Skewness	Kurtosis	Jarque–Bera	ADF
IDR	523	0.0005	0.0046	0.4981	15.416	3381.0***	-3.9660***
MYR	523	4.e29-05	0.0043	-0.6475	6.2985	273.60***	-5.4830***
PHP	523	9.61e-07	0.0032	0.1987	4.5888	58.450***	-5.3820***
SGD	523	-5.79e-05	0.0030	-0.1085	4.4686	48.030***	-5.9450***
THB	523	5.89e-05	0.0034	0.0992	11.445	1555.0***	-4.3220***
WTI	523	5.21e-05	0.0143	0.0858	6.3793	249.50 ***	-4.8360***

Note: *** in the Jarque–Bera test indicates that the null hypothesis of "normal distribution" was rejected at the 1% significance level. The maximum number of lags for the ADF test selected by the Schwarz information criterion (SIC) was 18. For the ADF test, *** means smaller than the critical value at the 1% significance level.

Tables 2 and 3 demonstrate descriptive statistics of the data from Table 1 for two periods—before and after July 1, 2014, which is the date that marks the beginning of the fall in the crude oil price. A comparison of the mean and standard deviation values showed a significant decrease and higher volatility of the WTI price in the second period. Exchange rates also had a higher rate of depreciation (excluding IDR) and became more volatile (excluding PHP and THB) in the second period.

Table 3. Daily logarithmic returns, July 1, 2014 to December 29, 2016

Variables	Obs.	Mean	Std. Dev.	Skewness	Kurtosis	Jarque–Bera	ADF
IDR	518	0.0002	0.0055	-0.3630	5.6458	162.50 ***	-4.9870***
MYR	518	0.0006	0.0066	-0.0957	4.6589	60.190***	-4.7430***
PHP	518	0.0002	0.0027	0.3726	3.7426	23.890***	-5.3040***
SGD	518	0.0003	0.0042	0.0441	7.8333	504.40***	-4.7720***
THB	518	0.0002	0.0030	0.2722	5.2367	114.40***	-5.0060***
WTI	518	-0.0013	0.0318	0.1256	4.4822	48.780***	-4.2580***

Note: *** in the Jarque–Bera test indicates that the null hypothesis of "normal distribution" was rejected at the 1% significance level. The maximum number of lags for the ADF test selected by the Schwarz information criterion (SIC) was 18. For the ADF test, *** means smaller than the critical value at the 1% significance level.

In the first period, MYR and SGD were skewed left, with a left tail longer than the right tail. Other variables were skewed right, with a right tail longer relative to the left tail. In the second period, IDR and MYR were skewed left and all other variables were skewed right. In both periods, the kurtosis values were higher than a standard normal distribution showing that the data set had heavy tails. The results of the Jarque–Bera and ADF tests substantiate the application of GARCH-type models for the data set in both periods.

4. Empirical findings

Table 4 presents the results of the multivariate DCC–GARCH model. The estimates for the mean equation show a negative and statistically significant relationship between WTI and the exchange rates. That means that an increase in the previous day's crude oil price logarithmic returns is associated with the present day's appreciation of exchange rates. PHP's returns are also positively and significantly affected by the previous day's returns of all other exchange rates. THB's returns are negatively and significantly affected by the previous day's returns of SGD.

