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RESEARCH PAPER

Dependence among Energy and Asian Emerging Stocks: A Dynamic Conditional Correlation Approach

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PAPER INFO	ABSTRACT
Corresponding Author: z_iqbalch@yahoo.com	This paper is an endeavor to investigate the contagion effect between energy market and Asian Emerging Equity Markets (AEEMs) during the Eurozone debt crisis. Multivariate GARCH-DCC model is applied on data series from 30-01-2005 to 31-01-2012. The results affirm a significant increase in dependence between energy market and equity markets at the time of Eurozone crisis as compared to pre-crisis time, therefore supporting the presence of contagion in the sense of Forbes and Rigobon's (2002). The study implies that investors should include other commodities as well in order to hedge the equity portfolio risk at the time of crisis.

Introduction

The 2018 began with a trend of increase in the prices of crude oil. After November 2014, the prices of crude oil experienced an increase and went beyond $80 per barrel (IEEJ May, 2018). The vigorous demand and supply side factors are believed to be the reasons behind the severe rise in the prices of crude oil. The global demand for crude oil has posted a strong yearly increase of 1.4 to 1.5 million barrels per day. This robust and ever increasing demand in crude oil, its vast use in the processes of production and its being part of production of final consumption goods has caught the eyes of many investors. The expanding significance of crude oil in the economy has become the reason why the economists, investors and policy makers have paid huge importance in studying the patterns of correlations between energy and stock markets.

Extant literature provides the strong evidence that linkages between crude oil and equity market is negative. Odusami (2009), by employing asymmetric GARCH-jump model, studied the relationship between US stock market and crude oil. The study found that linkages between crude oil and equity market are negative. Asteriou and Bashmakova, (2013) examined the developing markets of eastern and central European countries to explore the link between crude oil and stock market return by applying a multifactor model. The study explored that stock market behave negatively regardless of the upward or downward movement of oil prices. Moreover, the incorporation of crude oil futures in their portfolio, by investors, is because of the low and negative correlation of crude oil with stock prices (Geman&Kharoubi, 2008). However, the question is whether this pattern of movement between these two markets will sustain during recent Eurozone debt crises?

In finance literature numerous studies focused on investigating the nature of linkage between equity market and energy market. In some studies, this relationship is explored in the context of developed economies. The focus of some other studies has been on the emerging markets to investigate the nature of linkages between equity and energy market (Basher &Sadorsky, 2006; Asteriou&Bashmakova, 2013; Ajmi et al. 2014). Besides, less attention has been paid to explore the contagion effect between equity market and energy market. Investigations of (Buyuksahin and Robe, 2010; Tang and Xiong 2010, Lautier and Raynaud, 2011) examined the evolution of correlation between equity marketand energy market after GFC. Although, these investigations have not studied the contagion effect but they have provided some theoretical justification to study the pattern of co movement between stock market and energy market at the time of crisis.

Aloui, Hammoudeh and Nguyen, (2013), used a time varying copula approach to investigate the dependence structure between stock market and crude oil of CEE transition economies. The presence of contagion effect was revealed, as a positive correlation between equity market and energy market was found. Wen, Wei and Huang, (2012) also utilized copula approach in order to find the contagion effect between equity market and crude oil during GFC. Results showed a significant increasing dependence between these two markets hence proving the presence of contagion affect between equity market and energy market. The studies of (Ghorbel, Boujelbene & oujelbene, 2014; Fang & Egan, 2016; Zhang, 2018) also analyzed the presence of contagion effect between equity market and energy market. However, less attention was paid to explore the contagion effect between Asian emerging stock markets (AEEMs) and energy market. This study concentrates on the Eurozone debt crisis by investigating the financial contagion effect between Asian emerging equity markets and energy market.

This study adds to literature of portfolio diversification by exploring the contagion effect between Asian emerging market and energy market. This is the first study to address the issue of financial contagion between these markets, especially in the context of Asian emerging markets. The current study makes use of DCC-GARCH model to measure the changes in dynamic correlations between these economies. As measuring the dynamic correlation between equity market and energy market is

fundamental for hedging, derivatives pricing and optimization of portfolio during the times of crisis. The following are the reasons for measuring this affect in these economies:

In 1971, despite including the 10% share of Japan, Asia counted for only 14% of world GDP, which shows the minimum share of Asia in global GDP. The share of Japan dropped to 8% from 1971 to 2015 whereas Asian emerging markets share considerably increased to 22%. In 2015, however the share of Asia was 30% in world GDP. In addition to its economic performance, crude oil consumption of Asian markets increased significantly from 15% in 1971 to 42% in 2016 (IEEJ, May, 2018). Moreover, China and South Korea, the two Asian emerging markets are amongst the top 10 oil importing countries of the world (Cai,Tian, Yuan &Hamori, 2017). Therefore, Asia has become major consumer of crude oil. According to IEEJ outlook 2018, the focal point of international energy market is shifting towards Asia. China has become the largest importer of crude oil among the Asian emerging markets. The Chinese imports of crude oil have increased from 126.8 million tons in 2005 to 335.5 million tons in 2015 (Zhu, Su, Guo and Ren, 2016). This significant level of crude oil consumption indicates that oil has a huge effect on the economies of these countries. It also suggests the strong reliance of these economies' companies on the behavior and price of oil and relationship between crude oil price and stock market during bearish and bullish market situation. Therefore, understanding the stock-oil behavior and relationship in these economies is crucial for policy makers and investors of these economies during the times of crisis.

