The Impact of Crude Oil Price on Islamic Stock Indices of Gulf Cooperation Council (GCC) 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 (positive or negative) and size (stronger or weaker) is 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' correlations between the selected Islamic stock indices of Gulf Cooperation Council (GCC) countries and selected commodities. Particularly, by incorporating scale dependence, it is able to identify unique portfolio diversification opportunities for different set of investors bearing different investment horizons or holding periods. In order to address the research objectives, we have applied the vector error-correction model and several recently introduced appropriate wavelet decomposition techniques such as the Maximum Overlap Discrete Wavelet Transform (MODWT) and Continuous Wavelet Transform (CWT). The data used in this paper are the daily data of three commodities (crude oil, gold and corn) prices and Islamic stock indices from 1 June 2007 until 28 February 2014. Our findings tend to suggest that there is a theoretical relationship between the selected Islamic stock indices and selected commodities (as evidenced in the cointegration tests) and that the Islamic stock indices of Saudi Arabia, Oman and crude oil price are leading the other Islamic stock indices and the commodities (as evidenced in the Vector Error-Correction models). Our analysis based on the application of the recent wavelet technique MODWT indicates mixed results in that in the short run, the crude oil price is leading the other Islamic indices but in the long run, it is the other way around. From the point of view of portfolio diversification benefits, our results tend to suggest that an investor will obtain diversification benefit if his/her investment horizon is below 128 days (as evidenced in the continuous wavelet transform analysis). This result is consistent with the cointegration test that indicates that the diversification benefits for crude oil and the other Islamic indices is minimised in the long run because the variables under review tend to move together toward the same direction. Our analysis based on the recent applications of the wavelet decompositions helps us unveil the portfolio diversification opportunities for the investors with heterogeneous investment horizons or holding stocks over different periods.

Key Words: Commodity, Islamic Stock Index Returns (ISIR), MODWT, CWT, 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 remain 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 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 in order to provide Islamic investors and fund managers an idea on risk mitigation and potential international portfolio diversifications benefits.

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 stock market including Gulf Cooperation Council (GCC) Islamic stock market. GCC countries consists of United Arab Emirates (UAE), Saudi Arabia, Oman, Qatar, Kuwait and Bahrain which are oil-dependent and thus, shocks that hit the volatile oil market affect them directly. They collectively accounted for about 16% of the world's 76.5 million barrels-a-day of total production in 2002. They possessed 47% of the world's 1018.8 billion barrels of oil proven reserves and 17% of the world's natural gas reserves. Moreover, they are located in an area that had at least three major wars in the last 20 years. On the other hand, their oil-dependent economies rely to a large extent on foreign labor and thus are very similar in many different ways (Hammoudeh and Li 2008). By referring to Table 1, we also notice that GCC countries play important role in exporting crude oil to the world market. Therefore, intuitively, we believe that the impact of crude oil price fluctuation will affect the GCC ISIR significantly. Investors in Islamic stock market would like to know the correlation of crude oil with GCC Islamic stock market in order to obtain diversification benefit and to mitigate risk.

The main objective of this paper is to examine the causal relationship between crude oil price and the Islamic stock index in the GCC countries. Other commodities such as gold and corn prices also included as control variables and for robustness test. We would like to find out the lead-lag relationship between the 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 under review.

The unique contribution of the paper, among others, which enhances the existing literature is in empirically testing for the ‘time-varying’ and ‘scale dependent’ 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 cointegration exist between the commodities such as crude oil, corn and gold with the Islamic stock indices of GCC countries?
ii. Does the crude oil price cause the prices of the other commodities and the Islamic stock indices of GCC countries to increase/decrease in which past values of crude oil price are able to improve the prediction of other commodities (gold and corn) and Islamic stock indices of GCC countries?
iii. Among the exogenous variables, which one is more exogenous in different time horizons?
iv. Which commodities and Islamic stock market should an investor invest in along with crude oil in order 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 investors in their decisions concerning portfolio allocations and investment horizons. In summary, using recent data and recent 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 GCC 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 for GCC Countries

Country	Oil - export (bbl/day)	World Export Ranking
Saudi Arabia	7,635,000	1st
United Arab Emirates	2,395,000	3rd
Kuwait	2,127,000	6th
Qatar	1,038,000	22nd
Oman	592,300	27th
Bahrain	239,900	49th

Source (Cia 2010)