Table 4. Results of the multivariate DCC–GARCH model

	IDR	MYR	PHP	SGD	THB	WTI
Mean						
IDR_{t-1}	-0.0542 (0.0338)	-0.0292 (0.0302)	0.0342** (0.0150)	-0.0317 (0.0207)	-0.0149 (0.0184)	-0.0423 (0.1187)
MYR_{t-1}	0.0350 (0.0245)	-0.0396 (0.0446)	0.0905*** (0.0179)	-0.0153 (0.0274)	-0.0030 (0.0229)	-0.0621 (0.1770)
PHP_{t-1}	-0.0286 (0.0264)	0.0581 (0.0437)	0.0620*** (0.0241)	-0.0263 (0.0306)	-0.0212 (0.0283)	0.3845** (0.1728)
SGD_{t-1}	0.0122 (0.0368)	0.0019 (0.0615)	0.2135*** (0.0301)	-0.0257 (0.0436)	-0.1184*** (0.0347)	-0.0264 (0.2643)
THB_{t-1}	0.0408 (0.0294)	0.0174 (0.0509)	0.1960*** (0.0279)	0.0012 (0.0355)	0.1234*** (0.0371)	0.0423 (0.1975)
WTI_{t-1}	-0.0196*** (0.0041)	-0.0483*** (0.0061)	-0.0055** (0.0026)	-0.0239*** (0.0043)	-0.0162*** (0.0031)	-0.0511 (0.0317)
Constant	0.0003*** (0.0001)	0.0002* (0.0001)	-9.88e-06 (0.0001)	0.0001 (0.0001)	4.9e-05 (0.0001)	0.0001 (0.0005)
Variance						
α_1	0.1902*** (0.0344)	0.1275*** (0.0263)	0.0971*** (0.0367)	0.0478*** (0.0118)	0.1068*** (0.0261)	0.0822*** (0.0230)
β_1	0.8269*** (0.0236)	0.8448*** (0.0312)	0.7781*** (0.0983)	0.9369*** (0.0140)	0.8395*** (0.0359)	0.9236*** (0.0211)
ω	2.16e-07*** (7.56e-08)	1.19e-06*** (4.00e-07)	7.56e-07* (4.25e-07)	2.51e-07*** (8.44e-08)	6.01e-07** (2.00e-07)	4.11e-06* (2.50e-06)
DCC						
λ_1	0.0139*** (0.0050)					
λ_2	0.8801** (0.0419)					
Diagnostic						
$Q_{(10)}$	16.2792 (0.0919)	17.1125 (0.0719)	16.7547 (0.0800)	9.3371 (0.5004)	13.2743 (0.2087)	9.6979 (0.4674)
$Q^2_{(10)}$	4.6984 (0.9104)	3.4301 (0.9694)	6.1772 (0.8002)	24.4779 (0.0064)	2.2336 (0.9942)	6.5517 (0.7670)

Note: The numbers in parentheses are standard errors. Q (10) is the Ljung–Box Q statistic for the null hypothesis which states that there is no autocorrelation up to order of 10 for standardized residuals. The *, ** and *** mean significance at the 10%, 5% and 1% levels.

The estimates for the variance equation show that the previous information and variances affect the conditional variances of all variables. The Ljung–Box Q statistic states that there is no autocorrelation up to orders of 10 for standardized residuals and squared standardized residuals.

DCC coefficients based on variances and covariances derived from the multivariate DCC–GARCH model estimations are depicted in Figure 2. The horizontal reference line indicates zero, and the vertical reference line indicates July 1, 2014 as the beginning of the crude oil price fall. The average values of the coefficients of DCC of the exchange rates of IDR and MYR with WTI were negative, and after July 1, 2014, their absolute values were larger compared to the period before that date. That means that oil price logarithmic returns after July 1, 2014, were associated with relatively lower exchange rate logarithmic returns of IDR and MYR. The same coefficients for other exchange rates were negative, and after July 1, 2014, their absolute values were relatively smaller. That means that oil price logarithmic returns after July 1, 2014, were associated with relatively higher exchange rate logarithmic returns of IDR and MYR. In addition, the standard deviation values of DCC coefficients for all exchange rates with WTI were higher (that means a higher volatility) for the period of the fall in crude oil price.