The remaining part of paper is segmented as follows. Section 2 of discusses the recent work on the relationship between energy market and equity market from previous literature and the section 3 explains the data and methodology used in this study. Section 4 presents the results and explains findings of the study. The last section of this paper includes conclusions and future recommendations.

Literature Review

In literature plethora of studies explored the relationship between stock prices and crude oil. The pioneer study on this relationship was undertaken by Hamilton (1983). Hamilton studied the link between macroeconomic variables and energy market and found that oil price has negative association with other macroeconomic variables. Some other researchers also discovered that linkages between equity market and crude oil are negative. Jones and Kaul (1996) explored the relationship between stock prices of (United States, Canada, Japan and the UK) and oil prices. Results depicted the presence of negative association between these variables. Sadorsky (1999) also supported the results of Jones and Kaul, (1996). Asteriou and Bashmakova, (2013) considered the emerging markets of central and eastern European countries in order to study the relationship between stock market return and risk of oil prices by employing an international multifactor model. The study also utilized the panel data approach for the time period of 1999 to 2007. It is observed that stock market negatively behave either movement of oil prices is upward or downward. Negative association between

equity market and crude oil is also predicted by (Hammoudeh& Li, 2005; Ghouri 2006; Basher &Sadorsky 2006; Hammoudeh& Choi 2007; Nandha&Haff, 2008; Driesprong, Jacobsen, & Maat, 2008). These studies concluded that there exist inverse pattern of co-movement between equity market and energy market.

Some researchers reported the existence of positive link between crude oil and stock market. Sadorsky, (2001) explored the relationship between oil prices and oil and gas firms and found the positive effect of higher oil prices on these companies. In the market of UK El-Sharif et al. (2005) discovered the relationship between stock prices and oil and gas company and found the presence of positive relationship. Basher and Sadorsky (2006) explored the impact of crude oil prices on the prices of stock market of 21 emerging markets (Argentina, Brazil, Chile, Colombia, India, Indonesia, Israel, Jordan, Korea, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, South Africa, Sri Lanka, Taiwan, Thailand, Turkey, and Venezuela). Study utilized the high frequency data for the time span of 1992 to 2005. Results denoted that changing in crude oil significantly affect the equity return of emerging markets. Moreover, Narayan and Narayan (2010) also found the positive relationship between these two markets in the context of vietnam's market. Faff and Brailsford (1999) and Arouri and Rault (2012), also proved the positive relationship between energy market and equity market.

In the context of oil price volatility Masih and Mello (2010), examined the volatility of oil price and stock price relationship by using Vector error correction model by considering interest rate, economic activity, real stock returns, real oil prices and oil prices volatility. Study found the dominant role of oil price volatility on stock returns. Agren (2006) study the volatility spillover from oil prices to stock prices in five developed (Japan, Norway, Sweden, the U.K., and the U.S.) countries by using BEKK GARCH model. Study denote that volatility spillover from oil prices to stock market exist in all the countries except Sweden. In the market of US Malik and Hammoudeh (2007) explored the diffusion of volatility among oil market, stock market of US and three market of Gulf (Bahrain, Kuwait, and Saudi Arabia). Results revealed that volatility from oil to stock prices exist for all Gulf markets whereas volatility from stock prices exists only for Saudi Arabia.

The above cited literature indicated that there exists a significant negative as well as positive relationship between these two markets. Additionally, this relationship is not same for all the economies. Moreover, the issue of financial contagion between these two markets has also been investigated by some researchers. Like, wen et al., (2012) studied the presence of contagion effect oil prices and stock prices. By employing time varying copula approach study found that contagion effect exists in these markets. In chines context Fang and Egan, (2018)also investigated the contagion effect from energy market to chines stock market sectors. Study presented that although the contagion effect between chines stock sector and oil market is weaker but not negligible.Zhang and Liu, (2018) explored the contagion effect between energy markets and stock markets. Study utilized the time varying copula and VAR-DAG model. Results supports presence of contagion in developed and developing markets. Moreover to study the presence of contagion between energy market and GCC economies Shazly and Lou, (2016) used the hybrid model. The main benefit of this

model is to capture the strength of pulse which transfers between these two markets. Results revealed that spillover effect varies from crude oil to equity market with respect to country and time. Time varying copula approach was also applied by Aloui, Hammoudeh and Nguyen, (2013), in the context of transition economies to study contagion effect between oil and stock market. Study found the positive dependence among the central and eastern European transition economies and oil price which indicated the existence of contagion effect.