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. Mehrara (2007) examine Granger causality between energy consumption and income for 11 oil-exporting developing countries over the period 1971–2002. Panel integration and cointegration techniques are applied to investigate the relationship between the two economic series: energy consumption and output. Utilizing Granger causality within the framework of a panel cointegration model, his findings suggest that there is one-way strong causality running from GDP to energy consumption with no feedback effects for oil exporting countries, so that it is the GDP that drives the energy consumption, not vice versa. Therefore energy conservation is a feasible policy with no damaging repercussions on economic growth for this group of countries. Energy prices are often heavily regulated in the countries that are net exporters of oil. In most of these countries, the energy sector is dominated by a few large state-owned enterprises and the government typically controls energy prices through export restrictions or other such measures. The below-market prices result in the implicit subsidization of energy consumption. Energy consumption growth has been much faster than economic growth. In other words, generous subsidies for energy are responsible for implausibly high energy intensity in these countries. High levels of domestic consumption resulting from these price distortions can even turn net exporters into net importers, as some analysts forecast may eventually happen in Iran. So, it has been recognized that price reform is a key policy element for achieving increased energy conservation and fuel substitution. As the relative price rise, it is expected that producers switch away from the now more expensive energy input to technologies which are less energy intensive (Mehrara 2007).

Nandha and Faff (2008) examines the impact of oil price changes on 35 industry sectors, which are based on the standard FTSE Global Classification System. Their findings indicate that oil price changes do have a negative impact on equity returns from all industries, with the exception of mining, and oil and gas. Perhaps the broad oil price impact across industries, such as on banks, health and insurance, appears too pervasive, but one must consider that crude oil has a huge array of by-products, which find applications from aviation fuel through to shampoo and shoes. Moreover, higher oil prices might have an impact on interest rates and depress consumer confidence, creating indirect channels for reflecting higher oil prices into equity prices. Furthermore, analysis demonstrates that oil price increases and decreases have a symmetric impact on the equity markets. On the applications side, their findings suggest that internationally diversified portfolios are unlikely to achieve full diversification benefits unless they include some assets with positive sensitivity to oil price changes. The obvious hedging asset to include would be a portfolio of stocks of oil producing companies. Alternatively, international portfolio investors might consider hedging for oil price risk using oil-based derivatives (Nandha and Faff 2008).

The stock markets of the countries of the Gulf Cooperation Council (GCC) have been known to be very volatile because of their connection with the oil markets and the geopolitics of their region. Attempts to measure volatility of these markets using the standard GARCH models have overstated the persistence of volatility. A more realistic approach, particularly for these markets, is to incorporate dummy variables into these models to account for sudden changes in variance as done by Hammoudeh and Li (2008). The change points for the dummies correspond to global and regional events that have impacted the volatility of these markets. Result from their investigation show significant reductions in volatility persistence for all GCC markets, suggesting that less weight be given to past values of volatility and more to the current shocks in constructing forecasts of future volatility. Reductions in volatility are relevant for asset pricing,

hedging strategies and for evaluating regulatory proposals that aim at restricting international capital flows. Most of the sudden changes for the GCC markets are due to global factors, specifically the 1997 Asian crisis, the 1998 Russian crisis, the collapse of the oil prices at the end of 1998, the 2000 adoption of a new oil pricing mechanism by OPEC and the September 11th attack. On the other hand, country-specific factors such as small overall market and individual company capitalizations, thin trading, stock market scandals and opening up to foreign ownership had increased the number of sudden shifts in the case of Oman (Hammoudeh and Li 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).

In 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 contradictory 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 prices 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 wavelet decomposition methodologies used in this paper make 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 six countries (UAE, Saudi Arabia, Kuwait, Qatar, Oman and Bahrain) from 1 June 2007 until 28 February 2014. All data are 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 Islamic stock indices of GCC countries. 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 $\tilde{\upsilon}_{X,j}^{2}$ 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).

4.3 Continuous Wavelet Transformation (CWT)

To answer the fifth objective 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. 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. 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 three cointegrating vector at 95% significance level on the basis of maximal eigenvalue statistics and two cointegrating vector on the basis 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 modelling technique (Table 3) with one cointegrating vector to identify exogeneity and endogeneity of the variables. From Table 3, we can identify that the crude oil, Saudi Arabia and Oman Islamic stock indices are exogenous but the UAE, Qatar, Kuwait and Bahrain Islamic stock indices, corn and gold prices are endogenous. That tends to indicate that the UAE, Qatar, Kuwait and Bahrain Islamic stock indices, corn and gold prices would respond to the crude oil, Saudi Arabia and Oman Islamic stock indices. The error correction model helps us distinguish between the short run and long run Granger causality. The error correction term stands for the long run 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 GCC Islamic Stock Indices and Commodities Prices

Ho	H_1	Statistic	95% Crit.	90% Crit.
Maximum Eigenvalue Statistics				
$r = 0$	$r = 1$	66.46	61.27	58.09
$r \leq 1$	$r = 2$	55.34	55.14	52.08
$r \leq 2$	$r = 3$	51.45	49.32	46.54
Trace Statistics				
$r = 0$	$r \geq 1$	265.11	222.62	215.87
$r \leq 1$	$r \geq 2$	198.65	182.99	176.92
$r \leq 2$	$r \geq 3$	143.31	147.27	141.82