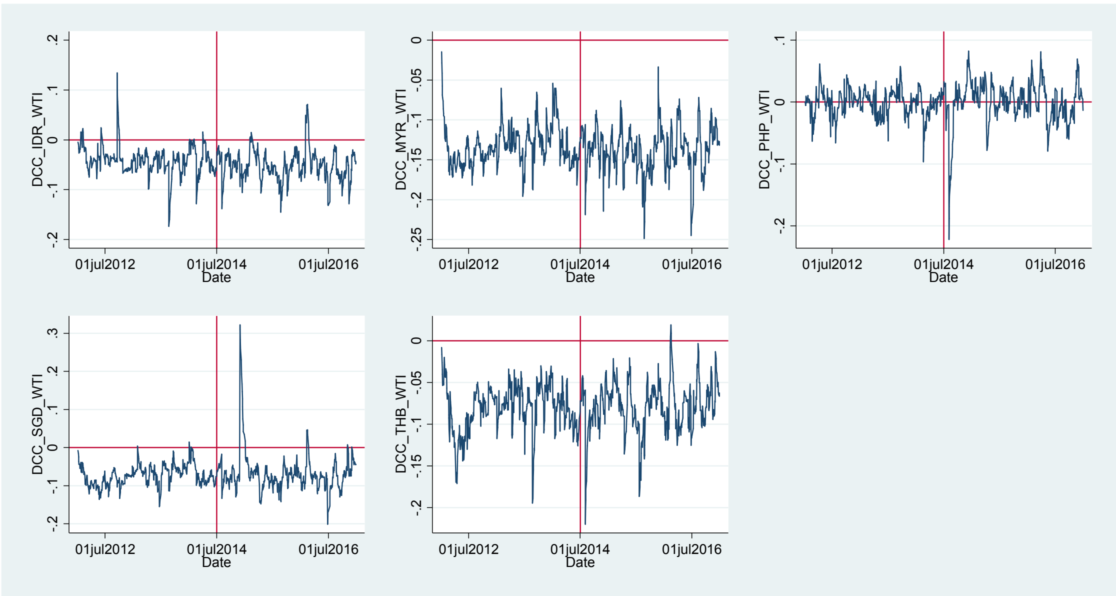

Figure 2. DCC coefficients from the DCC–GARCH model

Table 5 presents the results of the EGARCH model for the period of January 4, 2012 to June 30, 2014. The estimates for the mean equation show a significant impact of the previous day's returns on the current day's returns for IDR, PHP and THB. The estimates for the variance equation show that the conditional variances of all variables are significantly affected by their own previous information (excluding IDR) and variances. Estimations for PHP and SGD indicate that positive innovations (unanticipated exchange rate depreciations) are more destabilizing than negative innovations. It is an indication of a leverage effect. However, this asymmetric effect is substantially smaller than the symmetric effect. The Ljung–Box Q statistics do not reject the null hypothesis of no autocorrelation up to orders of 10 for standardized residuals and squared standardized residuals.

Table 5. Results of the EGARCH model, January 4, 2012 to June 30, 2014

Variable	IDR	MYR	PHP	SGD	THB	WTI
Model	G(1, 1, 1)	G(1, 1, 1)	G(1, 1, 1)	G(1, 1, 1)	G(1, 1, 1)	G(3, 1, 1)
			Mean			
a_1	-0.0921** (0.0382)	-0.0091 (0.0469)	0.1096** (0.0432)	-0.0465 (0.0449)	0.0705* (0.0409)	-0.0491 (0.0413)
a_2						-0.0136 (0.0433)
a_3						-0.0253 (0.0455)
Constant	0.0003*** (0.0001)	0.0001 (0.0002)	6.96e-05 (0.0001)	3.06e-05 (0.0001)	5.63e-06 (0.0001)	0.0004 (0.0006)
			Variance			
γ_1	0.0184 (0.0862)	0.0179 (0.2850)	0.0684** (0.0307)	0.0557** (0.0250)	0.0136 (0.0329)	-0.0353 (0.0215)
α_1	0.7849 (0.4985)	0.1356** (0.0548)	0.1574*** (0.0551)	0.1456*** (0.0472)	0.1594*** (0.0539)	0.0603* (0.0348)
β_1	0.9722*** (0.0124)	0.9704*** (0.0236)	0.9710*** (0.0216)	0.9858*** (0.0133)	0.9717*** (0.0187)	0.9888*** (0.0127)
ω	0.0886 (0.4384)	-0.3201** (0.2588)	-0.3344 (0.2506)	-0.1665*** (0.1558)	-0.3177 (0.2127)	-0.0948 (0 .1075)
lndfm2	-1.9650 (1.3442)	1.5848 (0.3484)	1.9417*** (0.4671)	2.2011*** (0.6156)	1.1308*** (0.3127)	1.4867*** (0.4620)
			Diagnostic			
$Q_{(10)}$	13.169 (0.2144)	10.075 (0.4340)	12.251 (0.2686)	10.008 (0.4398)	6.8223 (0.7421)	7.1875 (0.7076)
$Q^2_{(10)}$	3.0538 (0.9801)	5.1601 (0.8802)	11.725 (0.3039)	4.1701 (0.9393)	2.5394 (0.9903)	12.955 (0.2262)

Note: The numbers in parentheses are standard errors. Q (10) is the Ljung–Box Q statistic for the null hypothesis that states that there is no autocorrelation up to orders of 10 for standardized residuals. The *, ** and *** show the significance at the 10%, 5% and 1% levels.

Table 6 presents the results of the EGARCH model for the period of July 1, 2014, to December 29, 2016. The estimates for the mean equation show a positive and significant impact of 2-day lagged returns for PHP. The estimates for the variance equation show that the conditional variances of all variables were significantly affected by their own previous information (excluding PHP and SGD) and variances (excluding SGD). Estimations for THB indicate that positive innovations (unanticipated exchange rate depreciations) were more destabilizing than negative innovations. This asymmetric effect was substantially smaller than the symmetric effect. Estimations for SGD and WTI indicate that negative innovations were more destabilizing than positive innovations. This asymmetric effect for SGD was substantially larger than the symmetric effect. The effect for WTI was substantially smaller than the symmetric effect. Additional dummy variables (D) for presence of structural breaks included in the equations for IDR, PHP and SGD show a significant effect in the mean for IDR and in variance for PHP and SGD[3]. The Ljung–Box Q statistics do not reject the null hypothesis of no autocorrelation up to orders of 10 for standardized residuals and squared standardized residuals.

