The Impact of Crude Oil Price on Islamic Stock Indices of South East Asian (SEA) Countries: A Comparative Analysis

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The Impact of Crude Oil Price on Islamic Stock Indices of South East Asian (SEA) Countries: A Comparative Analysis

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Abstract:
An understanding of how volatilities of and correlations between commodity returns and Islamic stock indices change over time including their directions and size are of crucial importance for both the domestic and international investors with a view to diversifying their portfolios for hedging against unforeseen risks. This paper is the first attempt to add value to the existing literature by empirically testing for the 'time-varying' and 'scale dependent' volatilities of and correlations between the selected Islamic stock indices of South East Asian countries and selected commodities for enhancing portfolio diversification benefits. The methodologies appropriate to achieving the objectives were the recently introduced dynamic conditional correlations and wavelet decompositions. Our findings tend to suggest that there is a theoretical relationship between the selected Islamic stock indices and the selected commodities and that the Islamic stock indices of Singapore, Philippines and Indonesia are leading the other Islamic stock indices and the commodities (as evidenced in the Vector Error-Correction models). Consistent with these results, our analysis based on the application of the recent wavelet technique MODWT tends to indicate that the Singapore Islamic index is leading the other Islamic indices and the commodities. From the point of view of portfolio diversification benefits based on the extent of dynamic correlations between variables, our results tend to suggest that an investor should be aware that the Philippine Islamic stock index is less correlated with the crude oil in the short run (as evidenced in the continuous wavelet transform analysis) and that an investor holding the crude oil can gain by including the Malaysian Islamic stock index in his/her portfolio (as evidenced in the Dynamic conditional correlations analysis).

Key Words: Commodity, Islamic Stock Index Returns (ISIR), MODWT, CWT, DCC-MGARCH, Diversification, Causality;

1. Introduction

Crude oil prices have remained low during the 1980s until 2000 with an average price of US$20 per barrel. From 2004 onward, the crude oil price has increased significantly with an increase from US$31 per barrel in 2004 to US$140 per barrel in 2008. By the year 2013 the crude oil price has remained within the range of US$100 – US$110. The demand for crude oil remains strong especially because of the growth of the emerging economies such as China and India and also with the capacity constraints on the supply side, oil prices are expected to remain within US$100 per barrel for time being. Crude oil price changes affect almost all sectors of the economies. Many studies in the past on crude oil have focused their attention on whether and how oil price fluctuations impact on conventional stock market returns. Aloui, Jammazy et al. (2008) find that changes in crude oil (CO) prices cause significantly the volatility of the stock market returns of six developed countries using univariate and multivariate approaches (Aloui, Jammazy et al. 2008). Park and Ratti (2008) report that oil price shocks have a statistically significant impact on real stock returns for the US and 13 European oil importing countries (Park and Ratti 2008). Although many different studies have been done, there is no consensus about the effect of the CO shocks on the conventional stock market returns and the Islamic stock market returns.

The underlying Islamic fund in global financial institutions is around $1.3 trillion, while the size of the Islamic financial market is estimated to be around US$230 billion, growing at a rate of 12% to 15% per year. The number of *Shariah*-compliant investment funds has increased from nine funds with a collective value of US$800 million in 1994 to approximately 126 funds in year 2006, with US$16 billion under their management. This implies that the Islamic investment funds have grown at an average annual rate in excess of 28% during this period. Within Islamic investment funds, the equity funds market is one of the fastest-growing sectors. There are approximately 100 Islamic equity funds worldwide currently. The total assets managed through these funds exceed US$5 billion, growing by 12-15% per annum (Sadeghi 2008). Therefore, the study on Islamic stock market is important to provide Islamic investors and fund managers an idea on riskiness and potential international portfolio diversification benefits.

Most of the SEA countries have a high rate of oil usage in the development of their economy and all of these countries under review are net importer of crude oil with the exception of Malaysia as highlighted in Table 1. Due to the importance of crude oil in an economy, therefore, the changes in the crude oil price will have a significant impact on the economy including Islamic stock market of SEA countries. Investors in Islamic stock markets would like to know the time-varying volatilities of and the dynamic correlations between crude oil and Islamic stock markets in order to obtain their diversification benefits and to mitigate risk.

The main objective of this paper is to examine the dynamic causal relationship between crude oil price and Islamic stock indices in South East Asian (SEA) countries. Other commodities such as gold and corn prices also included as a control variable and for robustness test. We would like to find out the lead-lag relationship between the eight variables under review and to identify the direction of Granger-causality among those variables. We also would like to find any diversification benefits of the variables.

The unique contribution of the paper, among others, which enhances the existing literature is in empirically testing for the 'time-varying' and 'scale dependent' volatilities of and correlations between the sample variables. Particularly, by incorporating the scale dependence, the paper is able to identify unique portfolio diversification opportunities for different set of investors bearing different investment horizons or stock-holding periods. Hence, the specific research questions of this study are as follows:

i. Does a cointegrating (or theoretical) relationship exist between the commodities such as crude oil, corn and gold and the Islamic stock indices of Malaysia, Singapore, Thailand, Indonesia and Philippine?
ii. Does the crude oil price cause the prices of the other commodities and Islamic stock indices to increase/decrease in which past values of crude oil price were able to improve the prediction of other commodities (gold and corn) and Islamic stock indices of Malaysia, Singapore, Indonesia, Thailand and Philippine?
iii. Among the exogenous variables, which one is more exogenous at different time horizon?
iv. Which commodities and Islamic stock markets the investors should invest in to gain portfolio diversification benefits?
v. How would the portfolio diversification benefits change given different investors' investment horizons or stock-holding periods?

The results from each of the research questions are expected to have significant implications for the investors in their decisions concerning portfolio allocations and investment horizons. In summary, using recent data and modern empirical methodologies, this paper humbly attempts to fulfil the strategic information needs of investors intending to diversify their portfolios in commodity markets and Islamic stock indices in the South East Asian countries.

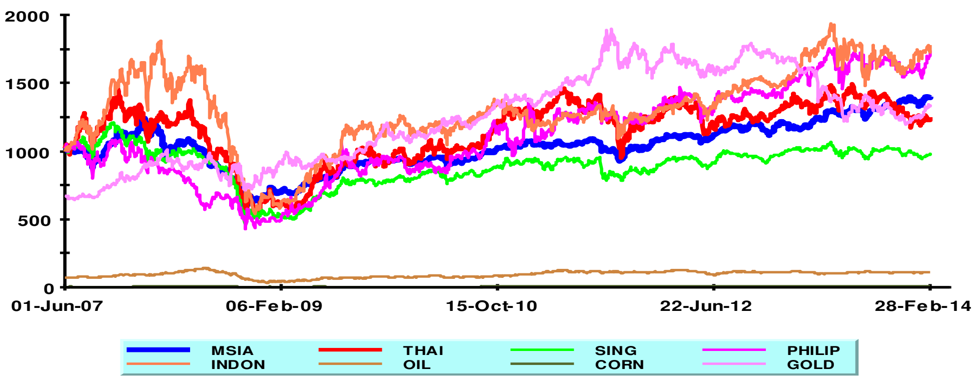
The following sections of the paper are organized as follows. Section 2 reviews the relevant literature related to commodities portfolio diversification and stock market index in time varying and scale dependence. Section 3 briefly reviews the theoretical foundations being assumed in this paper. Section 4 details out the methodologies to be employed to achieve the research objectives of this paper. Section 5 contains the comprehensive data analysis and empirical results. Section 6 discusses the results obtained from the previous section using plausible explanations and past findings in literature. References make up the end of this paper.