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

Dependent Variable	DOil		DGold		DCorn		DUAE		DSaudi		DKuwait		DQatar		DOman		DBahrain	
DOil(1)	-0.009	(0.03)	-0.03	(0.02)	-0.046	(0.03)	0.081	(0.03)	0.026	(0.02)	0.0207	(0.02)	0.051	(0.02)	0.09297	(0.02)	0.027	(0.02)
DGold(1)	0.0334	(0.04)	0.001	(0.03)	0.026	(0.04)	-0.039	(0.04)	-0.009	(0.03)	0.0007	(0.03)	0.043	(0.03)	-0.0201	(0.03)	-0.03	(0.03)
DCorn(1)	0.0841	(0.02)	0.053	(0.01)	0.02	(0.02)	0.076	(0.03)	0.007	(0.02)	-0.022	(0.02)	0.03	(0.02)	0.04074	(0.01)	0.013	(0.02)
DUAE(1)	0.0233	(0.02)	0.013	(0.02)	-0.018	(0.03)	-0.009	(0.03)	0.021	(0.02)	0.0202	(0.02)	0.017	(0.02)	0.01936	(0.02)	-0.01	(0.02)
DSaudi(1)	0.1196	(0.04)	0.071	(0.03)	0.111	(0.04)	0.086	(0.05)	0.049	(0.03)	0.0252	(0.03)	0.154	(0.03)	0.10133	(0.03)	0.059	(0.03)
DKuwait(1)	-0.018	(0.04)	0.009	(0.02)	-0.052	(0.04)	0.064	(0.04)	0.02	(0.02)	0.0055	(0.03)	0.064	(0.03)	0.05646	(0.02)	0.053	(0.03)
DQatar(1)	-0.059	(0.04)	-0.03	(0.02)	-0.004	(0.04)	0.009	(0.04)	-0.003	(0.03)	0.0385	(0.03)	0.066	(0.03)	-0.05	(0.02)	-0.03	(0.03)
DOman(1)	-0.021	(0.04)	0.051	(0.03)	-0.061	(0.04)	-0.024	(0.05)	-0.028	(0.03)	0.0064	(0.03)	-0.017	(0.03)	0.01674	(0.03)	0.028	(0.03)
DBahrain(1)	-0.017	(0.04)	-0.03	(0.02)	-0.053	(0.04)	0.035	(0.04)	0.022	(0.03)	0.0091	(0.03)	-0.019	(0.03)	0.02957	(0.02)	0.061	(0.03)
ECM (-1)	-0.001	(0.003)*	0.005	(0.002)	-0.009	(0.003)	0.009	(0.003)	1E-04	0.002)*	0.0117	(0.002)	0.01	(0.002)	0.00164	(0.002)*	0.011	(0.002)
Chi - square SC(1)	2.6002	(0.107)	2.075	(0.15)	4.018	(0.045)	3.057	(0.08)	14.08	(0.00)	13.788	(0.00)	9.458	(0.002)	2.94E-04	(0.98)	1.371	(0.24)
Chi - square FF(1)	4.7721	(0.029)	1.492	(0.222)	0.01	(0.92)	0.207	(0.649)	8.366	(0.004)	0.7745	(0.379)	0.125	(0.723)	14.9415	(0.00)	1.656	(0.19)
Chi - square N(2)	1467	(0.00)	2134	(0.00)	474.4	(0.00)	13650	(0.00)	62102	(0.00)	12193	(0.00)	23144	(0.00)	48102.6	(0.00)	18455	(0.00)
Chi - square Het(1)	45.058	(0.00)	10.49	(0.001)	10.09	(0.001)	26.96	(0.00)	41.39	(0.00)	35.977	(0.00)	41.04	(0.00)	49.5771	(0.00)	38.81	(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, 2 and 3, 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