Table 6. Results of the EGARCH model, July 1, 2014 to December 29, 2016

Variable	IDR	MYR	PHP	SGD	THB	WTI
Model	G(1, 1, 1)	G(1, 1, 1)	G(2, 1, 2)	G(1, 1, 1)	G(1, 1, 1)	G(2, 1, 1)
Mean						
a_1	-0.0520 (0.0449)	0.0250 (0.0473)	0.0266 (0.0432)	-0.0588 (0.0423)	0.0490 (0.0440)	-0.0511 (0.0410)
a_2			0.0903** (0.0394)			-0.0356 (0.0458)
D	-0.0006* (0.0003)		0.0003 (0.0003)	-0.0010 (0.0003)		
Constant	0.0008*** (0.0002)	0.0007*** (0.0002)	8.74e-05 (0.0001)	0.0005 (0.0003)	0.0001 (0.0001)	-0.0020* (0.0012)
Variance						
γ_1	-0.0441 (0.0529)	-0.0326 (0.0430)	0.0095 (0.0275)	-0.2328*** (0.0821)	0.0699* (0.0405)	-0.0935*** (0.0244)
α_1	0.4251*** (0.0886)	0.3265*** (0.0792)	0.0983 (0.0647)	0.0966 (0.0965)	0.2096*** (0.0765)	0.1110*** (0.0306)
D	-0.0132 (0.0402)		0.5118* (0.2736)	0.7180** (0.3380)		
β_1	0.9043*** (0.0397)	0.9369*** (0.0358)	0.3156*** (0.0500)	0.0110 (0.2984)	0.8916*** (0.0544)	0.9957*** (0.0111)
β_2			-0.9304*** (0.0752)			
ω	-0.9627** (0.4310)	-0.6291* (0.3659)	-19.354*** (1.0332)	-11.4901*** (3.5032)	-1.2442** (0.6316)	-0.0280 (0.0780)
lndfm2	0.6210 (0.4079)	1.4203*** (0.3806)	2.2225*** (0.5048)	1.3004*** (0.3359)	1.3373*** (0.3945)	1.6865*** (0.3880)
Diagnostic						
$Q_{(10)}$	7.4395 (0.6834)	16.278 (0.0919)	8.0723 (0.6218)	9.7081 (0.4665)	14.314 (0.1591)	12.043 (0.2822)
$Q^2_{(10)}$	5.1900 (0.8781)	4.0348 (0.9458)	13.769 (0.1838)	4.2381 (0.9360)	4.2801 (0.9338)	3.5225 (0.9663)

Note: The numbers in parentheses are standard errors. Q (10) is the Ljung–Box Q statistic for the null hypothesis that states that there is no autocorrelation up to orders of 10 for standardized residuals. The *, ** and *** show the significance at the 10%, 5% and 1% levels.

Table 7 shows the estimation results for causality-in-mean and variance from the crude oil price to foreign exchange markets before and after July 1, 2014. In both periods, there was a causality-in-mean from the crude oil price to exchange rates (excluding THB before July 1, 2014) at lags 1 to 5. That means that before and after July 1, 2014, the changes in logarithmic returns of the exchange rate of all currencies (excluding THB before July 1, 2014) were significantly affected by changes in logarithmic returns of the crude oil price.

For the period of the decrease in the crude oil price (after July 1, 2014), we note a causality-in-variance from WTI to the IDR (at lag 5) and MYR (at lags 1 to 5) exchange

[3] The structural break points are October 13, 2015 for IDR, April 22, 2016 for PHP and December 2, 2014 for SGD. Dummy variables used in estimations improve estimation results (log-likelihood ratio). Explanation of the reasons for structural breaks is beyond the scope of this paper.

rates. That means the volatility of logarithmic exchange rate returns of IDR and MYR were significantly affected by the volatility of logarithmic WTI price returns after July 1, 2014.

