The Impact of Falling Crude Oil Price on Financial Markets of Advanced East Asian Countries

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Abstract: We analysed the response of the financial markets of advanced East Asian countries to the significant decline in crude oil price which occurred in 2014. We used daily logarithmic returns of the representative exchange rates of national currencies and stock prices from 1 January, 2013 to 31 December, 2015. The empirical findings showed a significant change in both the dynamic correlation of exchange rates and stock prices and the causality relationship between the commodity, foreign exchange and stock markets during the period of declining crude oil price and instability. This paper highlights the response of the financial markets of advanced East Asian economies to a sharp decline in and instability of crude oil price, thereby contributing to the empirical literature and providing guidance for investment portfolio management.

Keywords: Declining oil price, financial markets, East Asia, advanced economies.

1. INTRODUCTION

The increasing demand for crude oil, primarily in emerging economies, in the first decade of the new millennium caused the price of crude oil to rise to a record height. The global recession of 2008, however, decreased the demand for energy and, consequently, the price of crude oil declined for several months. Then, in 2009, the price increased again.

In 2014, crude oil price became more unstable and dropped sharply. The price for West Texas Intermediate (WTI), which is one of the most important benchmarks in oil pricing, decreased by 49.4% from 1 July, 2014 to 31 December, 2014. Since then, crude oil price, determined by expectations, increased supply and decreased demand in the world energy market, has remained very low.

The decline and instability in crude oil price considerably affected international trade and, accordingly, major oil-exporting and importing countries. Japan, South Korea and Taiwan – three advanced economies in East Asia – are resource-poor and rely heavily on energy imports. The rapid decrease in the price of crude oil could thus have a significant impact on the macroeconomic fundamentals of these countries.

The impact of crude oil price on oil-importing economies has been the focus of a growing number of studies, among them Diaz *et al*. (2016), Le and Chang (2016), Thenmozhi and Srinivasan (2016), Zhu *et al*. (2014) and Lu and Hamori (2013). These studies have also investigated the relationship between oil price and financial markets in the context of several East Asian countries. Diaz *et al*. (2016), for instance, demonstrated a negative response of G7 stock markets to an increase in oil price volatility. They indicated that global oil price volatility has a more significant impact on stock markets than national oil price volatility. Le and Chang (2016) suggested that oil price has limited implications in the long run but is more useful for forecasting fluctuations (in Japanese financial variables) in the short run. According to Thenmozhi and Srinivasan (2016), in oil-importing countries, exchange rates tend to have negative and stock indices positive relationship with oil price. They argued that oil price and stock indices in major oil-importing countries are correlated in the long and medium term, but not in the short term. Zhu *et al*. (2014) showed that the co-dependence between crude oil price and Asia-Pacific stock returns is generally weak but increases significantly in the event of crisis. Lu and Hamori (2013) demonstrated that financial markets in Japan, South Korea and Taiwan have different causality relationships: Such relationships are relatively strong in Japan's financial markets, and relatively weak in South Korea's financial markets.

Except for Lu and Hamori (2013), the aforementioned studies used data for a period longer than 10 years. Yet, because the relationship between the commodity, foreign exchange and stock markets can be incongruent in different sub-periods, we focused on a specific period wherein a significant decline in crude oil price occurred – namely, 2014 – and how financial markets responded to this downward trend.

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We used nominal daily logarithmic returns of the representative exchange rates of national currencies and stock prices from 1 January, 2013 to 31 December, 2015. This period includes 1.5 years before and 1.5 years after the date on which the price of oil started to decline. We investigated how the changes in oil price affected the dynamic conditional correlation (DCC) between exchange rates and stock price returns. Afterwards, we tested the unidirectional causality from the commodity market (crude oil price) to the financial markets (foreign exchange and stock markets). Additionally, we estimated the dynamic linkage (causality relationship) between foreign exchange and stock markets to assess how this relationship changed when the price of crude oil declined.

The paper's findings, which highlight the response of the financial markets of advanced East Asian economies to a sharp decline and instability in crude oil price, contribute to the literature assessing the impact of oil declining price and can serve as guidance for investors in portfolio management.

2. DATA DESCRIPTION

In this section, we describe data attributes for the entire period, as well as for two sub-periods before and during the oil price decline: 30 June, 2014 was marked as the beginning of crude oil price decline. The whole period comprises 711 observations from the beginning of January 2013 until the end of December 2015. The first sub-period includes 348 observations, while the second includes 363 observations. Weekends and holidays were excluded. The disparity in the number of observations is mainly related to different national holidays in the selected countries.

The monetary authorities of each country were the source of the data on nominal daily representative exchange rates. Stock price indices were derived from Google Finance. The data on crude oil price (WTI) were derived from Thomson Reuters statistics, available via Independent Statistics and Analysis of the US Energy Information Administration.

Table **1** demonstrates the statistics for the daily logarithmic returns of the variables for the whole period. The mean values show a decreasing trend for crude oil price (WTI) and an increasing trend for exchange rates and stock prices (excluding North Korea's stock [KOSPI] price). As the logarithmic returns of exchange rates are derived from nominal exchange rates as numbers of national currency per unit of USD, the increasing trend of exchange rates corresponds to their depreciation. Standard deviation values show comparatively higher volatility for crude oil price and Japanese stock (NIKKEI) price indices.

The skewness values show longer tails on lower returns for WTI, NIKKEI and Taiwan's stock price (TAIEX), and longer tails on higher returns for other variables. The kurtosis values are all higher than a standard normal distribution. 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 the presence of a unit root for all variables.