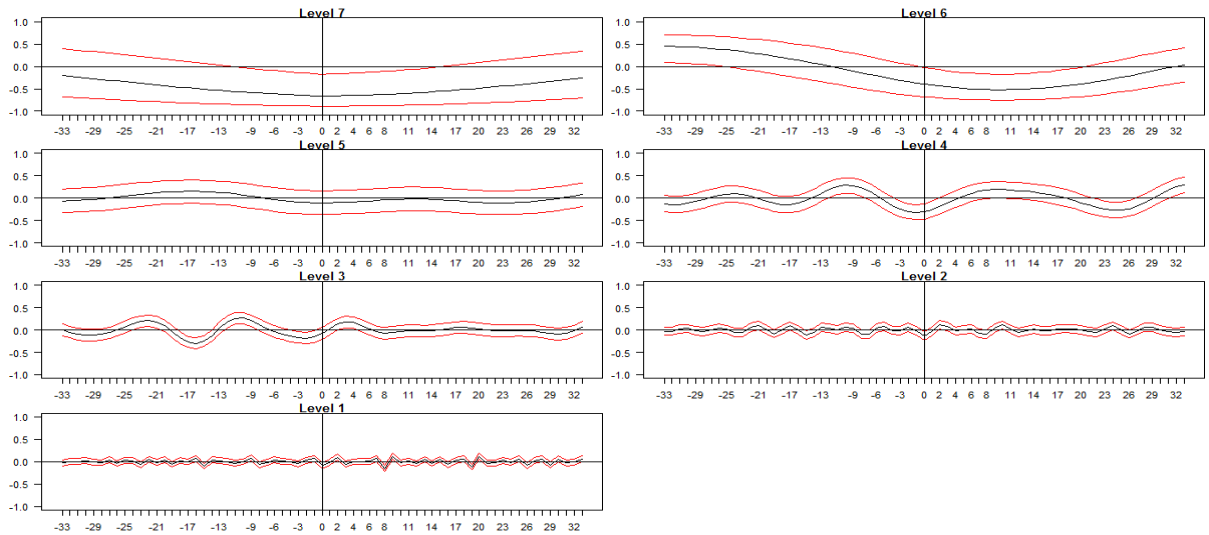
λ_1 …, λ_8 which are associated with changes of 1-2, 2-4, 4-8, 8-16, 16-32, 32-64, and 64-128 days. The red lines bound approximately 95% confidence interval for the wavelet cross-correlation. If the curve is significant on the right side of the graph, the second variable is leading. If the curve is 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 crude oil price return (COPR) with Saudi Arabia ISIR. From this figure, we could observe that:

- ***i)*** At the wavelet levels 1, 2,5 and 7, there is no clear lead-lag relationship evidence between the COPR and Saudi Arabia ISIR;
- ***ii)*** At the wavelet levels of 3, and 4, we can observe that the graph skewed to the left which indicate that the COPR leads the Saudi ISIR;
- ***iii)*** At the wavelet level 6 which associated with 32-64 days, the graph skewed to right hand side with significant negative value which implies that the Saudi Arabia ISIR is leading the COPR.

We can conclude here that on the lower levels (level 3 & 4), COPR lead Saudi Arabia ISIR but at high level (level 6), it is the other way around. This is because Saudi Arabia as the world largest oil exporter (please refer to Table 1) with an export of 7,635,000 billion barrels per day (bbl/day) by year 2010 (Cia 2010), has influence over the crude oil price through her ISIR. More importantly, there will be diversification benefit between these two variables under review in the long-run.

Figure 1: Maximum Overlap Discrete Wavelet Transformation: Crude Oil PR vs. Saudi Arabia ISIR



The Figure 2 shows that the wavelet cross-correlation between crude oil price return (COPR) with Oman ISIR. From this figure, we derive the following facts:

- ***i)*** At the wavelet levels 6 and 7, there is no clear lead-lag relationship evidence between these two variables under review;
- ***ii)*** At the wavelet levels of 1, 2, 3, 4 and 5, we can observe that the graph skewed to the left which indicate that the COPR leads the Oman ISIR;

We can conclude here that on the most of levels the COPR leads Oman ISIR with the exception of scale 6 and 7 which doesn't indicate any clear lead-lag relationship. Oman as the world 27th crude oil exporter (please refer to Table 1) with an export of 592,300 bbl/day (Cia 2010) indicate that her ISIR would respond to crude oil price fluctuation.

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

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

We may conclude that, the Oman ISIR leads the Saudi Arabia ISIR in the long-run with negative correlation but in the short-run, it is the other way around.

Figure 2: Maximum Overlap Discrete Wavelet Transformation: Crude Oil PR vs. Oman ISIR