In literature there are comparatively limited studies which addressed the issue of financial contagion between stock market and energy market. Though some studies tried to investigate the contagion effect between energy and equity market, but very less attention has been paid to Asian emerging markets and energy markets. Accordingly, this paper measures the contagion effect between energy market and Asian emerging equity markets at the time of Eurozone debt crisis.

Material and Methods

Data Description

This paper attempts to examine the contagion between energy market and AEEMs during the Eurozone debt crisis. To find out the contagion and interdependence among energy marker and AEEMs, daily data from 30-01-2005 to 31-01-2012 of stock indices and WTI is utilized which cover the incidence of Eurozone debt crisis. The sample includes the stock-index returns of the nine AEEMs (China, Taiwan, Pakistan, Malaysia, Philippine, Thailand, India, South Korea, Indonesia) and energy market. The selection of sample countries is based on the classification of MSCI (2018). The data of all the markets is taken in Dollar form, as Rigobon, (2002) reported that use of local indices or dollar indices does not alter the results. For oil spot daily crude oil prices of the WTI in dollars per barrel is used. Data of all the markets is obtained from Bloomberg.

For studying the effect of crisis on the relationship among these variables one issue is to identify the exact date and duration of crises. The time period of tranquil and turmoil chosen for this study is same as Ahmad, ehgal and Bhanumurthy, (2013). To measure the contagion, it is required that sample must be split into pre crises and crises period. Hence, in this study data is divided into tranquil 31-01-2005 to 18-10-2009 and turmoil 19-10-2009 to 31-01-2012 period for the crisis under investigation.

Econometric Technique

To study the correlation among the return of different assets over time, it is required to estimate the time varying correlation. In literature number of methods are suggested to study the time varying correlation especially in multivariate GARCH family (Silvennoinen&Tersvirta, 2009). These methods are burdensome in estimation and difficult to interpret. Engle (2002) proposed a pragmatic model for studying the time varying correlation among the different assets return over time known as "Dynamic conditional correlation (DCC) model". The Multivariate Dynamic

Conditional Correlation (DCC) specification model proposed by Engle (2002) is specified as follows:

$$H_t = D_t C_t D_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .1$$

Where $D_t = diag\left(h_{11t}^{\frac{1}{2}} \ldots\ldots h_{NNt}^{\frac{1}{2}}\right)$ The estimates of time-varying standard Deviation are obtained from univariate GARCH (1, 1) models with $\sqrt{h_{ii,t}}$ on the ith diagonal. The C_t is an $N \times N$ time-varying conditional correlation matrix. The elements of D_t are generated by the following univariate GARCH (1, 1) process:

$$H_{i,t} = \alpha_i + \alpha_i \mu_{i,t-1}^2 + \beta_t h_{i,t-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

where α_i is the constant term, α_i captures the Auto Regressive Conditional Heteroscedasticity (ARCH) effect and β_t measures the persistence of the volatility. The evolution of correlation in the DCC model is given by:

$$Q_t = (1 - \alpha - \beta)\overline{Q} + \alpha U_{t-1} U_{t-1}' + \beta Q_{t-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where $Q_t = (q_{ij,t})$ is the $N \times N$ time-varying covariance matrix of residuals, $\overline{Q} = E[\mu_t \mu_t]$ is the $N \times N$ time-invariant variance matrix of u_t, while α and β are nonnegative scalar parameters satisfying $\alpha + \beta < 1$. Because Q_t does not have unit elements on the diagonal, the correlation matrix Ct is obtained by scaling it as follows:

$$C_t = (diag(Q_t))^{-\frac{1}{2}}(diag(Q_t))^{-\frac{1}{2}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

A typical element of C_t has the form:

$$P_{ij,t} = q_{ij,t}/\sqrt{q_{ii,t}}q_{jj,t}, \text{i,j} = 1,2\ldots\ldots.n, \text{ and } i \neq j \ldots\ldots\ldots\ldots\ldots\ldots .5$$

Thus, the correlation coefficient at time t is defined as follows:

$$P_{ijt} = \frac{(1-\alpha-\beta)\overline{q}_{ij}+\alpha\,\mu_{it-1}\mu_{jt-1}+\beta q_{ijt-1}}{\sqrt{(1-\alpha-\beta)\overline{q}_{ii}+\alpha\mu_{it-1}^2+\beta q_{iit-1}}\sqrt{(1-\alpha-\beta)\overline{q}_{jj}+\alpha\mu_{jt-1}^2+\beta q_{jt-1}}} \ldots\ldots\ldots\ldots\ldots .6$$

In this study correlation coefficient are of significant importance because these coefficients produce key evidence on pattern of correlation between crude oil and stock return series over time. Since the volatility is adjusted by the procedure, the time varying correlation (DCC) does not have any bias from volatility. Unlike the volatility-adjusted cross-market correlations employed in Forbes and Rigobon (2002), DCC-GARCH continuously adjusts the correlation for the time-varying volatility. Hence, DCC provides a superior measure for dynamic correlation. This notion is also supported by number of studies.