Tables **2** and **3** present descriptive statistics of the data for two sub-periods – before and after 30 June, 2014, which marked the start of the decline in crude oil price. Mean values show that KRW (the national currency of North Korea) and KOSPI exhibited a decreasing trend, and all other variables an increasing trend, in the first period. WTI, KOSPI and TAIEX demonstrated a decreasing trend in the second period. All other variables showed an increasing trend in the

Table 1: Daily Logarithmic Returns of Oil Price, Nominal Exchange Rates and Stock Prices; Full Period

Variables	Obs.	Mean	Std. Dev.	Skewness	Kurtosis	Jarque–Bera	ADF
WTI	711	-0.00126	0.02101	-0.12719	6.72856	413.8***	-4.950***
JPY	701	0.00047	0.00624	0.08171	5.62169	201.5***	-6.104***
KRW	703	0.00011	0.00451	0.19866	3.48516	11.52***	-5.517***
TWD	711	0.00017	0.00263	0.71542	10.9925	1953***	-5.784***
NIKKEI	701	0.00086	0.01487	-0.35866	5.70022	228.0***	-6.127***
KOSPI	703	-0.00003	0.00757	0.06564	3.98676	29.03***	-6.109***
TAIEX	711	0.00011	0.00823	-0.44782	6.05734	300.7***	-5.685***

Note: The maximum number of lags for the augmented Dickey–Fuller (ADF) test selected by the Schwarz information criterion (SIC) was 19.

Table 2: Daily Logarithmic Returns of Oil Price, Nominal Exchange Rates and Stock Prices; before 30 June, 2014

Variables	Obs.	Mean	Std. Dev.	Skewness	Kurtosis	Jarque–Bera	ADF
WTI	348	0.00046	0.01125	-0.22896	3.62023	8.618**	-4.953***
JPY	348	0.00047	0.00709	0.03543	5.13466	66.15***	-5.629***
KRW	347	-0.00015	0.00391	0.37676	3.67363	14.77***	-4.277***
TWD	348	0.00009	0.00183	1.27432	10.4254	893.7***	-4.594***
NIKKEI	348	0.00107	0.01637	-0.55995	4.85672	68.17***	-4.863***
KOSPI	347	-0.00001	0.00760	0.05159	3.81798	9.828***	-5.424***
TAIEX	348	0.00054	0.00693	-0.29430	3.72877	12.72***	-4.747***

Note: The maximum number of lags for the augmented Dickey–Fuller (ADF) test selected by the Schwarz information criterion (SIC) was 16.

Table 3: Daily Logarithmic Returns of Oil Price, Nominal Exchange Rates and Stock Prices; after 30 June, 2014

Variables	Obs.	Mean	Std. Dev.	Skewness	Kurtosis	Jarque–Bera	ADF
WTI	363	-0.00290	0.02718	0.05106	4.60462	39.10***	-3.434**
JPY	353	0.00049	0.00529	0.18964	5.39778	86.68***	-4.131***
KRW	356	0.00039	0.00503	0.04902	3.17975	0.622	-4.313***
TWD	363	0.00026	0.00321	0.48993	8.59058	487.2***	-4.093***
NIKKEI	353	0.00066	0.01325	0.00671	6.92349	226.4***	-4.373***
KOSPI	356	-0.00004	0.00755	0.07951	4.15487	20.16***	-4.098***
TAIEX	363	-0.00030	0.00929	-0.43307	6.12436	159.0***	-4.738***

Note: The maximum number of lags for the augmented Dickey–Fuller (ADF) test selected by the Schwarz information criterion (SIC) was 16.

second period. Standard deviation values show that WTI, KRW, TWD (the national currency of Taiwan) and TAIEX were more volatile in the second period. Other variables were less volatile in the second period as compared with the first period.

In the first period, WTI, NIKKEI and TAIEX are skewed left and show longer tails on lower returns. All other variables are skewed right and show longer tails on higher returns. In the second period, only TAIEX is skewed left and has longer tails on lower returns. All other variables are skewed right and have longer tails on higher returns. The Jarque–Bera test rejects the null hypothesis of 'normal distribution' at the 1% to 5% significance level for all variables in both periods (excluding KRW in the second period). The standard ADF test statistics reject the null hypothesis of the presence of a unit root for all variables (at the 1% to 5% significance levels) in both periods.

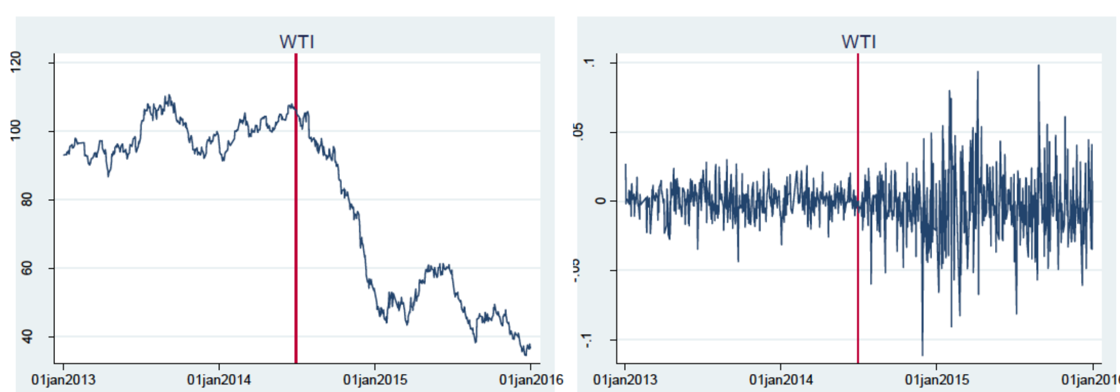

Figure 1: Daily levels of oil price and their logarithmic returns.