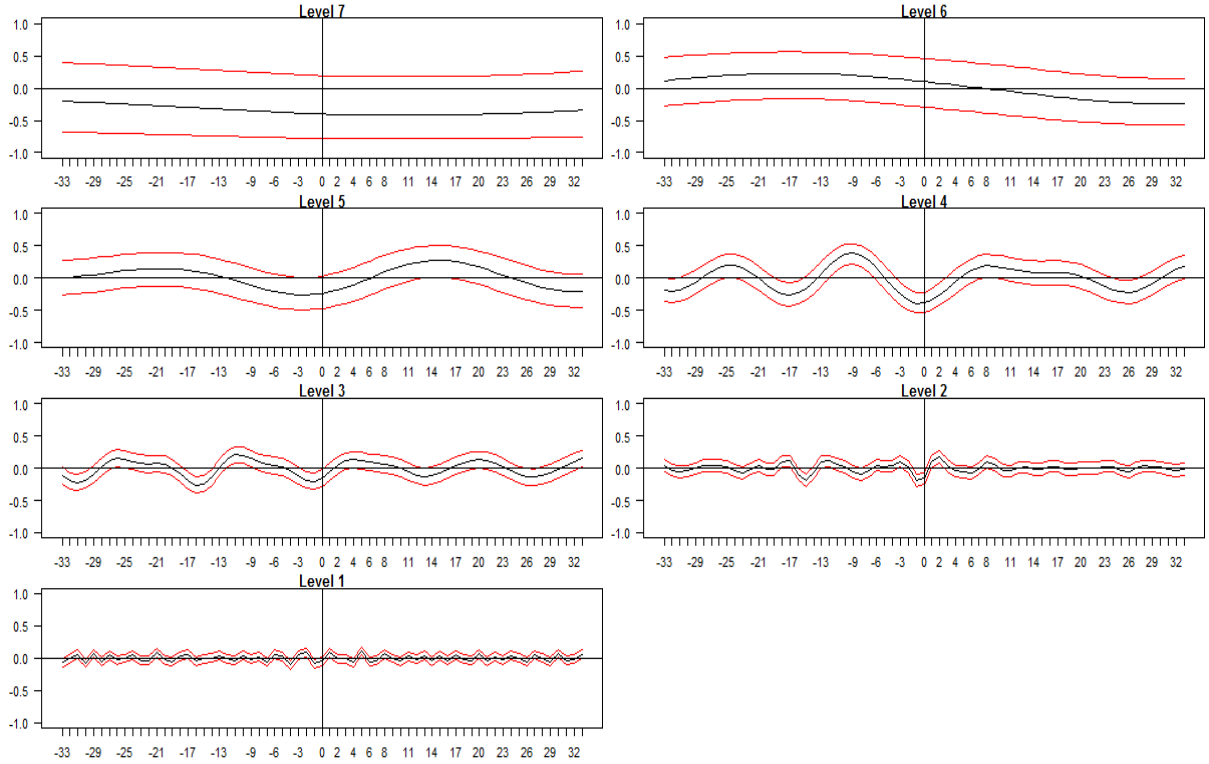
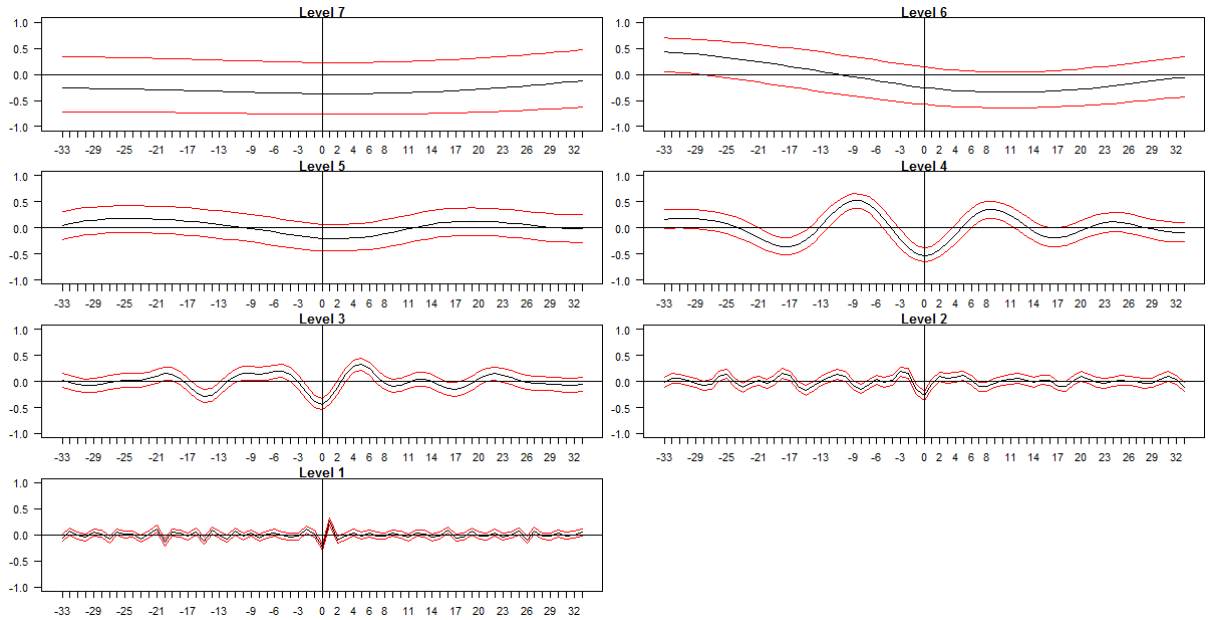


Figure 3: Maximum Overlap Discrete Wavelet Transformation: Saudi Arabia ISIR vs. Oman ISIR



5.3 Correlation of Crude Oil Price Return (COPR) with the GCC Islamic Stock Indices at Different Time and Investment Horizons based on Continuous Wavelet Transform

Chart 1 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 GCC 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 1 below, any investor that would like to invest in Saudi Arabia Islamic stock index and at the same time having exposure in crude oil, he/she should not hold his/her portfolio more than 128 days in order to obtain diversification benefit. The correlation between Saudi Arabia Islamic stock index and crude oil is highly correlated in high scale (more than 128 days) period.