Table 1: List of Crude Oil Export and Import for SEA Countries

Country	Oil - export (bbl/day)	Oil - import (bbl/day)	Net exporter/(importer) (bbl/day)
Singapore	1,374,000	2,052,000	(678,000)
Malaysia	644,900	355,300	289,600
Indonesia	404,100	767,400	(363,300)
Thailand	269,100	807,100	(538,000)
Philippine	60,460	338,400	(277,940)

Source (Cia 2010)

Chart 1: Commodity Prices and South East Asian Islamic Stock Indices



2. Literature Review

Many researchers have studied the impact of crude oil price on other commodities. Among the earliest study on the price co-movement is a research done by Pindyck and Rotemberg (1990) that introduce the excess co-movement hypothesis (ECH) between commodity prices. They argue that due to herd behaviour in financial markets, prices tend to move together. Pindyck and Rotemberg found that price of largely unrelated raw commodities have a persistence tendency to move together. Further study by Baffes (2007) estimates the degree of pass-through of crude oil price changes to the prices of 35 other internationally-traded primary commodities. The results indicated that the elasticity for the non-energy commodity index was estimated at 0.16 and the fertilizer index displayed the largest pass-through, followed by the index for food commodities. The implications of this finding is that if crude oil prices remain high, the recent commodities price increase are likely to last longer than previous boom cycle, especially for the food commodities, fertilizers, and precious metals (Baffes 2007).

Research on the impact of crude oil is not only with other commodities but also with stock market variables, exchange rate and macroeconomic variables. Wong, Penn et al. (2004) study the co-movement of developed and emerging markets. Due to the liberalization of stock markets and the emergence of new capital markets in recent years, there has been an increase in investors' interest in international diversification which will allow investors to have a larger basket of foreign securities to choose from as part of their portfolio assets. This is to enhance the reward-to-volatility ratio. However, this benefit would be limited if national equity markets tend to move together in the long run. They find that there is a co-movement between some of the developed and emerging markets, but some emerging markets do differ from the developed markets with which they share a long-run equilibrium relationship. They also observed that there has been increasing interdependence between most of the developed and emerging markets since the 1987 Stock Market Crash and it has strengthened after the 1997 Asian Financial Crisis. Due to the increasing occurrence of co-movement between developed and emerging stock markets, the benefits of international diversification become limited (Wong, Penm et al. 2004) .

Park and Ratti (2008) investigate on the impact of oil price shock on real stock returns in the U.S. and 13 European countries. They find that Norway as an oil exporter shows a statistically significantly positive response of real stock returns to an oil price increase. The median result from variance decomposition analysis is that oil price shocks account for a statistically significant 6% of the volatility in real stock returns. They also find that for many European countries, increased volatility of oil prices significantly depresses real stock returns. The contribution of oil price shocks to variability in real stock returns in the U.S. and most other countries is greater than that of interest rate. An increase in real oil price is associated with a significant increase in the short-term interest rate in the U.S. and eight out of 13 European countries within one or two months (Park and Ratti 2008).

Jammazi and Aloui (2010) research on the impact of crude oil price on stock market and find that the stock market variables respond negatively and temporarily to the crude oil changes during moderate (France) and expansion (UK and France) phases but not at level to plunge them into a recession phase. However, the effect of West Texas Intermediate (WTI) changes occurred in the expansion period has driven the Japanese stock market into a recession phase. This illustrate the important role that policy makers has to play in order to counteract any inflationary impact of higher prices with monetary policy such as in UK and France. This is in contrary to policy maker in Japan, who may be unable to completely offset the increased variability of oil shocks which has contributed into the vulnerability of the stock market in Japan (Jammazi and Aloui 2010).

Vacha and Barunik (2012) investigated on the co-movement of the energy market by researching the interconnections between the main components of the energy sector in the time-frequency space. They find that some energy pairs show strong dynamics in co-movement in time during various investment horizons. The results suggest that when looking at the dependence of energy markets, one should always keep in mind its time-varying nature and look at it for various investment horizons. While the strongest dependence occurs during the periods of sharp price drops, it seems that the periods of recession creating fear in the markets imply a much higher downside risk to a portfolio based on these commodities. This inefficiency of the energy market is muted after recovery from the recession. They also find that the three commodities, heating oil, gasoline and crude oil strongly co-move, thus for the manager willing to keep a well-diversified portfolio, the trio will imply great exposure to risk. On the other hand, natural gas seems to be unrelated to all three commodities for all investment horizons as well as the studied time periods (Vacha and Barunik 2012).

In a summary, the literature studying crude oil price and its resulting impact for portfolio diversification strategies for stock market is limited (especially for Islamic stock market) and inconclusive with results reporting contradicting evidence. Hence this subject needs further investigation.

3. Theoretical Background

Two theories have been identified for this study. The first theory is by Pindyck and Rotemberg (1990) that introduce the excess co-movement hypothesis (ECH) between commodity prices, arguing that due to herd behaviour in financial markets prices tend to move together. They find that price of largely unrelated raw commodities have a persistence tendency to move together.

The second theory is by Markowitz on portfolio diversification theory. Markowitz shaped the modern portfolio theory where the volatility of a portfolio is less than the weighted average of the volatilities of the securities it contains given that the portfolio consists of assets that are not perfectly correlated in returns. The variance of the expected return on a portfolio can be calculated as:

$$\sigma_p^2 = (\Sigma W_i^2 \sigma_i^2 + \Sigma\Sigma W_i W_j Cov_{ij})$$

Where the sums are over all the securities in the portfolio, W_i is the proportion of the portfolio in security i, σ_i is the standard deviation of expected returns of security i, and Cov_{ij} is the covariance of expected returns of securities of i and j. Assuming that the covariance is less than one (invariably true), this will be less than the weighted average of the standard deviation of the expected returns of the securities. This is why diversification reduces risk (Markowitz 1959).

One of the criticisms of the earlier models of modern portfolio theory was the assumptions that the portfolio variances are normally distributed. Markowitz thought normally distributed variance is inadequate measure of risk. However, subsequent models have been developed that use asymmetric and fat tailed distributions that are closer to real world data. The methodology to be adopted in this paper M-GARCH-DCC has the ability to adopt a student-*t* distribution of variances which is more appropriate in capturing the fat-tailed nature of the distribution of index returns (Pesaran and Pesaran 2010). Furthermore, the use of wavelet transform methodologies makes no assumptions and is tantamount to producing more realistic results (In and Kim 2013). The paper elaborates the methodologies to be adopted in achieving the research objectives in the following section.

4. Methodology

4. 1 Data

The data used in this paper is the daily data of three commodities (crude oil, gold and corn) prices and Islamic stock indices of five countries (Malaysia, Thailand, Singapore, Philippine and Indonesia) from 1 June 2007 until 28 February 2014. All data obtained from DataStream at INCEIF (International Centre for Education in Islamic Finance).

4.2 Time Series Techniques

This study employs a time series technique namely cointegration and error correction modeling in order to find empirical evidence of the nature of relations between crude oil price and other stock indices. Standard time-series approaches has been adopted to test the hypothesis whether crude oil price leads (or lags) the other commodities and Islamic stock indices under review. The recent time series studies based on cointegration have applied either vector error correction and/or variance decomposition methods for testing Granger causality or lead-lag relationship. We would apply the following standard procedures to test the lead-lag relationship: We will examine the unit-root tests and the order of the VAR, and then we will apply Johansen cointegration test. However, the evidence of cointegration cannot tell us which variable is leading and lagging. Therefore, we have to test through vector error correction model (VECM) that can indicate the direction of Granger causality both in the short and long run (Masih, Al-Elg et al. 2008). The VECM, however, cannot inform us which variable is relatively more exogenous or endogenous. The appropriate technique to identify the most exogenous and endogenous variable is variance decomposition technique. However, the software that we use to test the time-series techniques is limited to 150 observations for testing variance decomposition. Our daily data consist of 1,762 observations. Therefore, the 150 observations only produce a result that covers 5 month observation of our total data which is insufficient to give a reliable opinion. Therefore, we apply Maximum Overlap Discrete Wavelet Transformation (MODWT) to test the lead and lag of the identified exogenous variables in different time scale.