DCC-GARCH model has been utilized by Chiang et al. (2007) to explore the presence of contagion effect at the time of Asian crisis. Results of the study support the existence of contagion effect. Lahrech and Sylwester (2011) explored the dynamic relationship between the stock markets of Latin America and U.S. by using DCC-

GARCH model. They denoted the significant increase in correlation of U.S. and American markets. Kuperand and Lestano, (2007) studied the pattern of time varying correlation between the Thailand and Indonesian stock markets. The study reported that correlation is time varying and there exist significant interdependence between these countries stock markets.

This study employs one tail t-test to examine the presence of contagion effect. This test finds the mean of DCC correlation in crises and normal time period, moreover this test clarifies that either mean of DCC correlations are higher at the turmoil time as compared to tranquil time. The study define the null and alterative hypothesis as

$$H_0 = \mu_p^{crises} \leq \mu_p^{pre-crises} \quad H_1 = \mu_p^{crises} > \mu_p^{pre-crises}$$

μ_p^{crises} denotes the means of dynamic conditional correlation at the time of crises and $\mu_p^{pre-crises}$ denotes the means of dynamic conditional correlation in pre-crises time. The value of t statistics is compared with critical value. If the value of t statistics is higher than critical value, H_0 is rejected and H_1 is accepted which supports the evidence for the existence of contagion.

Empirical Findings

Descriptive statistics

Table 1
Descriptive statistics overall sample

	BSE	JCI	KOSPI	KSCI	PSEI	PSX	SET50	SSE	TWSE	WTI
Mean	0.000433	0.000723	0.000399	0.000234	0.000572	0.000356	0.00228	0.00030	8.48E-05	0.000407
Median	0.000662	0.000957	0.000764	0.000207	0.00000	0.000122	0.00000	0.00024	0.000257	0.000000
Maximum	0.146179	0.076231	0.112844	0.042587	0.093653	0.082547	0.10577	0.09033	0.065246	0.164137
Minimum	-0.11096	-0.10954	-0.11172	-0.09979	-0.13089	-0.06042	-0.16063	-0.09261	-0.06735	-0.12827
Std. Dev.	0.016635	0.015441	0.015120	0.00825	0.013942	0.014789	0.014288	0.01787	0.013611	0.025464
Skewness	-0.23493	-0.69493	-0.58480	-1.29151	-0.72056	-0.30483	-1.10918	-0.33692	-0.38455	0.027050
Kurtosis	10.11667	9.81978	9.978683	18.05749	11.44048	5.260538	18.74626	6.106859	5.97813	7.897894
Jarque-Bera	3836.281	3653.276	3776.112	17602.25	5529.441	413.4129	19070.31	762.2079	713.4999	1809.418
Probability	0	0	0	0	0	0	0	0	0	0

Table 1 describes the summary statistics of whole sample. Summary statistics includes Mean (mean), Median(med), Minimum(min), Maximum (max), Standard Deviation (SD), Skewness (skew), Kurtosis (kur) and Jorque-Bera (jb) test. Sample includes China (Shanghai SE composite), Taiwan (Taiwan stock exchange weighted index), Pakistan (PSX-100), Malaysia (Kuala Lumpur-Stock Index KSCI), Philippine (Philippine stock exchange composite index PSEi), Thailand (Bangkok SET50 index), India (Bombay stock exchange BSE), South Korea (Korea Stock exchange composite KOSPI), Indonesia (Jakarta stock exchange composite index JCI) and WTI(oil).

This table represents the descriptive statistics of stock-index returns of the nine Asian emerging markets China, Taiwan, Pakistan, Malaysia, Philippine, Thailand, India, South Korea, Indonesia and oil market. Table 4.1 only contains the summary of whole sample whereas Table 2 and 3 contain the summary statistics of Eurozone pre crises time and crises time.

This table represents the descriptive statistics of whole sample which depict the average positive daily return of all the markets. The highest average daily return is of Taiwan (8.97E-05) which is followed by Indonesia. Whereas average lowest return in the given sample is of China stock market. The unconditional normality statistics shown in table 1 shows that the parameter/coefficient of skewness is nil for a symmetric normal distribution. Data is negatively skewed as depicted by negative values of all the emerging stock markets and oil market. Moreover, Kurtosis parameter is valued at three for normal distribution, which is also called zero value of excess kurtosis. All return have positive excess kurtosis, which depicts the return series are heavily tailed non normal ones, in which random return series tends to contain more extreme values. Jarque-Bera test for all the series is significant which further confirm that all the returns are sampled from an unconditional non-normal distribution.

