Comovement between crude oil prices and shariah stock indices: MGARCH-DCC and wavelet analysis

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Abstract: This paper tries to answer the following two questions: (1) Should the Shariah Investors invest in USA, European or Emerging markets to gain international portfolio diversification benefits with respect to the oil price shocks? From our analysis using MGARCH-DCC method, we can see that the conditional volatilities of all shariah index returns tend to move more or less simultaneously except during the 2008 global financial crisis when there seems to be high convergence of volatility among shariah stock index returns of oil price, emerging market index and Shariah 350 European index during the period of the 2008 crisis and earlier part of 2016 being another shock in oil prices. Results from the conditional correlations show that the Shariah 500 index having the lowest unconditional correlations with respect to the oil price. It can be suggested that investors are better off investing in US shariah stock markets to gain more portfolio diversification compared to other shariah stock markets of the major trading partners. (2) how would the international portfolio diversification strategy change given different investor stock holding periods (e.g. 2-4 Days, 4-8 Days, 8-16 Days, and so on). The MODWT result shows that for the time scale as 16-32 days, 128-256 days and 256-512 days, the correlations are strong which as the number shows more than 0.6. The correlation results between crude oil prices and S&P Shariah 500 are moderately correlated as most of correlations are in the range of 0.44 to 0.60. However, correlations between crude oil and S&P Shariah 350 index having the highest correlations with 0.90790415 at the scale of 256-512 days. It shows that there is a significant comovement between the crude oil prices and shariah stock markets implying relatively low portfolio diversification opportunities.

Keywords: Shariah stock prices, crude oil prices, portfolio diversification, MGARCH, Wavelets

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Introduction

Oil has played a significant role in the economic and political development for most part of countries in the world. Oil prices shocks are considered to be one of the important determinants in measuring growth and stability of the economic conditions of a country especially in the developing countries. Most studies show that the initial impact of an oil price shock will be on the countries' terms of trade but will later on impact those countries in terms of raising inflation and interests rate.

From the oil exporting countries perspective, increase in oil prices will provide an increase in real income and this will provide big income boost which is reflected in GDP especially when export represents the majority part of those countries GDP. On the other hand, the developing countries which are mainly the oil-importing countries will be most negatively affected as the direct effect of increase of oil prices as imports represent higher percentage of their GDP.
The impact of lower GDP income to the oil importing countries will reflect the real income declines as the cost of oil and other related products and services rise. This in turn will raise inflation and interest rate which result in lower demand and reduced competitiveness and output will decline.

The past ten years has been an ups and downs for oil prices, one that market participants especially the investors who have probably not enjoyed it much. The period includes much volatility and one sharp crashes i.e. in 2008. On the other aspect, stock prices have also been falling and these moves have frequently followed the course of oil prices, a development much mentioned on by the financial research. The tendency for stocks to fall along with oil prices is surprising and need more attention as the normal understanding is that a decline in oil prices is good news for the economy, at least for net oil importers like the United States and China and some other countries such as Malaysia, Russia etc. One possible explanation of the tendency for stocks and oil prices to move together is that both are reacting to a common factor which means that they are positively correlated which lead to the softening of global aggregate demand, which hurts both corporate profits and demand for oil.

Given the importance of oil to the emerging economies of today, it is of utmost priority for global portfolio investors to understand the level of exposure of stock prices in these stock markets to movements in global oil prices. As investors turned more optimistic on oil prices, financial demand for crude oil fueled by cheap liquidity, has also picked up as what happened in 2008 as well as in early 2011.

As we are in the globalized financial markets where shares are trading with very much high volumes and liquidity, the integration and comovement among the stocks are becoming more important as compared to the diversification of the portfolios. As a result, the study on the comovements and correlations among the stocks markets with oil price are getting more attention and growing in numbers.

The current investors' preferences are changing with respect to the time dimension of the market dynamics. The spectrum of investors ranges diverse rapidly and it can start even for few hours and developed into the time horizon of several days to several weeks or months or years as the case for long run investors such as in the form of pension funds. In short, in addition to the time domain, we can have another aspect on the investors behavior, which is the frequency domain which represents multiple investment horizons.