4.3 Maximum Overlap Discrete Wavelet Transformation (MODWT)

According to literature, both Discrete Wavelet Transform (DWT) and Maximal Overlap Discrete Wavelet Transform (MODWT) can decompose the sample variance of a time series on a scale-by-scale basis via its squared wavelet coefficients. However, the MODWT-based estimator has been shown to be superior to the DWT-based estimator (Percival 1995; Gallegati 2008). Therefore, we are going to apply Maximal Overlap Discrete Wavelet Transform (MODWT) in our study.

Whitcher et al. (1999, 2000) extended the notion of wavelet variance for the maximal overlap DWT (MODWT) and introduced the definition of wavelet covariance and wavelet correlation between the two processes, along with their estimators and approximate confidence intervals. To determine the magnitude of the association between two series of observations X and Y on a scale-by-scale basis the notion of wavelet covariance has to be used. Following Gençay et al. (2001) and Gallegati (2008) the wavelet covariance at wavelet scale j may be defined as the covariance between scale j wavelet coefficients of X and Y, that is $\gamma_{XY,j} = \mathrm{Cov}[\tilde{\omega}_{j,t}^{X}\tilde{\omega}_{j,t}^{Y}]$.

An unbiased estimator of the wavelet covariance using maximal overlap discrete wavelet transform (MODWT) may be given by the following equation after removing all wavelet coefficients affected by boundary conditions (Gallegati 2008),

$$\tilde{\gamma}_{XY,j} = \frac{1}{\tilde{N}_j} N - 1 \sum_{t=L_{J-1}}^{N-1} \tilde{\omega}_{j,t}^{X}\tilde{\omega}_{j,t}^{Y}$$

Then, the MODWT estimator of the wavelet cross-correlation coefficients for scale j and lag τ may be achieved by making use of the wavelet cross-covariance, $\tilde{\gamma}_{\tau,XY,j}$, and the square root of their wavelet variances $\tilde{\sigma}_{X,j}$and $\tilde{\sigma}_{Y,j}$ as follows:

$$\tilde{\rho}_{\tau,XY,j} = \frac{\tilde{\gamma}_{\tau,XY,j}}{\tilde{\sigma}_{X,j}\tilde{\sigma}_{Y,j}}$$

The wavelet cross-correlation coefficients $\tilde{\rho}_{\tau,XY,j}$, similar to other usual unconditional cross-correlation coefficients, are between 0 and 1 and offers the lead/lag relationships between the two processes on a scale-by-scale basis.

Starting from spectrum $S_{\omega\, X,j}$ of scale j wavelet coefficients, it is possible to determine the asymptotic variance Vj of the MODWT-based estimator of the wavelet variance (covariance). After that, we construct a random interval which forms a 100(1 − 2p)% confidence interval. The formulas for an approximate 100(1 − 2p)% confidence intervals MODWT estimator robust to non-Gaussianity for $\tilde{\upsilon}^2_{X,j}$ are provided in Gençay et al. (2002) and Gallegati (2008). According to empirical evidence from the wavelet variance, it suggests that Nj = 128 is a large enough number of wavelet coefficients for the large sample theory to be a good approximation (Whitcher, Guttorp et al. 2000; Gallegati 2008).

4.4 Multivariate GARCH – Dynamic Conditional Correlation

We also relied on the Multivariate Generalised Autoregressive Conditional Heteroscedastic (MGARCH) model in Pesaran and Pesaran (2010) to answer our fourth research question. We tested for both normal and *t* distributions, to determine which would model our case at optimum level. Results of unconditional correlation coefficients could suffice to provide empirical evidence to answer our fourth research question. However, we require the computation of conditional cross-asset correlations in order to address the fourth objective in more comprehensive through using DCC-MGARCH computation as

$$\tilde{\rho}_{ij,t-1}(\phi) = \frac{q_{ij,t-1}}{\sqrt{q_{ii,t-1}q_{jj,t-1}}}$$

Where $q_{ij,t-1}$ are given by

$$q_{ij,t-1} = \bar{\rho}_{ij}(1 - \phi_1 - \phi_2) + \phi_1 q_{ij,t-2} + \phi_2 \tilde{r}_{i,t-1}\tilde{r}_{j,t-1}$$

In the above, $\bar{\rho}_{ij}$ is the (*i,j*)th unconditional correlation, ϕ_1 and ϕ_2 are parameters such that $\phi_1 + \phi_2 < 1$, and $\tilde{r}_{i,t-1}$ are the standardized asset returns.

We also test whether the computed volatility is mean-reverting by estimating $(1 - \lambda_{i1} - \lambda_{i2})$. Some diagnostic tests are conducted to substantiate the validity of our models. For more detail regarding this model, it can be found in Pesaran and Pesaran (2010).

4.4 Continuous Wavelet Transformation (CWT)

To answer the fifth question of our research, we need to apply continuous wavelet transform (CWT). A number of authors have recently started to use the continuous wavelet transform (CWT) in economics and finance research for example Saiti (2012). The CWT maps the original time series, which is a function of just one variable time-separate into function of two different variables such as time and frequency. One major benefit CWT has over DWT/MODWT is that we need not define the number of wavelets (time-scales) in CWT which generates itself according to the length of data. Other than that, the CWT maps the series correlations in a two-dimensional figure that allows us to easily identify and interpret patterns or hidden information (Saiti 2012). For both MODWT and CWT, we use the Daubechies (1992) least asymmetric wavelet filter of length L=8 denoted by LA (8) based on eight non-zero coefficients (Daubechies 1992). Previous studies on high-frequency data have shown that a moderate-length filter such as L = 8 is adequate to deal with the characteristic features of time-series data (Gençay, Selçuk et al. 2001; Gençay, Selçuk et al. 2001; In and Kim 2013). In the literature, it is argued that an LA (8) filter generates more smooth wavelet coefficients than other filters such as Haar wavelet filter.

The continuous wavelet transform (CWT) $W_X(u,s)$ is obtained by projecting a mother wavelet ψ onto the examined time series $x(t) \in L^2(\mathbb{R})$, that is:

$$W_X(u,s) = \int_{-\infty}^{\infty} x(t) \frac{1}{\sqrt{s}} \psi\left(\frac{t-u}{s}\right) dt$$

The position of the wavelet in the time domain is given by *u*, while its position in the frequency domain is given by *s*. Therefore, the wavelet transform, by mapping the original series into a function of *u* and *s*, gives us information simultaneously on time and frequency. We need to apply a bivariate framework which is called wavelet coherence to be able to study the interaction between two time series, how closely X and Y are related by a linear transformation. The wavelet coherence of two time series is defined as:

$$R_n^2(s) = \frac{\left|S(s^{-1}W_n^{xy}(s))\right|^2}{S(s^{-1}|W_n^x(s)|^2 . S(s^{-1}\left|W_n^y(s)\right|^2}$$

Where *S* is a smoothing operator, *s* is a wavelet scale, $W_n^x(s)$ is the continuous wavelet transform of the time series X, $W_n^y(s)$ is the continuous wavelet transform of the time series Y, $W_n^{xy}(s)$ is a cross wavelet transform of the two time series X and Y (Madaleno and Pinho 2012). For further details, interested readers may refer to Gencay et al (2001; 2002) and In and Kim (2013).

5. Empirical Findings and Interpretations

5.1 Findings and Interpretations of Standard Time-Series Techniques

We tested the unit roots of all the variables and found that they could be taken as I(1) on the basis of ADF tests. We also find that the optimal order of the VAR is two for AIC meanwhile for SBC, the optimal order of VAR is one. Therefore, we rely on AIC test by taking the optimal level of VAR as two. We applied the standard Johansen cointegration test (Table 2) and found them to have one cointegrating vector at 95% significance level on the basis of maximal Eigenvalue statistics and three cointegration vectors under trace statistics. An evidence of cointegration implies that the relationship among the variables is not spurious and indicates that there is a theoretical relationship among the variables and they are in equilibrium in the long run. It also indicate that the diversification benefits for variables under review is minimised in the long run because they tend to move in the same direction. The cointegration test, however, cannot inform us the direction of Granger causality as to which variable is leading and which variable is lagging. We have applied the vector error correction model technique (Table 3) with one cointegrating vector to identify the exogeneity and endogeneity of the variables. From Table 3, we can identify that the Singapore, Philippine and Indonesia Islamic stock indices are exogenous but the Malaysia and Thailand Islamic stock indices, crude oil, corn and gold prices are endogenous. That tends to indicate that the Malaysia and Thailand Islamic stock indices, crude oil, corn and gold prices would respond to the Singapore, Philippine and Indonesia Islamic stock indices. The error correction model helps us distinguish between the short-term and long-term Granger causality. The error correction term stands for the long-term relations among the variables. The impact of each variable in the short-term is given by the ‘F ’-test of the joint significance or insignificance of the lags of each of the ‘differenced’ variables. The diagnostics of all the equations of the error correction model (testing for the presence of autocorrelation, functional form and heteroskedasticity) tend to indicate that the equations are more or less well-specified.