Table 2
Descriptive statistics Eurozone pre-crisis

	BSE	JCI	KOSPI	KSCI	PSEI	PSX	SET50	SSE	TWSE	WTI
Mean	0.00065	0.000704	0.000437	0.000199	0.000463	0.00033	1.95E-05	0.000709	0.000137	0.000433
Median	0.001517	0.000927	0.001035	0.000223	0	0.000122	0	0.000874	0.000324	0.000267
Maximum	0.146179	0.076231	0.112844	0.042587	0.093653	0.082547	0.10577	0.090332	0.065246	0.164137
Minimum	-0.11096	-0.10954	-0.11172	-0.09979	-0.13089	-0.06042	-0.16063	-0.09261	-0.06735	-0.12827
Std. Dev.	0.018777	0.016468	0.016048	0.009127	0.015276	0.016619	0.015157	0.0198	0.014443	0.02789
Skewness	-0.25447	-0.65349	-0.58129	-1.35735	-0.74667	-0.28234	-1.32388	-0.34649	-0.33841	0.039584
Kurtosis	9.064733	9.31402	10.42895	17.42794	11.13605	4.599128	20.58803	5.635887	5.904272	7.531182
Jarque-Bera	1882.867	2113.398	2874.162	10956.37	3478.286	146.1999	16081.1	377.5963	452.0544	1044.009
Probability	0	0	0	0	0	0	0	0	0	0

Table 2 describe the summary statistics of Eurozone pre crises 31-01-2005 to 18-10-2009 time. Summary statistics includes Mean (mean), Median (med), Minimum (min), Maximum (max), Standard Deviation (SD), Skewness (skew), Kurtosis (kur) and Jorque-Bera (jb) test. Sample includes China (Shanghai SE composite), Taiwan (Taiwan stock exchange weighted index), Pakistan (PSX-100), Malaysia (Kuala Lumpur-Stock Index KSCI), Philippine (Philippine stock exchange composite index PSEi), Thailand (Bangkok SET50 index), India (Bombay stock exchange BSE), South Korea (Korea Stock exchange composite KOSPI), Indonesia (Jakarta stock exchange composite index JCI) and WTI (oil).

Table 4.3
Descriptive statistics Eurozone crisis

	BSE	JCI	KOSPI	KSCI	PSEI	PSX	SET50	SSE	TWSE	WTI
Mean	-1.62050	0.00076	0.00032	0.00030	0.00079	0.000408	0.000661	-0.00052	-2.25050	0.000354
Median	0.00000	0.00099	0.00032	0.00017	0.00042	0.000124	0.000149	0.00000	0.000171	0.000000
Maximum	0.03243	0.07013	0.04900	0.02403	0.04078	0.028161	0.057515	0.04094	0.044594	0.098980
Minimum	-0.03794	-0.09300	-0.06420	-0.0253	-0.05261	-0.04058	-0.05812	-0.05283	-0.05742	-0.08535
Std. Dev.	0.01094	0.01307	0.01301	0.00605	0.01067	0.010005	0.012298	0.01299	0.011716	0.019537
Skewness	-0.11340	-0.8081	-0.57223	-0.37013	-0.33633	-0.31814	-0.15872	-0.4100	-0.55467	-0.06283
Kurtosis	3.47632	10.1662	5.99406	4.83034	5.45537	4.667211	6.277685	4.44502	5.241134	5.297297
Jarque-Bera	6.84340	1326.70	252.580	95.8324	159.332	78.28429	266.5814	67.8632	153.7273	130.1285
Probability	0	0	0	0	0	0	0	0	0	0

Table 3 describes the summary statistics of Eurozone crises (19-10-2009 to 31-01-2012) time. Summary statistics includes Mean (mean), Median(med), Minimum(min), Maximum (max), Standard Deviation (SD), Skewness (skew), Kurtosis (kur) and Jorque-Bera (jb) test. Sample includes China (Shanghai SE composite), Taiwan (Taiwan stock exchange weighted index), Pakistan (PSX-100), Malaysia (Kuala Lumpur-Stock Index KSCI), Philippine (Philippine stock exchange composite index PSEi), Thailand (Bangkok SET50 index), India (Bombay stock exchange BSE), South Korea (Korea Stock exchange composite KOSPI), Indonesia (Jakarta stock exchange composite index JCI) and WTI (oil).

Table 2 depicts the descriptive statistics before Eurozone crises and Table 3 depicts the descriptive statistics of Eurozone crises time. In pre-crises time the average return of all the markets is positive but in crises time Table 3 depicts that the average return for markets of China, Taiwan and India is negative. Same like pre-crises period, all the markets show the high value of Kurtosis in crises timewhich leads towards the rejection of null hypothesis that series are normally distributed.