For investor that interested to hold portfolio of crude oil and Oman Islamic stock index, he/she should hold that investment for not more than 150 days in order to obtain the diversification benefit. If his/her investment is beyond 150 days, he/she will be exposed to high correlation (please refer to Chart 2). From the Chart 2 also we noticed the correlation of crude oil with Oman Islamic stock index is lower compare against the Saudi Arabia Islamic stock index. This is due to Saudi Arabia is a biggest oil exporter country compare against Oman which is

only ranked 27th as oil exporter country. Therefore, Saudi Arabia Islamic stock index may be more sensitive toward crude oil price fluctuation.

Bahrain, Qatar and Kuwait ISIR exposure to crude oil prices is quite similar to Oman exposure. By referring to Chart 3, 4 and 5, we notice that in lower scale below 150 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 150 days onward, the correlation between the variables under review is very high and this minimise the diversification benefit of the portfolio.

From Chart 6, we notice that UAE ISIR correlation with crude oil is quite similar to Saudi Arabia ISIR. The correlation is very low from 1 day to 128 days holding period but become highly correlated beyond 128 days holding period. Any investor that would like to invest in UAE Islamic index can obtain diversification benefit with crude oil prices return if his holding period is less 128 days. UAE ranked 3rd place as oil exporter in the world. Therefore, Bahrain is more sensitive toward crude oil price fluctuation compare to other GCC countries (with the exception of Saudi Arabia).

Among the commodities under review, gold prices return is the least correlated with crude oil prices return. The correlation of gold and corn with crude oil prices return is low in short investment horizon within 32 days. After 32 days holding period, the correlation of the commodities under review are high especially for corn prices return.

Table 4: 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 1: CWT – COPR vs. Saudi Arabia ISIR