The proportion of the variance decomposition explained by its own past shocks can determine the relative exogeneity/endogeneity of a variable. However, the software that we use to test the variance decomposition limits our observations into 150 only whereby our total observation is 1,762. Therefore, in order to identify the lead-lag relationship between the selected exogenous variables, we apply Maximum Overlap Discrete Wavelet Transformation (MODWT).

Table 2: Johansen ML Results for Multiple Cointegrating Vectors of SEA Islamic Stock Indices and Commodities Prices

Ho	H_1	Statistic	95% Crit.	90% Crit.
Maximum Eigenvalue Statistics				
$r = 0$	$r = 1$	60.98	55.14	52.08
$r \leq 1$	$r = 2$	45.87	49.32	46.54
Trace Statistics				
$r = 0$	$r \geq 1$	232.41	182.99	176.92
$r \leq 1$	$r \geq 2$	171.42	147.27	141.82
$r \leq 2$	$r \geq 3$	125.55	115.85	110.60
$r \leq 3$	$r \geq 4$	82.02	87.17	82.88

Table 3: Error Correction Model of SEA Islamic Stock Indices and Commodities Prices

Dependent Variable	DMsia		DThai		DSing		DPhilip		DIndon		DOil		DCorn		DGold	
DMsia(1)	-0.083	(0.03)	0.01138	(0.06)	-0.117	(0.04)	-0.013	(0.06)	-0.106	(0.06)	-0.048	(0.06)	-0.195	(0.07)	-0.0519	(0.04)
DThai(1)	0.0209	(0.01)	-0.0553	(0.03)	-0.052	(0.02)	-9E-04	(0.03)	0.043	(0.03)	-0.033	(0.03)	-0.039	(0.04)	-0.0164	(0.02)
DSing(1)	0.0479	(0.02)	-0.0234	(0.04)	-0.002	(0.03)	0.273	(0.04)	0.062	(0.04)	0.1758	(0.04)	0.125	(0.05)	0.11215	(0.03)
DPhilip(1)	-0.001	(0.01)	0.01094	(0.02)	-0.021	(0.02)	-0.013	(0.03)	0.027	(0.02)	-0.014	(0.03)	-0.027	(0.03)	0.00665	(0.02)
DIndon(1)	0.0716	(0.01)	0.04791	(0.03)	0.027	(0.02)	0.02	(0.03)	0.003	(0.03)	0.0037	(0.03)	0.002	(0.03)	-0.0231	(0.02)
DOil(1)	0.0605	(0.01)	0.10943	(0.02)	0.039	(0.02)	0.051	(0.03)	0.075	(0.03)	-0.02	(0.03)	-0.053	(0.03)	-0.0265	(0.02)
DCorn(1)	0.0284	(0.01)	0.06219	(0.02)	0.027	(0.02)	0.057	(0.02)	0.04	(0.02)	0.079	(0.02)	0.019	(0.02)	0.04893	(0.01)
DGold(1)	0.0099	(0.02)	0.02702	(0.03)	0.049	(0.03)	0.015	(0.04)	0.086	(0.04)	0.0191	(0.04)	0.022	(0.04)	-0.0096	(0.02)
ECM (-1)	0.0019	(0.001)	0.00893	(0.002)	9E-04	(0.001)*	-1E-03	(0.002)*	0.004	0.002)*	-0.006	(0.002)	-0.007	(0.002)	-0.0032	(0.001)
Chi - square SC(1)	22.385	(0.00)	2.6489	(0.10)	0.719	(0.40)	3.752	(0.05)	6.087	(0.01)	10.159	(0.001)	1.155	(0.28)	4.10E-02	(0.84)
Chi - square FF(1)	0.0075	(0.93)	4.9755	(0.03)	5.373	(0.02)	0.635	(0.43)	0.078	(0.78)	0.3387	(0.56)	0.429	(0.51)	8.8217	(0.003)
Chi - square N(2)	12173	(0.00)	2220.1	(0.00)	2826	(0.00)	2177	(0.00)	1930	(0.00)	1313.5	(0.00)	514.9	(0.00)	1923	(0.00)
Chi - square Het(1)	20.107	(0.00)	33.6934	(0.00)	76.37	(0.00)	52.99	(0.00)	12.57	(0.00)	54.702	(0.00)	14.35	(0.00)	28.7888	(0.00)

Notes: SEs are given in parenthesis. The diagnostics are chi-squared statistics for: serial correlation (SC), functional form (FF), normality (N) and heteroskedasticity (Het). The equations, therefore, are more or less well specified.
* Indicate significance at the 5% level.

5.2 Findings and Interpretations of Maximum Overlap Discrete Wavelet Transformation (MODWT)

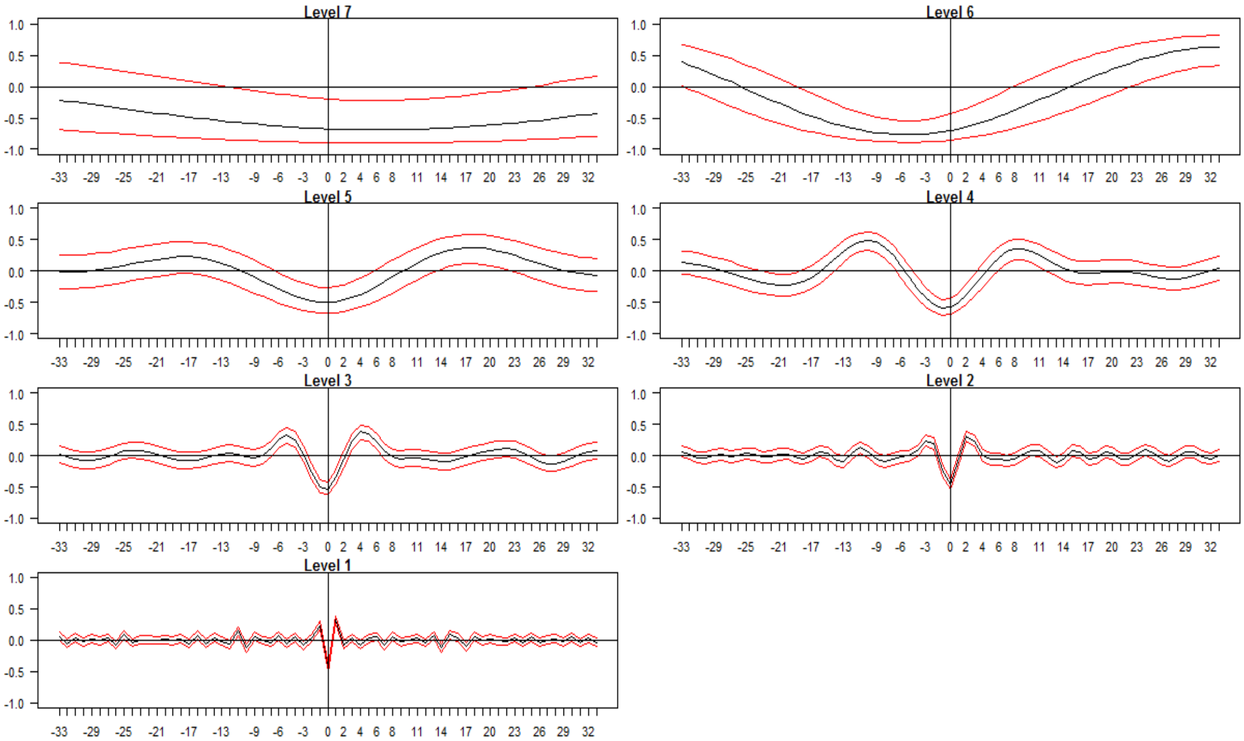
In Figure 1, we report the MODWT-based wavelet cross-correlation between the crude oil and gold at all period with the corresponding approximate confidence intervals, against time leads and lags for all scales, where each scale is associated with a particular time period. The individual cross-correlation functions correspond to – from bottom to top – wavelet scales λ_1 …, λ_8 which are associated with changes of 1-2, 2-4, 4-8, 8-16, 16-32, 32-64, and 64-128 days. The red lines bound approximately 95% confidence interval for the wavelet cross-correlation. If the curve is significant on the right side of the graph, the second variable is leading. If the curve is significant on the left side of the graph, it is the opposite. If both the 95% confidence levels are above the horizontal axes, it is considered as significant positive wavelet cross-correlation; if both the 95% confidence levels are below the horizontal axes, it is considered as significant negative wavelet cross-correlation.