Table 4
Dynamic conditional correlation coefficient and contagion effect test

	Mean	Variance	t-statistics
			$H_0 = \dfrac{\text{t-statistics}}{\mu_p^{crises} \leq \mu_p^{pre-crises}}$
Pre-crises DCC WTI_ China	0.040196249	0.001715332	61.270*
Crises DCC WTI _ China	0.172183002	0.003739949	
Pre-crises DCC WTI _Philipine	0.029275496	0.002101341	6.272*
Crises DCC WTI _Philippine	0.012521886	0.001901018	
Pre-crises DCC WTI_Taiwan	0.067682473	0.005014894	58.615*
Crises DCC WTI _Taiwan	0.224592381	0.005403779	
Pre-crises DCC WTI_Thailand	0.122530527	0.006722747	74.460*
Crises DCC WTI _ Thailand	0.207688163	0.005640794	
Pre-crises DCC WTI _ India	0.133725221	0.003243551	40.839*
Crises DCC WTI _ India	0.252523124	0.007286116	
Pre-crises DCC	0.066309579	0.003179434	56.528*

WTI_SouthKorea			
Crises DCC WTI _ South Korea	0.186195392	0.004152906	
Pre-crises DCC WTI_Pakistan	0.035786144	0.000700635	-9.758
Crises DCC WTI _ Pakistan	0.004088393	0.003083081	
Pre-crises DCC WTI_Malaysia	0.120712414	0.002145621	43.604*
Crises DCC WTI_ Malaysia	0.224849746	0.00667731	
Pre-crises DCC WTI_Indonesia	0.118482898	0.003157664	38.929*
Crises DCC WTI_ Indonesia	0.193724498	0.004436336	

Note: above table presents the dynamic correlation between WTI and Asian emerging equity markets in the turmoil and tranquil time of Eurozone crisis. Time period for pre-crisis is from 31-01-2005 to 18-10-2009and for crisis time is from 19-10-2009 to 31-01-2012. Rejection of null hypothesis against one sided alternative that at the time pf crisis the dynamic correlation increases is tested at 5% significant level denoted by *

Table 4 presents the results of dynamic conditional correlation between energy market and Asian emerging equity markets. The results show that the dynamic correlations are higher in crises time as compared to pre-crisis time for the markets of China, Taiwan, Malaysia, Philippine, Thailand, India, South Korea, Indonesia leads towards rejection of null hypothesis and signifies the presence of contagion effect in these markets. However, results revealed that the dynamic correlations are lower in crises time as compared to pre-crises time for the market of Pakistan, signifies that we cannot reject the null hypothesis for this market. The results of this study support the presence of contagion effect in AMEs. As t test confirms the higher correlation at the time of crises.

The results of dynamic conditional correlation in this paper show the significant positive time varying correlation between oil price and stock price. The application of conditional correlation modeling is workable for the oil risk management of large portfolio management in emerging Asian nations. Results revealed that emerging markets are characterized by the presence of time varying correlation. These results are consistent with empirical evidence shown by Gagnon and Karolyi, (2006) and Christofferson, (2011). They represent the higher level of correlation between the markets in turbulence time.

There may be two reasons for the significant rise in correlation coefficients in turmoil time period. One is that, financial crisis leads towards the uncertainties of macroeconomic fundamentals, so oil demand, supply and prices became more volatile. Such a demand-supply situation for oil prices reflected the uncertain economic expectations of the time, and stock prices responded accordingly. One other reason is that oil and stock market value any information and become more sensitive in the scenario of crisis. It is expected that in crisis time period these markets do not behave rationally as compared to normal time period. Additionally, financialization in the market of oil, increased the exposure of oil prices to financial shock and made them more susceptible to the mood of the financial market. For example, Broadstock and Filis, (2014) acknowledged that speculation in the market of crude oil is itself a driving factor of specific shock in oil market. The increased speculation in the oil market, due to the increased participation of hedge funds, had created an increased correlation

between the energy and equity market. So, such financialization in the market of oil provides justification for the presence of positive linkages between energy and equity market.

Furthermore, the results are in line with the definition of contagion which was given by Forbes and Rigobon, (2002). This is the most widely used definition of contagion and one which is used in this study. Similar findings were presented by Zhang and Liu, (2018) who explored the contagion effect between energy markets and stock markets. Study utilized the time varying copula and VAR-DAG model. The results provides the evidence for presence of contagion in developed and developing markets. The hypothesis that correlation of markets is higher at the time of crises is further confirmed by (Bala&Takimoto, 2017). Additionally, findings of present study are in line with the results provided by Aloui, Hammoudeh and Nguyen, (2013). Aloui, Hammoudeh and Nguyen presented the positive correlation between CEE transition economies and oil price at the time of crisis. In the context of chines market (Wen, Wei & Huang, 2012; Fang &Egan, 2018) provided the evidence for the presence of contagion effect between energy and stock market. Our results further confirm the presence of contagion in chines equity market along with other Asian emerging equity markets. Consistent with above cited literature the findings of this study confirm the presence of contagion effect between crude oil and equity markets in the context of Asian emerging markets.