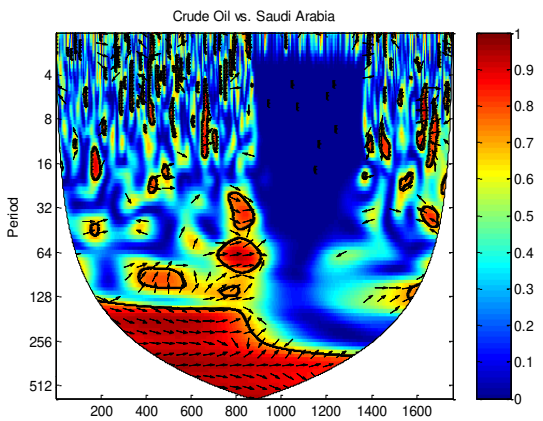


Chart 2: CWT – COPR vs. Oman ISIR

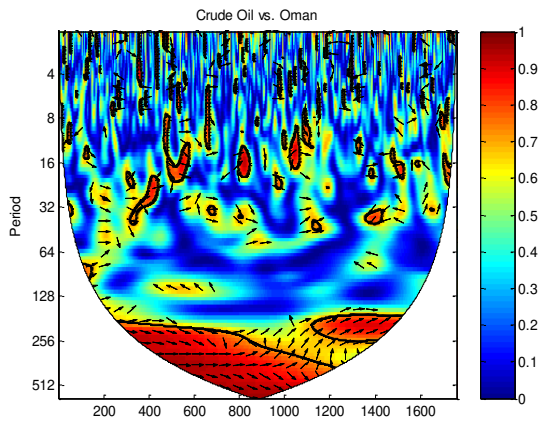


Chart 3: CWT – COPR vs. Bahrain ISIR

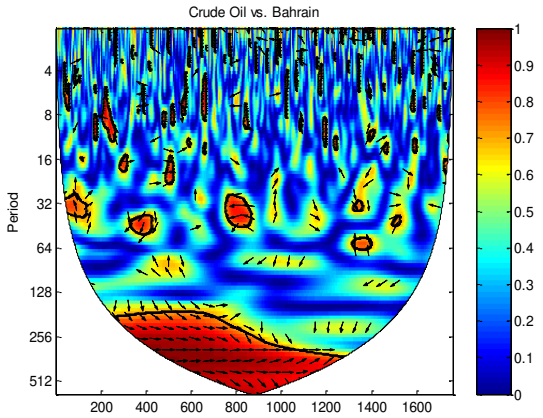


Chart 4: CWT – COPR vs. Qatar ISIR

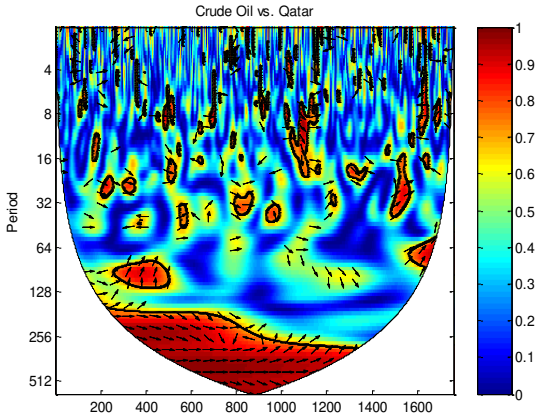


Chart 5: CWT – COPR vs. Kuwait ISIR

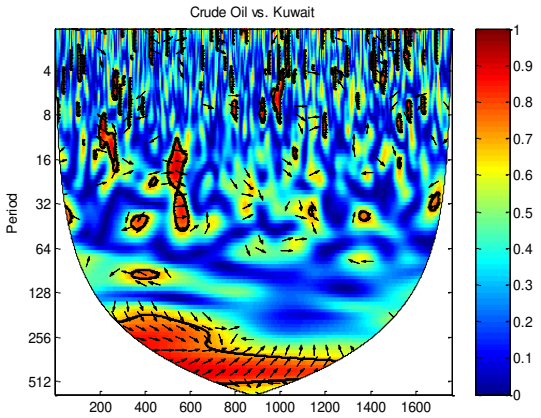


Chart 6: CWT – COPR vs. UAE ISIR

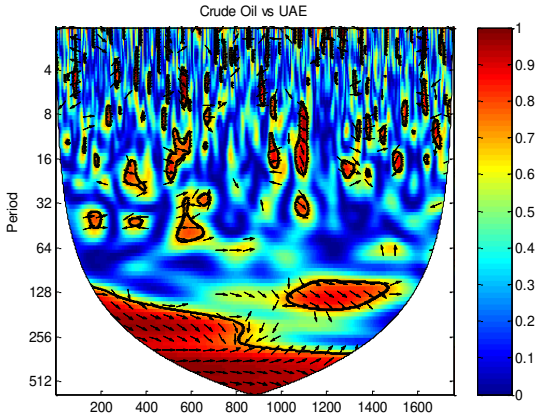
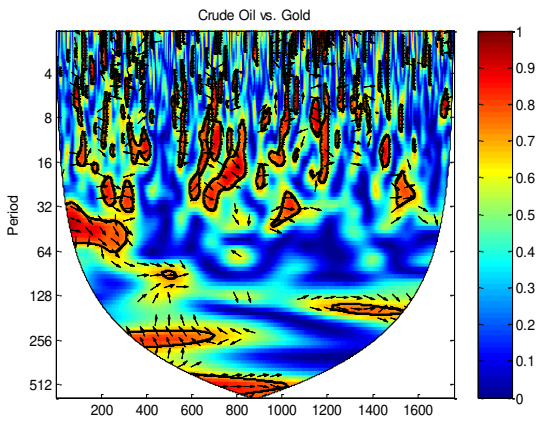
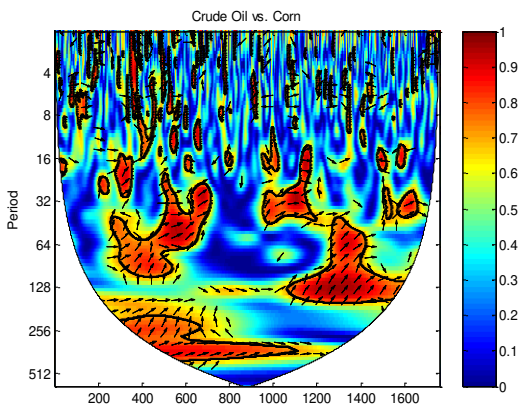


Chart 7: CWT – COPR vs. Gold PR

Chart 8: CWT – COPR vs. Corn PR





6. Concluding Remarks

In order to address research objectives, we have applied error-correction models and several recently introduced wavelet decomosition techniques such as, Maximum Overlap Discrete Wavelet Transformation (MODWT) and Continuous Wavelet Transformation (CWT). Our major findings are as follows:

Firstly, we found that cointegration does exist between the Islamic stock indices and selective commodities which indicate that in the long run, these variables tend to move together and minimise the diversification benefits. The cointegration of GCC ISIR is likely to be the reflection of ongoing attempts to synchronize market economies in preparation for an economic union and ultimately the introduction of a single currency (Bley and Chen 2006).The results also show that COPR, Saudi Arabia and Oman ISIR are leading the other GCC ISIR and commodities under review. That tends to indicate that the UAE, Qatar, Kuwait and Bahrain Islamic stock indices, corn and gold prices would respond to the crude oil prices, Saudi Arabia and Oman ISIR as evidenced in VECM test.