The good understanding of interdependence between crude oil prices and stock market enable sound investors to make a well balanced portfolio. Care has to be taken as the correlation of the two can be highly dynamic as the correlation might change rapidly over time as well as in the different frequencies. The research on the matter of time domain can be found in most publications but there is not so much research on the frequencies domain.

In spite of the fact that there is enormous number of studies in portfolio diversification issues focusing on oil price shocks and stock prices, the concentration of the studies was based on the conventional (Shariah non-compliant) stock indices. Thus, this paper attempts to study the portfolio diversification aspect with the focus only on the Sharia Indices of the selected regional financial markets. We concentrate in our study on three regional Islamic financial markets; those are US Shariah Fortune 500, European, and the Emerging Market. These markets represent a

global picture of the potential possibilities of portfolio diversification benefits as the result of oil price shocks. Hence, the specific research questions of this study are as follows:

1. Should the Shariah Investors invest in USA, European or Emerging markets to gain international portfolio diversification benefits with respect to the oil price shocks?

2. Given the answer from the previous research question, how would the international portfolio diversification strategy change given different investor stock holding periods (e.g. 2-4 Days, 4-8 Days, 8-16 Days and so on.)?

In order to deal with all these issues, wavelets are used as the main methodology. The wavelet methodology is appropriate because it allows a time series to be decomposed into different frequency components that extract the short-term behavior and the low-frequency components which capture the more long-term dynamics of a variable. This paper tries to combine those two approaches into time-frequency domain, which would bring results extremely valuable for investors and other decision makers.

Literature Review

According to most literature, oil price increase would result to increased costs, restraining profits and in greater extend, would cause a decrease in shareholders' value. Hence, any oil price increase should be accompanied by a decrease in the stock prices. Subsequently, many authors argue that oil price effect on stock markets is an indirect effect and it is fed through the macroeconomic indicators.

According to Bouri (2016) in his study on stock returns in Jordan around the Arab uprisings of 2010, the oil return shocks significantly impact the Financials and the Services sectors, while its effect is insignificant on the Industrials sector.

Another finding found by Pönkä (2016), indicate that real oil prices are useful predictors of the direction of stock returns in a number of markets over and above commonly used predictors, but

results vary substantially between countries. In addition to that find only limited evidence of asymmetric effects of oil price shocks. According to Diaz et.al (2016), from their studies, there is a negative response of G7 stock markets to an increase in oil price volatility. Results also indicate that world oil price volatility is generally more significant for stock markets than the national oil price volatility.

Nusair (2016) mentioned that there are significant positive oil price changes in all the cases with the expected positive sign, implying that increases in oil price lead to increases in real GDP. However, negative oil price changes are significant for only Kuwait and Qatar with the expected positive sign, suggesting that decreases in oil price lead to decreases in their real GDP.

Masih et. al. (2011) stated that their research results indicate the dominance of oil price volatility on real stock returns and emphasize how this has increased over time. The paper explains further that oil price volatility can have profound effect on the time horizon of investment and firms need to adjust their risk management procedures accordingly and this increase in dependency has been found in other net oil importing emerging equity markets.

However, according to Apergis and Miller (2009) report that international stock market returns do not respond in a large way to oil market shocks as the significant effects that exist prove small in magnitude.

According to Park and Ratti (2008), 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.

Literature review – empirical

On the issue of the effect of oil price shocks on stock market returns, several studies have contributed to the literature. Bouri (2016) stated that test for mean and variance causality between world oil prices and sectoral equity returns in Jordan before and after the Arab Uprisings that

started in 2010. The testing methodology is based on the sample of cross-correlation functions that are computed from the standardized residuals of a GARCH process and he found that in his study on stock returns in Jordan around the Arab uprisings of 2010, the oil return shocks significantly impact the Financials and the Services sectors, while its effect is insignificant on the Industrials sector.

Another studies by Sadorsky (1999) stated that from a vector auto regression show that oil prices and oil price volatility both play important roles in affecting real stock returns. There is evidence that oil price dynamics have changed. After 1986, oil price movements explain a larger fraction of the forecast error variance in real stock returns than do interest rates. There is also evidence that oil price volatility shocks have asymmetric effects on the economy.

