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

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ABSTRACT

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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.

Keywords: AEEMs stock markets, Contagion, DCC GARCH Model, Energy market, Eurozone 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 market and 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, et al 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:

\[ H_t = D_t C_t D_t \]  

Where \( D_t = \text{diag} \left( h_{i1t}, \ldots, h_{Nt} \right) \) The estimates of time-varying standard deviation are obtained from univariate GARCH (1, 1) models with \( \sqrt{h_{it}} \) on the ith diagonal. The elements of \( C_t \) are generated by the following univariate GARCH (1, 1) process:

\[ H_{it} = \alpha_i + \alpha_i^2 h_{i,t-1} + \beta_i h_{i,t-1} \]  

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

\[ Q_t = (1 - \alpha - \beta) \bar{Q} + \alpha U_{t-1} U_{t-1}' \beta Q_{t-1} \]  

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

\[ C_t = \left( \text{diag}(Q_t) \right)^{1/2} \left( \text{diag}(Q_t) \right)^{-1/2} \]  

A typical element of \( C_t \) has the form:

\[ C_{ij} = q_{ij} / \sqrt{q_{ii} q_{jj}} \]  

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

\[ p_{ijt} = \frac{(1 - \alpha - \beta) q_{ij} + \alpha \mu_{t-1} \mu_{t-1}' + \beta q_{ijt-1}}{\sqrt{(1 - \alpha - \beta) q_{ii} + \alpha \mu_{t-1}^2 + \beta q_{ii}'} \sqrt{(1 - \alpha - \beta) q_{jj} + \alpha \mu_{t-1}^2 + \beta q_{jj}'}} \]  

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 Thai 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 alternative hypothesis as

\[ H_0 = \mu_p^{\text{crises}} \leq \mu_p^{\text{pre-crises}} \]

\[ H_1 = \mu_p^{\text{crises}} > \mu_p^{\text{pre-crises}} \]

\( \mu_p^{\text{crises}} \) denotes the means of dynamic conditional correlation at the time of crises and \( \mu_p^{\text{pre-crises}} \) 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**

|          | 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| 0.00000 |
| Maximum  | 0.146179| 0.076231| 0.112844| 0.042587| 0.093653| 0.082547| 0.10577 | 0.09033 | 0.164137| 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 Jarque-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 describes 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 Jarque-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

| Indicator       | BSE       | JCI       | KOSPI     | KSCT     | PSEI      | PSX       | SET50     | SSE        | TWSE       | WTI        |
|-----------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|------------|------------|
| Mean            | -1.62050  | 0.00076   | 0.00032   | 0.00030   | 0.00079   | 0.000408  | 0.000661  | -0.0005    | -2.25050   | 0.000354   |
| Median          | 0.00080   | 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   | 0.02816   | 0.057515  | 0.04094    | 0.044594   | 0.098980   |
| Minimum         | -0.0379   | -0.0930   | -0.0642   | -0.0253   | -0.0526   | -0.04058  | -0.05812  | -0.0528    | -0.05742   | -0.08535   |
| Skewness        | -0.1134   | -0.8081   | -0.5722   | -0.3706   | -0.3365   | -0.31814  | -0.15872  | -0.4100    | -0.55467   | -0.06283   |
| Kurtosis        | 3.47632   | 10.16627  | 5.99406   | 4.83034   | 5.45537   | 4.66721   | 6.77685   | 4.4502     | 5.241134   | 5.297297   |
| Jarque-Bera     | 6.84340   | 1326.70   | 252.580   | 95.8324   | 159.332   | 78.2842   | 266.5814  | 67.8632    | 153.7273   | 130.1285   |
| Probability     | 0.00000   | 0.00000   | 0.00000   | 0.00000   | 0.00000   | 0.00000   | 0.00000   | 0.00000    | 0.00000    | 0.00000    |

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 Jarque-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-crisis 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-crisis period, all the markets show the high value of Kurtosis in crises time which leads towards the rejection of null hypothesis that series are normally distributed.

Table 4
Dynamic conditional correlation coefficient and contagion effect test

| Category                  | Mean       | Variance | t-statistics |
|---------------------------|------------|----------|-------------|
| Pre-crisis DCC WTI_China  | 0.040196249| 0.001715332| 61.270*     |
| Crises DCC WTI_China      | 0.172183002| 0.003739949|             |
| Pre-crisis DCC WTI_Philipine| 0.029275496| 0.002101341| 6.272*      |
| Crises DCC WTI_Philipine  | 0.012521886| 0.001901018|             |
| Pre-crisis DCC WTI_Taiwan | 0.067682473| 0.005041894| 58.615*     |
| Crises DCC WTI_Taiwan     | 0.224592381| 0.005403779|             |
| Pre-crisis DCC WTI_Thailand| 0.122530527| 0.006722747| 74.460*     |
| Crises DCC WTI_Thailand   | 0.207688163| 0.005640794|             |
| Pre-crisis DCC WTI_India  | 0.133725221| 0.003324355| 40.839*     |
| Crises DCC WTI_India      | 0.252523124| 0.007286116|             |
| Pre-crisis DCC            | 0.066309579| 0.003179434| 56.528*     |

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WTI_SouthKorea

| Crises DCC WTI_South Korea | 0.186195392 | 0.004152906 |
|-----------------------------|-------------|-------------|
| Pre-crisis DCC WTI_Pakistan | 0.035786144 | 0.00070635  |
| Crises DCC WTI_Pakistan     | 0.004088393 | 0.003083081 |
| Pre-crisis DCC WTI_Malaysia | 0.120712414 | 0.002145621 |
| Crises DCC WTI_Malaysia     | 0.224849746 | 0.00667731  |
| Pre-crisis DCC WTI_Indonesia| 0.118482898 | 0.003157664 |
| 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 18-10-2009 and 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.
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