Note: The price is given in units of USD. The vertical reference line marks 30 June, 2014: the start of the decline in oil price.

Figure 2: Daily nominal exchange rates and their logarithmic returns.

Note: Exchange rates are in numbers of national currency per unit of USD. The vertical reference line marks 30 June, 2014: the start of the decline in oil price.

Figure **1** illustrates daily spot price levels and logarithmic returns for crude oil. The prices are in units of USD. The vertical reference line marks 30 June, 2014. Crude oil price was increasing and comparatively stable before 30 June, 2014, but then decreased and became very unstable after 30 June, 2014.

Figure **2** illustrates daily nominal representative exchange rates and logarithmic returns of JPY (the national currency of Japan), KRW and TWD per unit of USD. The vertical reference line marks 30 June, 2014. JPY and TWD exhibited an increasing trend, and KRW a decreasing trend, before 30 June, 2014. After 30 June, 2014, all rates demonstrated an increasing trend. The returns were volatile for the whole period, but KRW and TWD became more unstable after 30 June, 2014.

Figure **3** illustrates daily stock prices and their logarithmic returns for the whole period. The vertical reference line marks 30 June, 2014. The Japanese stock price showed an increasing trend for the whole period, while KOSPI exhibited a variable trend (the trend sometimes increased and sometimes decreased). TAIEX demonstrated an increasing trend before 30 June, 2014, and a variable trend thereafter. The returns of all stocks were volatile for the whole period.

3. METHODOLOGY

We used the daily representative nominal exchange rates of JPY, KRW and TWD, the closing price indices of NIKKEI, KOSPI and TAIEX, and the price of WTI to

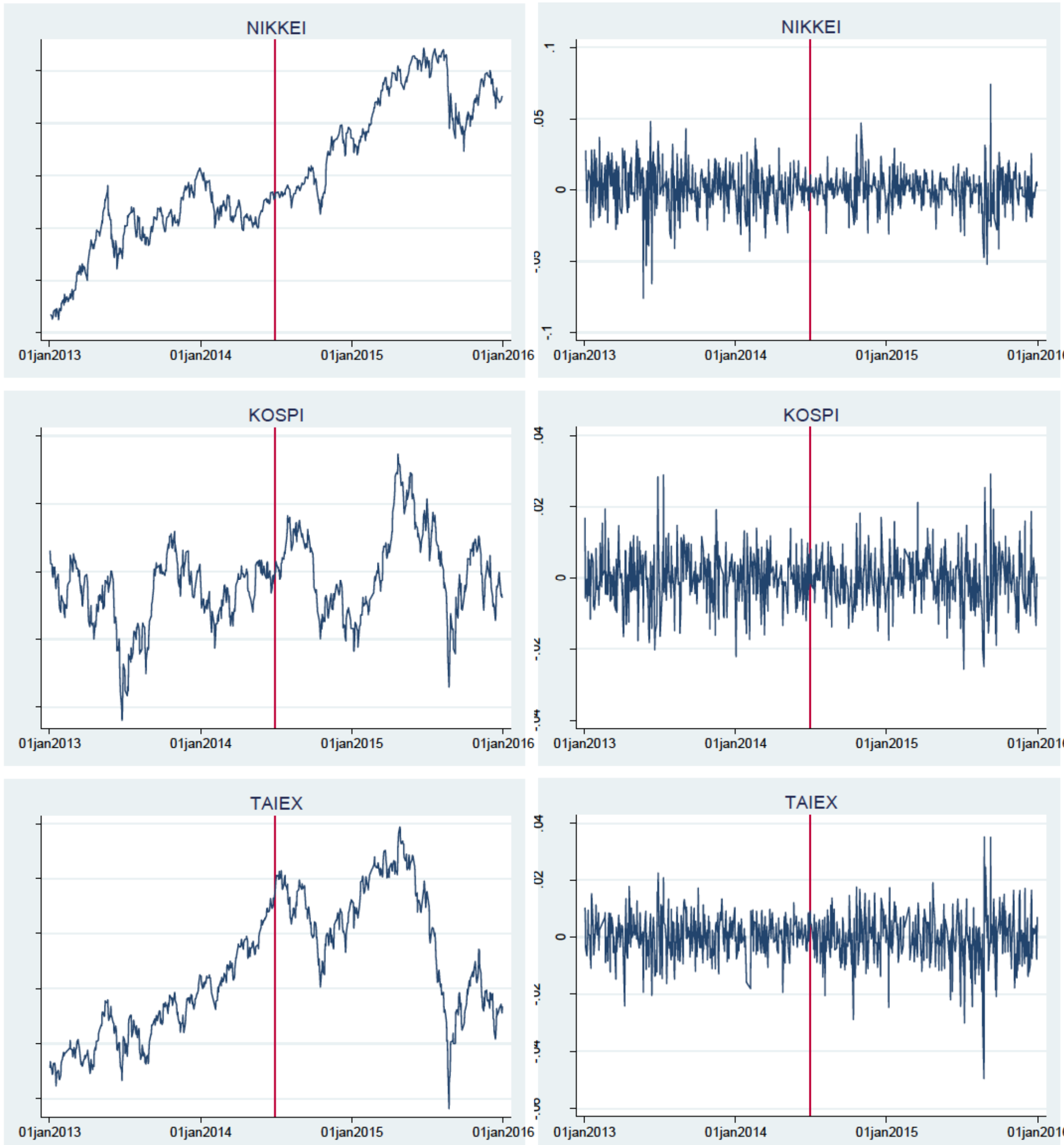

Figure 3: Daily stock prices and their logarithmic returns.