Secondly, after identifying the endogeneity/exogeneity of the variables, we noticed that COPR leads Saudi Arabia ISIR in the short run but in the long run it is the other way around as shown in the result from the MODWT test. The results also indicate that Oman ISIR is influenced by COPR both in the short run and long run. Saudi Arabia as the world largest oil exporter can influence the COPR in the long run but Oman is only ranked number 27th as oil exporter in the world and therefore, unable to influence the COPR like Saudi Arabia. However, a mixed result is shown between the lead-lag relation between Saudi Arabia and Oman ISIR in the MODWT test. We expect that Saudi Arabia is leading Oman ISIR both in the short run and long run but the results show that only in the short run, Saudi Arabia ISIR lead Oman ISIR. In the long run for scale 5 and 6, Oman ISIR is leading Saudi Arabia ISIR. The result is contrary to the findings by Bley and Chen 2006 that indicate that Saudi Arabian stock market leads Oman stock market mainly due to Saudi Arabia constituting the bulk of GCC market capitalization.

Last but not the least, findings of CWT confirm cointegration test in that it indicates that in the short run below 128 day holding period, there is diversification benefits for all ISIR under review with COPR. However, in the longer holding period beyond 128 days (for Kuwait, Bahrain and Qatar, it is beyond 150 days), the ISIR under review is highly correlated with COPR. To gain diversification benefits, investors should not hold their portfolio investment in the GCC ISIR longer than the mentioned days if they have exposure in crude oil. Our finding is similar with the finding of Ravichandran and Alkhathlan 2010 with the exception that their

finding does not clearly spell out the exact holding period for the investors to gain diversification benefits unlike our study (Ravichandran and Alkhathlan 2010).

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

References

Aloui, C., R. Jammazy, et al. (2008). "Crude oil market shocks and stock market returns." Journal of Energy Market **3**: 69-96.

Baffes, J. (2007). "Oil spills on other commodities." Resources Policy **32**(3): 126-134.

Bley, J. and K. H. Chen (2006). "Gulf Cooperation Council (GCC) stock markets: The dawn of a new era." Global Finance Journal **17**(1): 75-91.

Cia, C. (2010). "The world factbook." Retrieved August **20**: 2010.

Daubechies, I. (1992). Ten lectures on wavelets, SIAM.

Gallegati, M. (2008). "Wavelet analysis of stock returns and aggregate economic activity." Computational Statistics & Data Analysis **52**(6): 3061-3074.

Gençay, R., F. Selçuk, et al. (2001). "Differentiating intraday seasonalities through wavelet multi-scaling." Physica A: Statistical Mechanics and its Applications **289**(3): 543-556.

Gençay, R., F. Selçuk, et al. (2001). An introduction to wavelets and other filtering methods in finance and economics, Academic press.

Hammoudeh, S. and H. Li (2008). "Sudden changes in volatility in emerging markets: The case of Gulf Arab stock markets " International Review of Financial Analysis **17**: 47-63.

In, F. and S. Kim (2013). An introduction to wavelet theory in finance. Singapore, World Scientific Publishing.

Jammazi, R. and C. Aloui (2010). "Wavelet decomposition and regime shifts: assessing the effects of crude oil shocks on stock market returns." Energy Policy **38**(3): 1415-1435.

Madaleno, M. and C. Pinho (2012). "International stock market indices comovements: a new look." International Journal of Finance & Economics **17**(1): 89-102.

Markowitz, H. (1959). "Portfolio selection: efficient diversification of investments." New York.

Masih, M., A. Al-Elg and H. Madani (2009). "Causality between Financial Development and Economic Growth: An Apllication of Vector Error Correction and Variance Decomposition Methods to Saudi Arabia." *Applied Economics,* 41 (13), 1691 - 1699
.

Mehrara, M. (2007). "Energy consumption and economic growth: the case of oil exporting countries." Energy Policy **35**(5): 2939-2945.

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

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

Percival, D. P. (1995). "On estimation of the wavelet variance." Biometrika **82**(3): 619-631.

Pesaran, B. and M. H. Pesaran (2010). Time Series Econometrics Using Microfit 5.0: A User's Manual, Oxford University Press, Inc.

Ravichandran, K. and K. A. Alkhathlan (2010). "Impact of Oil Prices on GCC Stock Market." Research in Applied Economics **2**(1).

Sadeghi, M. (2008). "Financial performance of Shariah-compliant investment: evidence from Malaysian stock market." International Research Journal of Finance and Economics **20**: 15-26.

Whitcher, B., P. Guttorp, et al. (2000). "Wavelet analysis of covariance with application to atmospheric time series." Journal of Geophysical Research: Atmospheres (1984–2012) **105**(D11): 14941-14962.