Table 7. Causality-in-mean and variance from the oil price

	Causality in Mean					Causality in Variance				
	January 4, 2012 to June 30, 2014									
Lags	IDR	MYR	PHP	SGD	THB	IDR	MYR	PHP	SGD	THB
1	-0.114***	-0.124***	-0.134***	-0.133***	-0.039	-0.014	0.023	0.027	0.027	-0.004
2	0.086***	0.056***	-0.077***	0.065***	0.083	-0.018	-0.010	0.073	0.012	-0.003
3	0.068***	0.007***	0.091***	-0.000***	-0.030	-0.001	-0.057	0.002	-0.069	-0.019
4	0.049***	-0.017**	0.023***	0.013***	-0.015	-0.032	-0.046	-0.077	-0.073	-0.039
5	0.037***	0.003*	0.012***	-0.010**	-0.018	-0.030	-0.029	-0.061	-0.009	-0.056
	July 1, 2014 to December 29, 2016									
Lags	IDR	MYR	PHP	SGD	THB	IDR	MYR	PHP	SGD	THB
1	-0.200***	-0.312***	-0.140***	-0.155***	-0.168***	0.010	0.253***	-0.021	0.055	0.013
2	0.009***	0.043***	-0.131***	0.062***	0.045***	0.004	-0.015***	-0.060	0.001	-0.014
3	0.026***	0.058***	0.067***	0.078***	-0.009***	-0.031	-0.038***	0.001	-0.032	-0.020
4	0.137***	0.069***	-0.010***	0.064***	0.100***	0.006	-0.011***	-0.011	0.019	-0.040
5	-0.033***	-0.038***	0.053***	-0.077***	0.003***	-0.009*	0.054***	0.055	0.007	-0.023

Note: The *, ** and *** are significance at the 10%, 5% and 1% levels based on the standardized version of Cheung and Ng's (1996) chi-square test statistic proposed by Hong (2001).

An analysis of the causality relationship between the foreign exchange markets of ASEAN-5 shows that volatilities of the logarithmic exchange rate returns of PHP, SGD and THB were significantly affected by the volatility of the logarithmic exchange rate returns of IDR and MYR after July 1, 2014 (see Table 8). Based on these results, we can say that the volatility of crude oil price returns spilled over to the exchange rate returns of PHP, SGD and THB indirectly, which means through IDR and MYR.

Table 8. Causality-in-variance from IDR and MYR, July 1, 2014 to December 29, 2016

	IDR			MYR		
Lags	PHP	SGD	THB	PHP	SGD	THB
1	0.0569	-0.0078	-0.0118	0.2598***	-0.0176	0.0020
2	-0.0170	0.0240	0.0818	-0.0382***	-0.0142	-0.0340
3	-0.0293	-0.0217	-0.0449	-0.0165***	0.0185	-0.0031
4	-0.0335	0.0284	-0.0207	0.0386***	0.0264	0.0129
5	0.0216	0.0409	0.0137	0.0527***	0.0235	-0.0032*
6	0.1756***	0.0321	0.0008	-0.0523***	-0.0191*	-0.0365*

Note: The *, ** and *** are significance at the 10%, 5% and 1% levels based on the standardized version of Cheung and Ng's (1996) chi-square test statistic proposed by Hong (2001).

5. Conclusions

In this paper, we have investigated the effects of the recent oil price shock on foreign exchange markets of the five largest economies of ASEAN. In particular, we estimated DCC coefficients and the causality relationship between the daily logarithmic returns of crude oil price and exchange rates. The estimation findings demonstrated changes in DCC coefficients before and after July 1, 2014, which marked the beginning of the sharp fall in the crude oil price. Our causality analyses demonstrated a significant effect of crude oil price returns on exchange rate returns before and during the period of the crude oil price fall, as well as volatility spillover from crude oil price returns to the exchange rate returns during the period of the crude oil price fall. Our estimations showed that the volatility of crude oil price returns spilled over to the exchange rate returns of IDR and MYR directly and to the exchange rate returns of PHP, SGD and THB indirectly (which means through IDR and MYR).

Like Kisswani (2016), Raghavan (2015) and Vu and Nakata (2014), our empirical findings demonstrated a significant impact of oil price shocks on exchange rates of selected ASEAN countries, including Singapore and Malaysia[4].

Unlike existing studies of the crude oil price shock effects for ASEAN countries, we used daily data and focused on the impact of the crude oil price on only one important macroeconomic variable (i.e., the exchange rate). This enabled us to highlight many features of the dynamic relationship between crude oil price and exchange rates of ASEAN-5. Furthermore, the structural breaks in the logarithmic return series and relationship between foreign exchange markets of ASEAN-5 were considered in our estimation, which improved the derived results and made the calculation outcomes more informative.

This paper provides policymakers and investors with valuable information regarding the relationship between crude oil price and the foreign exchange markets of ASEAN-5. It contributes to academic research of the macroeconomic effects of the recent oil price shocks for ASEAN countries. Further investigation of some components, like the reasons for structural breaks in the logarithmic return series, will provide direction for future relevant research.

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