Note: The vertical reference line marks 30 June, 2014: the start of the decline in oil price.

calculate daily logarithmic return series. The returns were calculated using Equation 1.

$$R_t = \ln(x_t) - \ln(x_{t-1}) \quad (1)$$

R stands for daily logarithmic return; *x* represents the daily representative nominal exchange rate, the closing price index of stock or the price of crude oil; *t* denotes time (day). The use of returns enabled us to evaluate the relationships between the variables with the series of unequal values. The Wald test for a structural break at an unknown break date was conducted to test the returns for the presence of a structural break. For the break, we considered the impact of the structural change in time series and incorporated dummy variables in the equations of the models, which will be described below.

To assess the changes in dynamic conditional correlation between exchange rates and stock prices (when the oil price significantly fell), we estimated the parameters of DCC bivariate generalised autoregressive conditional heteroscedasticity (GARCH) models. The conditional variances were modelled as a univariate GARCH model (Bollerslev, 1986). The conditional co-variances were modelled as nonlinear functions of the conditional variances (Engle, 2002). The conditional mean equation of the model was

$$y_t = c + Mx_t + \varepsilon_t \quad (2)$$

where y_t is a vector of dependent variables, *M* stands for a matrix of parameters, x_t indicates a vector of independent variables, and ε_t denotes the error terms (or innovations) with respect to a mean process.

The conditional variance equation of the model was

$$\sigma_{i,t}^2 = \omega + \sum_{j=1}^{pi} a_j \varepsilon_{i,t-j}^2 + \sum_{j=1}^{qi} \beta_j \sigma_{i,t-j}^2 \quad (3)$$

The conditional variance is a function of the size of prior unanticipated innovations ($\varepsilon^2{}_t$) and the conditional variance (σ_i^2). The coefficients α_j and β_j are the ARCH and GARCH parameters ($\omega > 0$, $\alpha_j \geq 0$ and $\beta_j \geq 0$). For the time series with structural breaks, an additional dummy (*D*) with a value of 0 before the structural change date and a value of 1 thereafter was incorporated into the conditional variance equation. According to Engle (1982), the error term followed a Gaussian or normal distribution. However, the distribution of daily exchange rates and stock returns is frequently leptokurtic (a distribution with positive excess kurtosis), which allows us to assume that the errors follow the Student's *t* distribution or the generalised error distribution. Log-likelihood ratios and information criteria (Akaike information criterion – AIC; and Bayesian information criterion – BIC) were used to define the parameters (lags of dependent variables, *p*, *q*). The Ljung–Box Q test on standardised residuals and their squared values was used to diagnose the appropriateness of the equations and derived results. Variances and co-variances derived from Equations 2 and 3 were used in the estimation of the DCC coefficients.

In the next step, we applied a CCF approach developed by Cheung and Ng (1996) to examine dynamic linkage (the causality-in-mean and variance) between the logarithmic return series before and during the oil price decline period. We used an autoregressive (AR) model and an exponential GARCH (EGARCH) model (Nelson, 1991) to compute the conditional mean and conditional variance. The mean equation is

$$y_t = c + \sum_{j=1}^{k} a_j y_{t-j} + \varepsilon_t \quad (4)$$

and the variance equation is

$$\ln(\sigma_t^2) = \omega + \sum_{j=1}^{p} (\gamma_j \varepsilon_{t-j} / \sigma_{t-j} + \alpha_j (| \varepsilon_{t-j} / \sigma_{t-j} | - (2/\pi)^{1/2})) + \sum_{j=1}^{q} \beta_j \ln(\sigma_{t-j}^2) \quad (5)$$

where γ_j is the asymmetric response or leverage parameter. We used the standardised residuals and the squared standardised residuals from Equations 4 and 5 in cross-correlation function (CCF) to test the causality relationship. Cheung and Ng's (1996) chi-square test statistic was used to test the hypothesis of no causality from lag 1 to lag 10 in the cross-correlation coefficients. We used a generalised version of the test suggested by Hong (2001).

The generalised version of the test proposed by Hong (2001) is

$$Q = (S-k)/(2k)^{1/2} \quad (6)$$

where *k* is the number of lags used in estimation, and *S* is Cheung and Ng's (1996) chi-square test statistic coefficient, defined as

$$S = T \sum_{i=j}^{k} \hat{r}_{uv}(i)^2 \quad (7)$$

T is the sample size, and $\hat{r}_{uv}(i)$ is the sample cross-correlation coefficient at lag *i* for the standardised residuals (*u* and *v*) while estimating causality-in-mean, and for the squared standardised residuals while estimating causality-in-variance. The sample cross-correlation coefficient at lag *i* for the standardised residuals was estimated as

$$\hat{r}_{uv}(i) = c_{uv}(i)(c_{uu}(0)c_{vv}(0))^{1/2} \quad (8)$$

where $c_{uv}(i)$ is the *i*-th lag sample cross-covariance and $c_{uu}(0)$ and $c_{vv}(0)$ are the sample variances of *u* and *v*. Here, *u* and *v* are the standardised residuals derived from Equations 4 and 5 for a pair of variables explained in the data description section.