Conclusion and Recommendations

Using daily sample of WTI spot prices and stock indices of Asian emerging markets, this study attempts to investigate whether there exist contagion between stock markets and crude oil during the Eurozone debt crisis.For this purpose the study utilized the Multivariate GARCH DCC model on the data set of 30-01-2005 to 31-01-2012. Moreover, the data set was further divided into pre-crises and crises time to investigate dynamic conditional correlation differ in both crises and pre-crises time.

This study used the one tail t test to check either means of dynamic correlation are higher in crises time as compared to pre-crises time. Results revealed the significant increase in the dynamic correlation between energy market and Asian emerging equity markets except Pakistan. Thus, providing the presence of contagion effect in the sense of forbs and Rigobon, (2002), definition. It shows that Asian emerging markets and energy market contagion is significantly affected by Eurozone crisis.

It is observed from the analysis that at the time of crises the dynamic conditional correlation of equity markets and energy market got significance increase. This significant increase in correlation is not good sign for the portfolio investors. This suggest that at the time of crisis oil and Asian emerging equity markets do not provides diversification benefits and investors do not combine them in a diversified portfolio. The findings of the paper are interesting for the investors of emerging markets. Investors who combined oil and stock in their portfolio should include some other commodity in order to hedge the portfolio risk at the time of crisis.

References

Ahmad, W., Sehgal, S., &Bhanumurthy, N. R. (2013). Eurozone crisis and BRIICKS stock markets: contagion or market interdependence?*Economic Modelling*, 33, 209-225.

Ågren, M. (2006). *Does oil price uncertainty transmit to stock markets?* (No. 2006: 23). Working Paper.

Ajmi, A. N., El-Montasser, G., Hammoudeh, S., & Nguyen, D. K. (2014). Oil prices and MENA stock markets: New evidence from nonlinear and asymmetric causalities during and after the crisis period. *Applied Economics*, 46(18), 2167-2177.

Aloui, R., Hammoudeh, S., & Nguyen, D. K. (2013). A time-varying copula approach to oil and stock market dependence: The case of transition economies. *Energy Economics*, 39, 208-221.

Apergis, N., & Miller, S. M. (2009). Do structural oil-market shocks affect stock prices?. *Energy Economics*, 31(4), 569-575.

Arouri, M. E. H., &Rault, C. (2012). Oil prices and stock markets in GCC countries: empirical evidence from panel analysis. *International Journal of Finance & Economics*, 17(3), 242-253.

Asteriou, D., &Bashmakova, Y. (2013). Assessing the impact of oil returns on emerging stock markets: A panel data approach for ten Central and Eastern European Countries. *Energy Economics*, 38, 204-211.

Bala, D. A., &Takimoto, T. (2017). Stock market's volatility spillovers during financial crises: A DCC-MGARCH with skewed-t density approach. *Borsa Istanbul Review*, 17(1), 25-48.

Barsky, R. B., & Kilian, L. (2004). Oil and the Macroeconomy since the 1970s. *Journal of Economic Perspectives*, 18(4), 115-134.

Basher, S. A., &Sadorsky, P. (2006). Oil price risk and emerging stock markets. *Global finance journal*, 17(2), 224-251.

Basher, S. A., &Sadorsky, P. (2016). Hedging emerging market stock prices with oil, gold, VIX, and bonds: A comparison between DCC, ADCC and GO-GARCH. *Energy Economics*, 54, 235-247.

Büyükşahin, B., Haigh, M. S., & Robe, M. A. (2010). Commodities and Equities: A 'Market of One'?. *The Journal of Alternative Investments*, 12(3), 76-95.

Broadstock, D. C., &Filis, G. (2014). Oil price shocks and stock market returns: New evidence from the United States and China. *Journal of International Financial Markets, Institutions and Money*, 33, 417-433.

Cai, X. J., Tian, S., Yuan, N., &Hamori, S. (2017). Interdependence between oil and East Asian stock markets: Evidence from wavelet coherence analysis. *Journal of International Financial Markets, Institutions and Money*, 48, 206-223.

Chiang, T.C., Jeon, B.N., Li, H., 2007. Dynamic correlation analysis of financial contagion: evidence from Asian markets. *Journal of International Money and Finance* 1026– 1228.

Driesprong, G., Jacobsen, B., & Maat, B. (2008). Striking oil: another puzzle?. *Journal of financial economics*, 89(2), 307-327.

Engle, R. (2002). Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business & Economic Statistics,* 20(3), 339-350.

El-Sharif, I., Brown, D., Burton, B., Nixon, B., & Russell, A. (2005). Evidence on the nature and extent of the relationship between oil prices and equity values in the UK. *Energy Economics*, 27(6), 819-830.

El Shazly, M., & Lou, A. (2016). Measuring Contagion between Oil Prices and Stock Markets in the GCC Countries Using a Hybrid Artificial Neural Network Model. *International Journal of Trade, Economics and Finance*, 7(4).

Faff, R. W., &Brailsford, T. J. (1999). Oil price risk and the Australian stock market. *Journal of Energy Finance & Development*, 4(1), 69-87.