The Figure 1 indicates that the wavelet cross-correlation between Singapore Islamic stock index return (ISIR) and Indonesia ISIR. From this figure, we could observe that:

- ***i)*** At the wavelet levels 1, 2 and 5, there is no clear lead-lag relationship evidence between these two Islamic stock index returns;
- ***ii)*** At the wavelet levels of 3, 4 and 6, we can observe that the graph skewed to the left which indicate that the Singapore ISIR leads the Indonesia ISIR;
- ***iii)*** At the wavelet level 7 which associated with 64-128 days, the graph skewed to right hand side with significant negative value which implies that the Indonesia ISIR is leading the Singapore ISIR.

We can conclude here that on the most of levels the Singapore ISIR leads Indonesia ISIR with the exception of on scale 7. More importantly, there will be diversification benefit between these two indices in the long-run. Singapore as a developed country with a strong economy in the SEA region is expected to have influence on other countries in the region. Our result is in line with our expectation in most levels with the exception of level 7. The reason for the result of level 7 is that even though Singapore has strong economy, Indonesia GDP and population are much bigger compare to Singapore and therefore, Indonesia may influence other countries in the long run.

Figure 1: Maximum Overlap Discrete Wavelet Transformation: Singapore ISIR vs. Indonesia ISIR



The Figure 2 shows that the wavelet cross-correlation between Singapore ISIR and Philippine ISIR. From this figure, we derive the following facts:

- ***i)*** At the wavelet levels 1 and 5, there is no clear lead-lag relationship evidence between these two ISIRs;
- ***ii)*** At the wavelet levels of 2, 3, 4 and 7, we can observe that the graph skewed to the left which indicate that the Singapore ISIR leads the Philippine ISIR;
- ***iii)*** At the 6 wavelet level, we can observe that the graph skewed to the right which indicate that Philippine ISIR lead Singapore ISIR.

We can conclude here that on the most of levels the Singapore ISIR leads Philippine ISIR with the exception of on scale 6. The result also in line with our expectation that Singapore as the developed nation with stronger economy compare to Philippine may influence Philippine ISIR.

The Figure 3 shows that the wavelet cross-correlation between Indonesia ISIR and Philippine ISIR. From this figure, we may observe the followings:

- ***i)*** At the wavelet levels 1, 2 and 3, there is no clear lead-lag relationship evidence between these two ISIRs;
- ***ii)*** At the wavelet levels of 4, we can observe that the graph skewed to the left which indicate that the Indonesia ISIR leads the Philippine ISIR;
- ***iii)*** At level 5, 6 and 7, the graph skewed to right hand-side with significant negative value. This may imply that the Philippine ISIR leads Indonesia ISIR.

We may conclude that, the Philippine ISIR leads the Indonesia ISIR in the long-run with negative correlation.

Figure 2: Maximum Overlap Discrete Wavelet Transformation: Singapore ISIR vs. Philippine ISIR

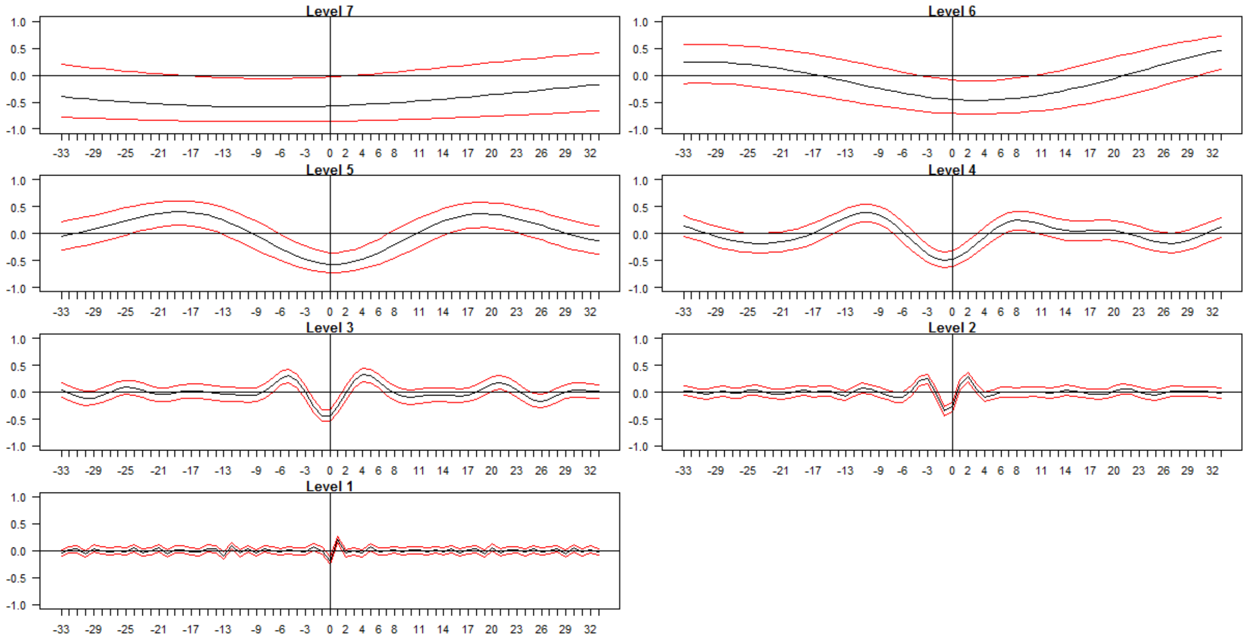
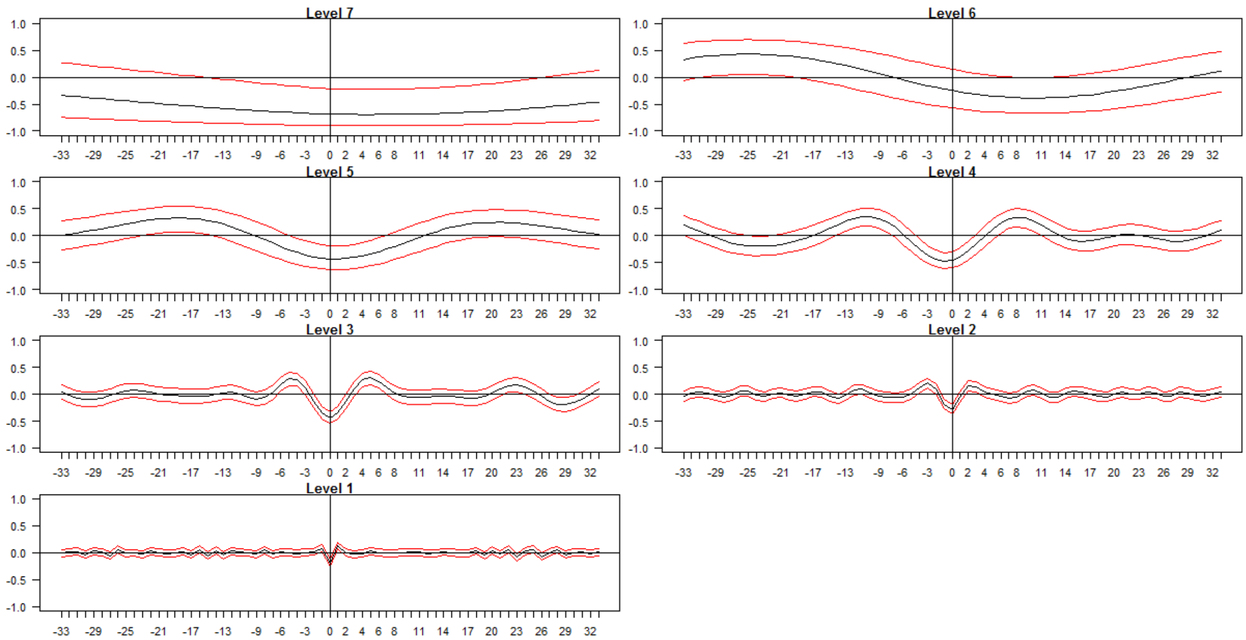