4. EMPIRICAL FINDINGS

To assess the changes in dynamic conditional correlation between the foreign exchange and stock markets, we used the logarithmic return series of the variable for the whole period and estimated the parameters of the bivariate DCC–GARCH model. The obtained results are presented in Tables **4** and **5**. The parameters of the model were determined based on the likelihood-ratios and information criteria (AIC and BIC). The coefficients of the mean equation showed a significant impact of the previous-day returns of JPY on the present-day returns of JPY, a significant impact of the previous-day returns of NIKKEI on the present-day returns of JPY and NIKKEI, and a significant impact of the previous-day returns of KOSPI on the present-day returns of KRW.

The coefficients for the variance equation showed a significant impact of previous-day information and

Table 4: Results of the Bivariate DCC–GARCH Model; the whole Period

JPY and NIKKEI		
	JPY	**NIKKEI**
Mean		
JPY L1	-0.1232*** (0.0424)	0.0634 (0.0964)
NIKKEI L1	0.0695*** (0.0143)	-0.0818* (0.0412)
Constant	0.0004** (0.0002)	0.0012*** (0.0004)
Variance		
α_1	0.0561*** (0.0139)	0.1110*** (0.0271)
β_1	0.9330*** (0.0143)	0.8635*** (0.0300)
ω	3.60e-07* (1.96e-07)	6.75e-06** (2.91e-06)
DCC		
λ_1	0.0471 (0.0338)	
λ_2	0.8188*** (0.1023)	
Diagnostic		
$Q_{(10)}$	8.3464 (0.5950)	6.4003 (0.7806)
$Q^2_{(10)}$	5.9163 (0.8222)	2.3752 (0.9926)

Note: The numbers in parentheses are standard errors.

Table 5: Results of the Bivariate DCC–GARCH Model; the whole Period

	KRW and KOSPI		**TWD and TAIEX**	
	KRW	**KOSPI**	**TWD**	**TAIEX**
Mean				
KRW L1	0.0636 (0.0405)	-0.0193 (0.0663)		
KRW L2	-0.0298 (0.0369)	0.0919 (0.0639)		
KRW L3	-0.0046 (0.0392)	0.0252 (0.0656)		
KRW L4	-0.0151 (0.0332)	-0.0905 (0.0696)		
KOSPI L1	-0.1756*** (0.0223)	0.0328 (0.0371)		
KOSPI L2	-0.0060 (0.0228)	0.0187 (0.0395)		
KOSPI L3	-0.0633*** (0.0219)	-0.0098 (0.0403)		
KOSPI L4	-0.0196 (0.0205)	-0.0206 (0.0427)		
TWD L1			-0.0216 (0.0462)	-0.1414 (0.1389)
TAIEX L1			-0.0038 (0.0061)	0.0076 (0.0360)
TWD D			2.04e-05 (0.0002)	
Constant	-8.67e-06 (0.0001)	7.48e-05 (0.0003)	6.63e-05* (3.98-05)	0.0004 (0.0003)
Variance				
α_1	0.0467*** (0.0142)	0.0508** (0.0210)	0.4429*** (0.1396)	0.0590 (0.0466)
β_1	0.9457*** (0.0147)	0.8777*** (0.0483)	0.6479*** (0.0783)	0.9163*** (0.0755)
ω	1.70e-07 (1.35e-07)	3.96e-06 (2.10e-06)	1.96e-07* (1.09e-07)	2.84e-06 (3.49e-06)
DCC				
λ_1	0.0055** (0.0028)		0.0293 (0.0183)	
λ_2	0.9941*** (0.0027)		0.9348*** (0.0451)	
Diagnostic				
$Q_{(10)}$	5.2535 (0.8736)	3.7652 (0.9573)	11.3844 (0.3284)	12.3725 (0.2609)
$Q^2_{(10)}$	12.7183 (0.2399)	7.3237 (0.6946)	8.2158 (0.6078)	7.5450 (0.6732)

Note: The numbers in parentheses are standard errors.