Fang, S., & Egan, P. (2018). Measuring contagion effects between crude oil and Chinese stock market sectors. *The Quarterly Review of Economics and Finance*, 68, 31-38.

Filis, G., &Chatziantoniou, I. (2014). Financial and monetary policy responses to oil price shocks: evidence from oil-importing and oil-exporting countries. *Review of Quantitative Finance and Accounting*, 42(4), 709-729.

Forbes, K. J., &Rigobon, R. (2002). No contagion, only interdependence: measuring stock market comovements. *The journal of Finance*, 57(5), 2223-2261.

Gagnon, L., & Karolyi, G. A. (2006). Price and volatility transmission across borders. Financial Markets, *Institutions & Instruments*, 15(3), 107-158.

Geman, H., &Kharoubi, C. (2008). WTI crude oil futures in portfolio diversification: The time-to-maturity effect. *Journal of Banking & Finance*, 32(12), 2553-2559.

Ghorbel, A., Abbes Boujelbene, M., &Boujelbene, Y. (2014). Behavioral explanation of contagion between oil and stock markets. *International Journal of Energy Sector Management,* 8(1), 121-144.

Ghouri, S. S. (2006). Assessment of the relationship between oil prices and US oil stocks. *Energy Policy*, 34(17), 3327-3333.

Hammoudeh, S., & Li, H. (2005). Oil sensitivity and systematic risk in oil-sensitive stock indices. *Journal of Economics and Business*, 57(1), 1-21.

Hammoudeh, S., & Choi, K. (2007). Characteristics of permanent and transitory returns in oil-sensitive emerging stock markets: The case of GCC countries. Journal of *International Financial Markets, Institutions and Money*, 17(3), 231-245.

Hamilton, J. D. (1983). Oil and the macroeconomy since World War II. Journal of political economy, 91(2), 228-248.

Jones, C. M., &Kaul, G. (1996). Oil and the stock markets. *The journal of Finance*, 51(2), 463-491.

Kuper G, Lestano. 2007. Dynamic Conditional Correlation Analysis of Financial Market Interdependence: An Application to Thailand and Indonesia. *Journal of Asian Economics* 18: 670-684.

Lautier, D., & Raynaud, F. (2011). *Energy derivative markets and systemic risk* (No. halshs-00640833).

Lahrech, A., &Sylwester, K. (2011). US and Latin American stock market linkages. *Journal of International Money and Finance*, 30(7), 1341-1357.

Malik, F., &Hammoudeh, S. (2007). Shock and volatility transmission in the oil, US and Gulf equity markets. *International Review of Economics & Finance*, 16(3), 357-368.

Masih, M., Algahtani, I., & De Mello, L. (2010). Price dynamics of crude oil and the regional ethylene markets. *Energy Economics*, 32(6), 1435-1444.

Nandha, M., & Faff, R. (2008). Does oil move equity prices? A global view. *Energy Economics,* 30(3), 986-997.

Narayan, P. K., & Narayan, S. (2010). Modelling the impact of oil prices on Vietnam's stock prices. *Applied energy*, 87(1), 356-361.

Odusami, B. O. (2009). Crude oil shocks and stock market returns. *Applied financial economics*, 19(4), 291-303.

Park, J., &Ratti, R. A. (2008). Oil price shocks and stock markets in the US and 13 European countries. *Energy economics*, 30(5), 2587-2608.

Rigobon, R. (2002). *Contagion: how to measure it?. In Preventing currency crises in emerging markets* (pp. 269-334). University of Chicago Press.

Sari, R., Hammoudeh, S., &Soytas, U. (2010). Dynamics of oil price, precious metal prices, and exchange rate. *Energy Economics*, 32(2), 351-362.

Sadorsky, P. (1999). Oil price shocks and stock market activity. *Energy economics*, 21(5), 449-469.

Sadorsky, P. (2001). Risk factors in stock returns of Canadian oil and gas companies. *Energy economics*, 23(1), 17-28.

Silvennoinen, A., &Teräsvirta, T. (2009). Multivariate GARCH models. In *Handbook of financial time series* (pp. 201-229). Springer, Berlin, Heidelberg.

Tang, K., &Xiong, W. (2012). Index investment and the financialization of commodities. *Financial Analysts Journal*, 68(6), 54-74.

Wen, X., Wei, Y., & Huang, D. (2012). Measuring contagion between energy market and stock market during financial crisis: A copula approach. *Energy Economics*, 34(5), 1435-1446.

Zhang, G., Lu, D., & Liu, H. (2018). *Strategies to utilize the positive emotional contagion optimally in crowd evacuation*. IEEE Transactions on Affective Computing.

Zhu, H., Su, X., Guo, Y., & Ren, Y. (2016). The Asymmetric Effects of Oil Price Shocks on the Chinese stock market: Evidence from a quantile impulse response perspective. *Sustainability*, 8(8), 766.