Figure 3: Maximum Overlap Discrete Wavelet Transformation: Indonesia ISIR vs. Philippine ISIR



5.3 Findings and Interpretations of MGARCH-DCC

In order to assess the diversification benefits of the selected commodities and SEA Islamic stock indices, we have applied Dynamic Conational Correlation (MGARCH-DCC) instead of Constant Conational Correlation in this Section. Table 4 summarises the maximum likelihood estimates of λ_{i1} and λ_{i2} for the commodities prices returns and Islamic stock indices, and δ_1 and δ_2, comparing multivariate normal distribution with multivariate student *t*-distribution.

The maximised log-likelihood value for the case of *t*-distribution [52,252.6] is larger than that obtained under the normality assumption [51,864.7]. The estimated degree of freedom for the *t*-distribution [7.984] was below 30; and any other value one would expect for a multivariate normal distribution. This suggests that the *t*-distribution is more appropriate in capturing the fat-tailed nature of the distribution of price returns. Henceforth our analysis will work with the *t*-distribution estimates.

Table 5 shows the estimated unconditional volatilities (diagonal elements) and the unconditional correlations (off-diagonal elements) of the eight variables. The numbers in parenthesis in the diagonal elements represent ranking of unconditional volatility (from highest to lowest). The ranking is characteristic of the volatility of the eight variables. The corn price, Philippine Islamic stock index and crude oil price tend to receive a larger share of speculative trades based on the unconditional volatility as illustrated in Table 5. Malaysia Islamic stock index show the lowest volatility, reflecting Malaysia as a stable and biggest Islamic capital market in the region.

Table 4: Estimates of λ_{i1} and λ_{i2}, and δ_1 and δ_2, for the Eight Variables under Review

		Multivariate Normal Distribution		Multivariate *t* Distribution	
		Estimate	T-Ratio	Estimate	T-Ratio
Lamda 1 (λ 1)	Msia	0.91678	42.9836	0.92370	3.7115
	Thai	0.88463	53.8265	0.87007	40.3920
	Sing	0.90985	75.7235	0.92219	76.6757
	Philip	0.73393	22.6003	0.75254	21.7652
	Indon	0.92778	92.4579	0.92418	57.8555
	Oil	0.95681	136.328	0.95782	127.3073
	Corn	0.93088	58.7293	0.94247	76.3719
	Gold	0.93180	99.5325	0.95692	135.8499
Lamda 2 (λ 2)	Msia	0.07543	4.1069	0.06955	4.6627
	Thai	0.09122	7.6898	0.09684	6.5717
	Sing	0.08279	7.7565	0.06883	6.7340
	Philip	0.20385	9.0179	0.18709	7.8104
	Indon	0.06538	7.6085	0.06588	5.0271
	Oil	0.04098	6.5202	0.03843	5.9477
	Corn	0.05255	5.0198	0.04445	5.3509
	Gold	0.05866	7.7464	0.03798	6.5889
Delta 1 ($\delta 1$)		0.96542	115.6400	0.95888	53.8541
Delta 2 ($\delta 2$)		0.01052	7.2760	0.01133	4.7656
Maximised log-likelihood		51864.7		52252.6	

Degree of freedom (df)	-	7.984

Note: λ_1 and λ_2 are decay factors for variance and covariance, respectively.

More relevant to the fourth objectives of this paper are the correlations among the commodities prices and Islamic stock index. A brief examination of the unconditional correlations reported in Table 6 highlight the fact that the gold price has the lowest correlations with other variables. To have a clearer picture of the relative correlation among prices, we ranked the unconditional correlations (from highest to lowest) as shown in Table 6.

Table 5: Estimated Unconditional Volatility Matrix for the Commodities Prices Return and SEA Islamic Stock Indices Return

	Msia		Thai		Sing		Philip		Indon		Oil		Corn		Gold	
Msia	0.004	(8)	0.3899		0.4341		0.3036		0.4335		0.1954		0.0977		0.0791	
Thai	0.3899		0.008	(5)	0.5224		0.256		0.4449		0.274		0.1508		0.0415	
Sing	0.4341		0.5224		0.006	(6)	0.28		0.4842		0.2761		0.1247		0.0578	
Philip	0.3036		0.256		0.28		0.0088	(2)	0.286		0.1218		0.0606		0.0624	
Indon	0.4335		0.4449		0.4842		0.286		0.0085	(4)	0.1984		0.1046		0.0738	
Oil	0.1954		0.274		0.2761		0.1218		0.1984		0.0087	(3)	0.2728		0.3004	
Corn	0.0977		0.1508		0.1247		0.0606		0.1046		0.2728		0.0097	(1)	0.1465	
Gold	0.0791		0.0415		0.0578		0.0624		0.0738		0.3004		0.1465		0.0058	(7)

Table 6: Ranking of Unconditional Correlations among Commodities Prices Return and SEA Islamic Stock Indices Return

Malaysia (MSIA)	Thailand (THAI)	Singapore (SING)	Philippine (PHILIP)	Indonesia (INDON)	Crude Oil (OIL)	Corn (CORN)	Gold (GOLD)
SING	SING	THAI	MSIA	SING	GOLD	OIL	OIL
INDON	INDON	INDON	INDON	THAI	SING	THAI	CORN
THAI	MSIA	MSIA	SING	MSIA	THAI	GOLD	MSIA
PHILIP	PHILIP	PHILIP	THAI	PHILIP	CORN	SING	INDON
OIL	OIL	OIL	OIL	OIL	INDON	INDON	PHILIP
CORN	CORN	CORN	GOLD a	CORN	MSIA	MSIA	SING
GOLD a	GOLD a	GOLD a	CORN	GOLD a	PHILIP	PHILIP	THAI

The above rankings inform us two important facts. First, for almost all Islamic stock indices under review, (with the exception of Philippine ISIR), the lowest correlation is with the gold commodity (see notation ‘a’ in Table 6). This implies that in order to fully benefit from portfolio diversification, an exposure in Islamic stock indices should include gold commodity. Gold also can act as an almost perfect hedge instrument against inflation (Worthington and Pahlavani 2007). Besides that, gold is also the second lowest in term of volatility as indicated in Table 5 and this fact increase gold role as a good diversification commodity for Islamic stock indices.

Second and more pertinent, crude oil price return has the lowest correlation with Philippine, Malaysia and Indonesia ISIR. Philippine and Indonesia is a net importer of energy resources as indicated in Table 1, thereby, their economic performance should be more sensitive toward crude oil price fluctuation compare to Malaysia that is a net exporter. However, the result indicates that the exposure of *Shariah*-compliant indices in Philippine, Malaysia and Indonesia with crude oil is low. Based on unconditional result in Table 6, any investor with an exposure in crude oil and want to obtain maximum diversification in Islamic stock index of SEA countries should invest in Philippine, Malaysia and Indonesia.