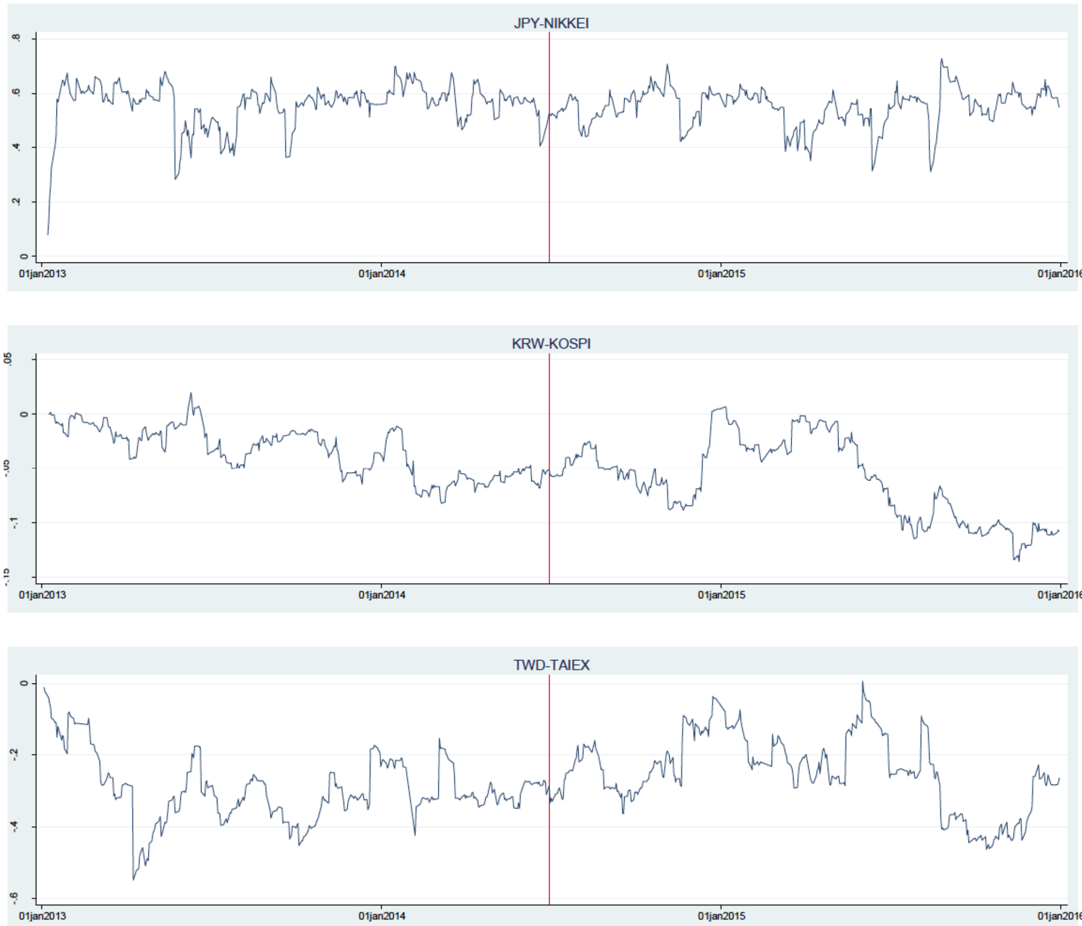

Figure 4: DCC coefficients from the DCC–GARCH model.

Note: The vertical reference line marks 30 June, 2014: the start of the decline in oil price.

volatility on present-day variation (excluding the impact of previous-period information for TAIEX, which was statistically insignificant). The white noise Q test for autocorrelation failed to reject the null hypothesis that there is no serial correlation up to an order of 10 for standardised residuals and their squared values.

We used variances and co-variances from estimations in Tables **4** and **5** in the calculation of the coefficients of the DCC. The coefficients are depicted in Figure **4**. We observed a significant change in DCC coefficients after 30 June, 2014. The average value of DCC coefficients was 0.560 for Japan, -0.034 for South Korea and -0.298 for Taiwan before 30 June, 2014. After 30 June, 2014, the average value of DCC coefficients was 0.547 for Japan, -0.062 for South Korea and -0.245 for Taiwan. The standard deviation value of DCC coefficients was 0.083 for Japan, 0.023 for South Korea and 0.091 for Taiwan before 30 June, 2014. After 30 June, 2014, the standard deviation value of DCC coefficients was 0.069 for Japan, 0.036 for South Korea and 0.103 for Taiwan.

Table **6** presents the estimation results for the AR-EGARCH model for the period before 30 June, 2014. Parameters of each equation were selected based on the likelihood-ratios and information criteria (AIC and BIC). The mean of KRW was significantly affected by its previous returns. The variance of JPY, TWD and NIKKEI was significantly affected by the previous-period information. The variance of KRW, TWD, NIKKEI, KOSPI and TAEX was significantly affected by their previous volatilities. For KRW, KOSPI and TAIEX, the impact of news on conditional variance was asymmetric. The white noise Q test for autocorrelation failed to reject the null hypothesis that there is no serial correlation up to an order of 10 for standardised residuals and their squared values.

Table **7** presents the estimation results for the AR–EGARCH model for the period after 30 June, 2014. Parameters of each equation were selected based on the likelihood-ratios and information criteria (AIC and BIC). The mean of TWD and TAIEX was significantly affected by their previous returns. The variance of JPY,

Table 6: Results of the AR-EGARCH Model; before 30 June, 2014

Variable	WTI	JPY	NIKKEI	WTI	KRW	KOSPI	WTI	TWD	TAIEX
Model	G(1, 1, 1)	G(1, 1, 1)	G(1, 1, 1)	G(1, 1, 1)	G(1, 1, 1)	G(1, 1, 1)	G(1, 1, 1)	G(3, 1, 1)	G(4, 1, 1)
a_1	0.0162 (0.0581)	-0.0412 (0.0347)	-0.0805 (0.0541)	0.0504 (0.0640)	0.1187* (0.0674)	-0.0175 (0.0600)	0.0159 (0.0500)	-1.04e-09 (5.22e-08)	-0.0076 (0.0778)
a_2								-2.34e-09 (5.87e-08)	-0.0769 (0.0643)
a_3								3.05e-11 (6.90e-08)	-0.0976 (0.0609)
a_4									0.0191 (0.0615)
Constant	0.0006 (0.0006)	0.0002 (00003)	0.0012*** (0.0002)	0.0005 (0.0006)	-0.0002 (0.0002)	3.16e-06 (0.0004)	0.0006 (0.0006)	-1.46e-12 (6.10e-11)	0.0007 (0.0005)
γ_1	-0.1694* (0.1013)	-0.0124 (0.0777)	-0.0885 (0.1378)	-0.0919 (0.0820)	0.1653*** (0.0551)	-0.1341*** (0.0341)	0.0712 (0.0997)	-0.1160 (0.0902)	-0.1197** (0.0553)
α_1	0.1670 (0.1222)	0.3515*** (0.1209)	0.1398** (0.0608)	0.0231 (0.1163)	0.1443 (0.1328)	-0.0045 (0.0393)	0.1236 (0.1476)	0.6596*** (0.1831)	0.0016 (0.0352)
β_1	0.1760 (0.1544)	-0.3156 (0.3307)	0.9120*** (0.1392)	0.1330 (0.2928)	-0.5275** (0.2139)	0.9391*** (0.0303)	-0.2121 (0.2943)	0.7659*** (0.0944)	0.9780*** (0.0249)
ω	-7.3607*** (1.3632)	-13.058*** (3.2638)	-0.7261 (1.1577)	-7.8439*** (2.6406)	-17.010*** (2.3516)	-0.6011** (0.2983)	-10.900*** (2.6586)	-2.9076** (1.1816)	-0.2274 (0.2460)
GED parameter	0.4060*** (0.1335)	0.1845* (0.1068)	0.3169** (0.1466)	0.5102*** (0.1319)	0.4117*** (0.1247)	0.4706*** (0.1187)	0.4036*** (0.1180)	-0.1880 (0.1355)	0.3550** (0.1678)
$Q_{(5)}$	3.7788 (0.5817)	6.0081 (0.3054)	0.8368 (0.9746)	3.9593 (0.5553)	0.3082 (0.9975)	1.5128 (0.9116)	0.6805 (0.9840)	7.6470 (0.1768)	5.1647 (0.3961)
$Q^2_{(5)}$	1.3600 (0.9286)	5.7717 (0.3291)	3.5790 (0.6115)	1.4096 (0.9233)	7.5248 (0.1844)	9.2488 (0.0995)	3.0892 (0.6862)	2.0305 (0.8449)	3.6082 (0.6071)

Note: The numbers in parentheses are standard errors.

TWD and NIKKEI was significantly affected by the previous-period information. The variance of JPY, KRW, TWD, NIKKEI, KOSPI and TAIEX was significantly affected by the previous period's volatility. For KRW, NIKKEI, KOSPI and TAIEX, the impact of news on conditional variance was asymmetric. The white noise Q test for autocorrelation failed to reject the null hypothesis that there is no serial correlation up to an order of 10 for standardised residuals and their squared values.

Table **8** presents causality relationships between the variables. The estimations were made for 10 lags. The weekends were excluded and thus 10 days was equivalent to two weeks in our estimation. First, we explained one-way causality from the commodity market to the stock and foreign exchange markets. Before 30 June, 2014, causality-in-mean was observed from the commodity market to the stock and foreign exchange markets of all three countries. When the oil price fell and became unstable (after 30 June, 2014), causality-in-mean was observed from the commodity market to the stock and foreign exchange markets of South Korea and Taiwan only. Before 30 June, 2014, causality-in-variance was observed from the commodity market to the stock markets of South Korea and Taiwan. When the oil price fell and became unstable (after 30 June, 2014), causality-in-variance was observed from the commodity market to the stock markets of Japan and Taiwan. Before 30 June, 2014, causality-in-variance was observed from the commodity market to the foreign exchange markets of Japan and South Korea. When the oil price fell and became unstable (after 30 June, 2014), weak causality-in-variance was observed from the commodity market to the foreign exchange markets of South Korea and Taiwan. Oil price instability (after 30 June, 2014) increased uncertainty in Japan's stock market and Taiwan's foreign exchange market.

Here, we explain two-way causality-in-mean and variance between the stock and foreign exchange