Thus far, our analyses and conclusions on volatilities and correlations have been made on unconditional basis. Unconditional basis mean we take the average volatility and correlation in the sample period. However, the assumption that volatility and correlation remain constant throughout a period spanning over 6 years does not appeal to intuition. It is more likely that volatility and correlation are dynamic in nature and it is this aspect which the Dynamic Correlation Coefficient (DCC) model employed in this paper addresses.

We start with observing the temporal dimension of volatility. We chart the conditional volatilities for the eight variables as per Chart 2 below. During those 6 years under observation, we noticed that Philippine Islamic stock index has the highest volatility compare to others. The lowest volatility during that period is Malaysia Islamic stock index. The highest increases in volatility are during the Global Financial Crisis in 2008 as illustrated in Chart 2. Philippine Islamic stock index is extremely volatile compare against other variables and it randomly volatile throughout those 6 years under observation. From the chart below, we can conclude that it is very risky to invest in Philippine Islamic stock index since it is highly volatile and unpredictable compare against other variables. We also notice that Malaysia Islamic stock index is the most stable variable index compare to the rest as illustrated in Chart 2.

Chart 2: Conditional Volatilities of All Commodities Prices Return and SEA Islamic Stock Index Return

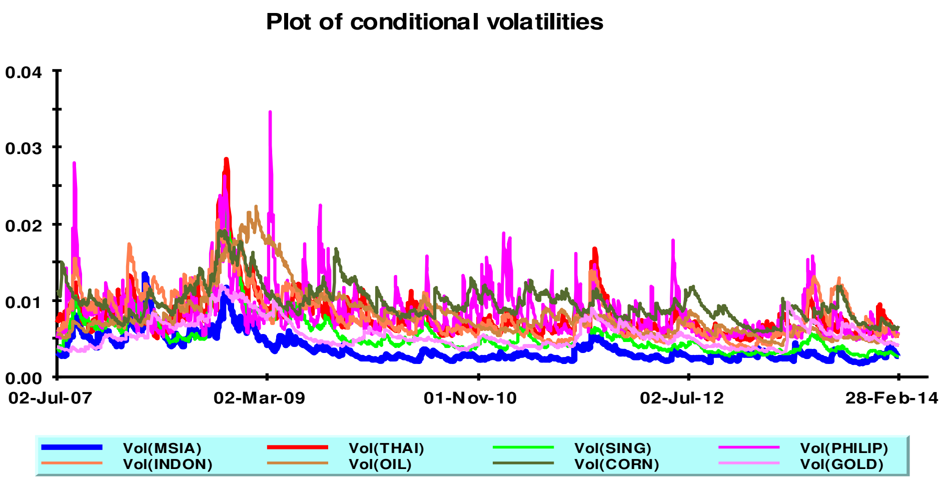
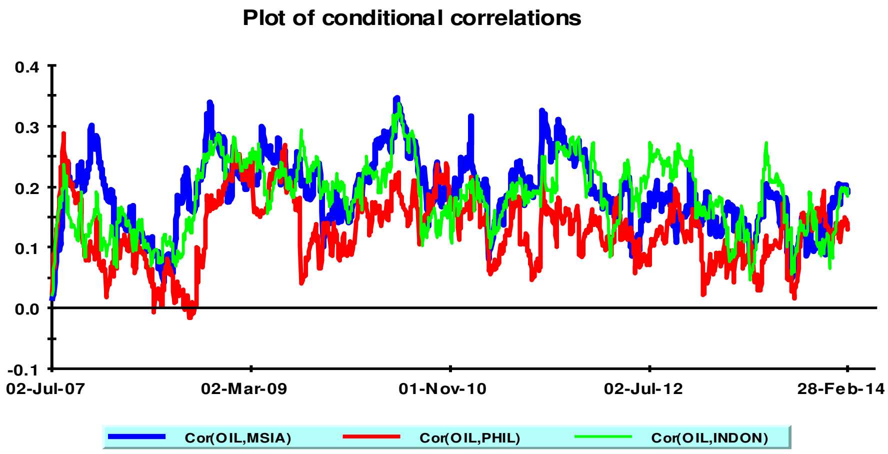


Chart 3: Conditional Correlation of Crude Oil Prices Return with Malaysia, Indonesia and Philippine ISIR



Through conditional correlations as described in Chart 3 above, we compare the correlation between crude oil price return with other SEA Islamic stock indices return of Malaysia, Philippine and Indonesia. Chart 3 depicted that from 2007, before Global Financial Crisis in 2008, the correlation of crude oil with Malaysia, Indonesia and Philippine ISIR is in downward trend. Whenever the Global Financial Crisis hit SEA in 2008, the correlation with crude oil for Malaysia, Indonesia and Philippine ISIR start to increase significantly. We also noticed that from year 2010 onward, the correlations show a slight downtrend until 2014. The highest correlation of crude oil is with Indonesia ISIR and the lowest correlation of crude oil is with Philippine ISIR. The second lowest correlation of crude oil is with Malaysia ISIR. Investor that having exposure portfolio in crude oil is better off with diversification in Malaysia ISIR than Philippine ISIR because Philippine ISIR volatility is too high which offset it benefit as a diversification portfolio. Malaysia ISIR is not only the second lowest correlation with crude oil but Malaysia ISIR has the lowest volatility as identified in our previous test (please refer to Table 5 and Chart 2). Besides that, Malaysia Islamic capital market is the largest in the region that will provide stability and liquidity to investors.

5.4 Correlation of Crude Oil Price Return (PR) with the Asian Islamic Stock Indices at Different Time and Investment Horizons Based on the Continuous Wavelet Transform

Chart 4 to 8 present the estimated continuous wavelet transform and phase difference for variables under review from scale 1 (one day) up to scale of 8 (approximately two market years, 512 days). Time is shown on the horizontal axis in terms of number of trading days, while the vertical axis refers to the investment horizon. The curved line below shows the 5% significance level which is estimated using Monte Carlo simulations. The figure follows a colour code as illustrated on the right with power ranges from blue (low correlations) to red (high correlations).

Any investor that has exposure in crude oil commodity and want to invest in Islamic stock indices of SEA countries in order to obtain diversification benefit, he/she will need to know the correlation between the crude oil price and the Islamic stock indices. From Chart 4 below, any investor that would like to invest in Singapore Islamic stock index and at the same time having exposure in crude oil, he should not hold his portfolio more than 16 days in order to obtain diversification benefit. The correlation between Singapore Islamic stock index and crude oil is highly correlated in high scale (more than 128 days) period. Between 16 days to 128 days investment horizon, the correlation between the two variables is high in certain period such as in year 2009 to 2010 but most of the time, the correlation of the two variables is low.

For investor that interested to hold portfolio of crude oil and Malaysia Islamic stock index, he should hold that investment for not more than a year (within 1 day to 256 days) in order to obtain the diversification benefit. If his investment is beyond one year or more than 256 days, he will be expose to high correlation (please refer to Chart 5). From the Chart 5 also we noticed the correlation of crude oil with Malaysia Islamic stock index is lower compare against the Singapore Islamic stock index. Singapore economy is more sensitive toward the crude oil price fluctuation compare against Malaysia mainly due to Singapore is net importer of crude oil and rely heavily on it for energy.

Indonesia and Thailand exposure to crude oil prices is quite similar to Singapore exposure. By referring to Chart 6 and 8, we notice that in lower scale below 32 days investment holding period, the diversification benefit will be obtained by investor since the correlation between the ISIR and crude oil prices return is low. At the high scale period from 128 days onward, the correlation between the two subjects is very high and this eliminates the diversification benefit of the portfolio. Between 16 days to 128 days investment horizon, the correlation between the variables under review is high in certain period but for most of the time, the correlation of the two variables is low.