Table 7: Results of the AR-EGARCH Model; after Decline in Oil Price

Variable	WTI	JPY	NIKKEI	WTI	KRW	KOSPI	WTI	TWD	TAIEX
Model	G(3, 1, 1)	G(1, 1, 1)	G(1, 1, 1)	G(2, 1, 1)	G(3, 1, 1)	G(1, 1, 1)	G(2, 1, 1)	G(2, 1, 1)	G(1, 1, 1)
a_1	-0.1288** (0.0512)	-0.0360 (0.0714)	-0.0181 (0.0675)	-0.1241** (0.0544)	0.0424 (0.0528)	0.0477 (0.0434)	-0.1687 (1.1027)	0.0604*** (0.0036)	0.0746** (0.0374)
a_2	0.0447 (0.0513)			0.0295 (0.0532)	0.0343 (0.0636)		0.0672 (0.0831)	0.0302*** (0.0014)	
a_3	-0.0277 (0.0567)				0.0110 (0.0519)				
Constant	-0.0046*** (0.0013)	0.0004 (0.0003)	0.0009 (0.0005)	-0.0049*** (0.0014)	0.0005* (0.0003)	-0.0001 (0.0004)	-0.0049 (0.0039)	-1.32e-11 (4.67e-09)	-0.0004 (0.0004)
γ_1	-0.0795*** (0.0187)	0.0175 (0.0566)	-0.2057*** (0.0521)	-0.0851*** (0.0191)	0.0561** (0.0224)	-0.1002*** (0.0321)	0.0114 (0.1008)	-0.1122 (0.0819)	-0.1196*** (0.0327)
α_1	0.0439** (0.0219)	0.2805* (0.1534)	0.2626*** (0.0861)	0.0503** (0.0234)	0.0236 (0.0786)	0.0592 (0.0427)	0.1286 (0.1941)	0.8030*** (0.2368)	0.0023 (0.0282)
β_1	1.0017*** (0.0058)	0.9104*** (0.0898)	0.9200*** (0.0406)	1.0015*** (0.0051)	1.0099*** (0.0459)	0.9496*** (0.0242)	-0.8336 (0.6729)	0.8664*** (0.0921)	0.9747*** (0.0117)
ω	0.0176 (0.0414)	-0.9342 (0.9418)	-0.7114* (0.3647)	0.0172 (0.0370)	0.1059 (0.4854)	-0.4927** (0.2383)	-13.290*** (4.8560)	-1.4670 (1.0615)	-0.2394** (0.1097)
GED parameter	0.3197*** (0.1122)	0.2778** (0.1155)	0.3092*** (0.1043)	0.3733*** (0.1251)	0.7264 (0.1273)	0.3819*** (0.1220)	0.1842 (0.1823)	-0.1666* (0.0999)	0.3646*** (0.1271)
$Q_{(5)}$	0.5037 (0.9920)	3.9021 (0.5636)	2.3970 (0.7919)	0.7430 (0.9805)	1.0023 (0.9624)	0.9638 (0.9654)	2.0711 (0.8392)	2.1292 (0.8310)	8.0216 (0.1551)
$Q^2_{(5)}$	2.1703 (0.8251)	3.1447 (0.6777)	1.9355 (0.8580)	2.0451 (0.8429)	2.4485 (0.7842)	3.8162 (0.5762)	6.2435 (0.2832)	3.8922 (0.5650)	3.0633 (0.6902)

Note: The numbers in parentheses are standard errors.

Table 8: Causality-in-Mean and Variance

Japan					
		WTI to NIKKEI	**WTI to JPY**	**JPY to NIKKEI**	**NIKKEI to JPY**
Causality-in-mean	Before June 30, 2014	5.543***	-1.415*	-1.166	6.501***
	After June 30, 2014	-1.086	-0.787	0.332	7.443***
Causality-in-variance	Before June 30, 2014	-1.184	1.969**	-1.445*	3.119***
	After June 30, 2014	2.440***	-1.105	2.965***	17.068***
South Korea					
		WTI to KOSPI	**WTI to KRW**	**KRW to KOSPI**	**KOSPI to KRW**
Causality-in-mean	Before June 30, 2014	8.539***	1.692**	-0.928	31.425***
	After June 30, 2014	5.424***	6.264***	-0.622	17.568***
Causality-in-variance	Before June 30, 2014	2.758***	6.857***	-0.694	19.982***
	After June 30, 2014	-1.099	-1.562*	1.038	-1.242
Taiwan					
		WTI to TAIEX	**WTI to TWD**	**TWD to TAIEX**	**TAIEX to TWD**
Causality-in-mean	Before June 30, 2014	10.081***	1.725**	-1.047	-1.510*
	After June 30, 2014	4.491***	4.876***	1.894**	1.069
Causality-in-variance	Before June 30, 2014	3.372***	-0.767	-1.244	-0.461
	After June 30, 2014	1.660**	-1.380*	1.149	-0.898

Note: A generalised version of Cheung and Ng's (1996) chi-square test statistic suggested by Hong (2001) is presented. Asymptotic critical values are 1.282 at the 10% level, 1.645 at the 5% level and 2.326 at the 1% level.

markets in every country. Before 30 June, 2014, causality-in-mean was not observed from the foreign exchange market to the stock market in all countries. When the oil price fell and became unstable (after 30 June, 2014), causality-in-mean was observed from the foreign exchange market to the stock market only in Taiwan. Before and after 30 June, 2014, causality-in-variance was observed from the foreign exchange market to the stock market only in Japan. The effect (in the case of Japan) was stronger after 30 June, 2014. Before 30 June, 2014, causality-in-mean was observed from the stock market to the foreign exchange market in all three countries. When the oil price fell and became unstable (after 30 June, 2014), causality-in-mean was observed from the stock market to the foreign exchange market only in Japan and South Korea. Before 30 June, 2014, causality-in-variance was observed from the stock market to the foreign exchange market in Japan and South Korea. When the oil price fell and became unstable (after 30 June, 2014), causality-in-variance was observed from the stock market to the foreign exchange market only in Japan. Oil price instability (after 30 June, 2014) increased volatility transition between the stock and foreign exchange markets in Japan considerably.

5. CONCLUDING REMARKS

In this paper, we analysed the response of the financial markets (foreign exchange and stock markets) of Japan, South Korea and Taiwan to a significant decline and increased instability in crude oil price, which began in mid-2014. Observations from the data showed that before 30 June, 2014, the price of crude oil was increasing and relatively stable. After 30 June, 2014, the price of oil mostly declined and became very unstable. The empirical findings showed a significant change in both the dynamic correlation of exchange rates and stock prices and the causality relationship between the commodity, foreign exchange and stock markets during the period of continued crude oil price decline and instability.

The paper's findings, which highlight the impact of oil price decline on the financial markets of advanced East Asian economies, contribute to the literature by assessing the impact of recent oil price decline on foreign exchange and stock markets. The findings will have vital importance for investment portfolio management in the context of East Asian financial markets.

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