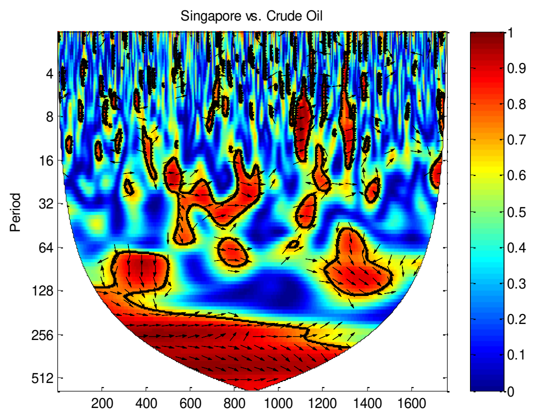
From Chart 7, we notice that Philippine has the lowest correlation with crude oil compare against other countries. The correlation is very low from 1 day to 256 days of holding period. After that period, it become highly correlated. Any investor that would like to invest in Philippine Islamic stock index can obtain diversification benefit with crude oil prices return if his holding period is less than a year.

Table 7: Date for Horizontal Axis

Horizontal Axis	Date
200	March 2008
400	December 2008
600	September 2009
800	June 2010
1000	April 2011
1200	January 2012
1400	October 2012
1600	July 2013

Chart 4: CWT – Singapore ISIR vs. Crude Oil PR

Chart 5: CWT – Malaysia ISIR vs. Crude Oil PR



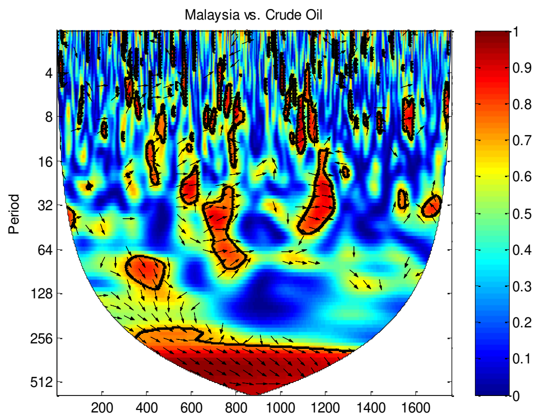


Chart 6: CWT – Indonesia ISIR vs. Crude Oil PR

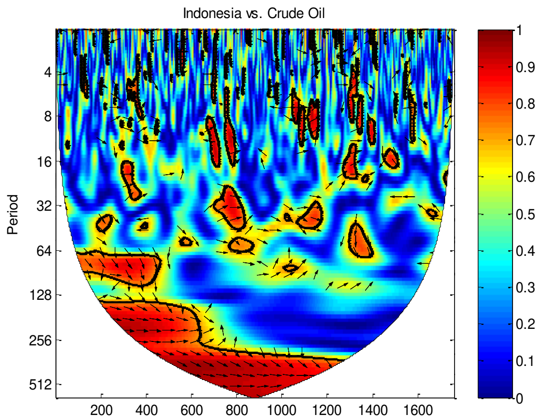


Chart 7: CWT – Philippine ISIR vs. Crude Oil PR

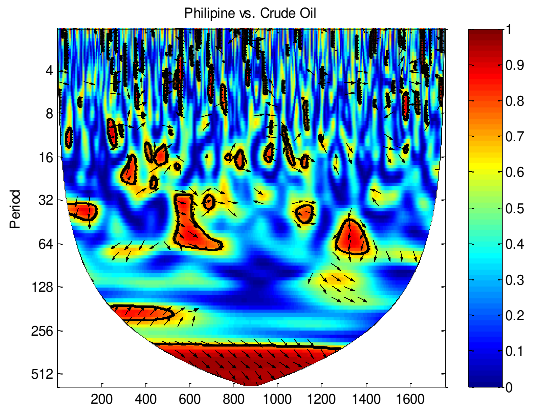
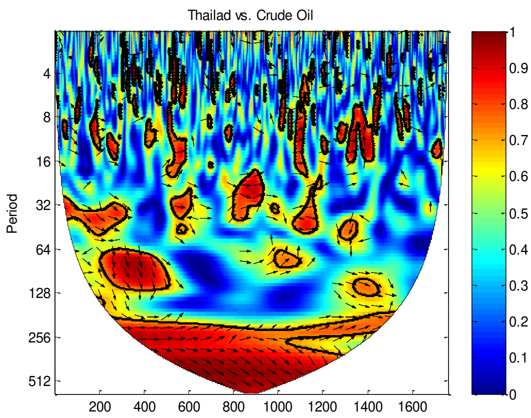


Chart 8: CWT – Thailand ISIR vs. Crude Oil PR



6. Concluding Remarks

In order to address the research objectives, we have applied cointegration test, error-correction modelling and several recently introduced econometric techniques such as Maximum Overlap Discrete Wavelet Transformation (MODWT), Continuous Wavelet Transformation

(CWT) and Multivariate GARCH – Dynamic Conditional Correlation. Our major findings as follows:

Firstly, we found that cointegrating (or theoretical) relationship does exist between Islamic stock indices and selective commodities as evidenced from cointegration test. This implies that in the long run, diversification benefits among the variables under review will be minimised because they tend to move in the same direction. The error-correction model results indicate that the Singapore, Philippine and Indonesia Islamic stock indices are exogenous but the Malaysian and Thailand Islamic stock indices, crude oil, corn and gold prices are endogenous. That tends to indicate that the Malaysian and Thailand Islamic stock indices, crude oil, corn and gold prices would respond to the Singapore, Philippine and Indonesia Islamic stock indices. Singapore as a developed nation with advanced capital market is expected to have influence on other nations in the region. Meanwhile for Indonesia, she is the largest economy in SEA region with most population and therefore is expected to lead other ISIR in the region. Our VECM causality results are in line with our expectations.

Secondly, by referring to Maximum Overlap Discrete Wavelet Transformation (MODWT) results, we can conclude that in most levels, the Singapore ISIR leads Indonesian Islamic stock index return with the exception of level 7. This is may be due to Indonesia being a bigger nation compared to Singapore and its GDP, population and ISIR are also larger. Therefore, in the long run, Indonesia ISIR is expected to lead Singapore ISIR. Our findings on Singapore and Philippine ISIR based on MODWT test also confirm our expectation that Singapore should lead Philippine almost at all levels due to Singapore's status as a developed nation with stronger economy and ISIR compared to that of Philippine. However, the MODWT test between Indonesia ISIR and Philippine ISIR does not conform to our expectation. The Philippine ISIR is leading Indonesian ISIR in the high level (level 5, 6 and 7) even though Indonesia is a bigger nation with stronger economy and more population compared to Philippine. This provides us with an opportunity for further research in the future to gain more understanding of the relation between these two ISIR.

Thirdly, the results of Multivariate GARCH – Dynamic Conditional Correlation tend to indicate that Malaysian Islamic stock indices show the lowest volatility, reflecting Malaysia as a stable and largest market in the Islamic capital market. Besides that, Malaysian ISIR is also the second least correlated with the crude oil price. Therefore, it is advisable for the investors that have exposure in crude oil and want to invest in ISIR of SEA countries, to invest in Malaysian ISIR to gain diversification benefits. Even though the Philippine ISIR is the least correlated with crude oil price return, her highly volatile index offsets its benefit as a diversification portfolio.

Last but not the least, the findings based on the Continuous Wavelet Transformation (CWT) tend to show that the diversification benefits can be obtained in ISIR of SEA countries with crude oil price return in the low scale holding period within 16 days. Between 16 days to 64 days of investment horizons, the correlation between ISIR of SEA countries with the crude oil price return is highly correlated in certain periods. Overall, the correlation in this period is still very low compared to the correlation in the longer term investment horizon from 64 days onward. The CWT results also confirm the results from the MGARCH – DCC that indicate that the Philippine ISIR is the least correlated with crude oil price return and the Malaysian ISIR is the second least correlated.

We can clearly see the contributions of the wavelet transformations in helping us understand portfolio diversification opportunities for the investors with different investment horizons or holding stocks over different periods.

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