According to Papapetrou (2001), the empirical evidence suggests that oil price changes affect real economic activity and employment and oil prices are important in explaining stock price movements. However, stock returns do not lead to changes in real activity and employment.

Wang et. al (2015) from VAR studies, the contribution of shocks to global real economic activity to real stock return variation rose sharply to 22% in 2009 (and remains 17% over 2009–2012) and the contribution of oil-market specific demand price shocks rose unevenly from 5% in the mid-1970s to about 15% in 2007, with a subsequent decline. Overall, the contribution of oil supply shocks has trended downward from 17% to 5% over 1973–2012.

Broadstock and Filis (2014) highlighted that several key points from their studies on the aggregate stock market indices from two countries, China and the US, : (i) correlations between oil price shocks and stock returns are clearly and systematically time-varying; (ii) oil shocks of different types show substantial variation in their impact upon stock market returns; (iii) these effects differ widely across industrial sectors; and finally (iv) China is seemingly more resilient to oil price shocks than the US.

With regard to hedging and portfolio diversification, Arouri (2011) suggested that taking the cross-market volatility spillovers estimated from the VAR-GARCH models often leads to diversification

benefits and hedging effectiveness better than those of commonly used multivariate volatility models such as the CCC-GARCH of Bollerslev (1990), the diagonal BEKK-GARCH of Engle and Kroner (1995) and the DCC-GARCH of Engle (2002).

Data analysis

Under this study, the oil price index is represented by Crude Brent Oil and the S&P Shariah 500 Shariah index is used as a proxy for the USA shariah stock index returns. The index includes 500 leading companies and captures approximately 80% coverage of available market capitalization., The S&P Europe 350 Shariah offers investors a tradable Shariah-compliant benchmark for the European market that includes the largest and most liquid companies in developed Europe. FTSE Shariah Emerging Index is used as proxy for the emerging market index. Under the three methodologies outlined below, (M-GARCH DCC, CWT and MODWT), all of them make use of the three shariah stock indices with regard to the oil price as the independent variable. Table 1 below lists the sample indices being considered in this study.

Table1: Selected indices for research

Symbol	Definition
OL	Crude Brent Oil
FO	S&P 500 Shariah
EM	FTSE Shariah Emerging Index
EU	S&P Europe 350 Shariah

We collected daily time series closing price data for the oil price and the three indices covering nine years starting from 08th April 2008. The stock indices returns were calculated as differences of the logarithmic daily closing prices of indices *{ln(pt) - ln(pt-1)}* where p is an index value.

Methodology

In this study, we relied on the Multivariate Generalized Autoregressive Conditional Heteroscedastic (MGARCH) from Pesaran and Pesaran (2009) and the Dynamic Conditional Correlations (DCC). We test for the normal and t distributions beforehand to find out which of the two actually fits our case better. The software *Microfit* is used to calculate both the unconditional correlation coefficients and the conditional cross-asset correlations.

In the MGARCH (p,q) model, the conditional variance and covariance of each asset will depend on both its own past conditional variance and of other assets. This technique helps the potential investors in their portfolio diversification decisions whereby investors will understand the behavior of oil prices and stock market volatility and correlations are changing over time. Low correlation between the two will indicate that the combination of the two assets are good diversifying tool to minimize risk. On the other hand, positive correlation indicates that the stock markets will have similar attributes to the change in oil price. This will indicate that; the stocks are not good bet for the diversification portfolio.

Empirical Findings and Interpretations

From the initial test of both normal and t distributions, the following table shows the comparison between the two with a summary of the maximized log-likelihood estimates of $\lambda 1$ and $\lambda 2$ and values of $\delta 1$ and $\delta 2$.

Table 2: Estimates of λ1, λ2, δ1 and δ2 for the oil prices and the three stock markets

	Multivariate Normal Distribution		Multivariate t-Distribution	
Parameter	Estimate	T-Ratio[Prob]	Estimate	T-Ratio[Prob]
lambda1_Oil	0.94517	127.5419[.000]	0.9456	106.3948[.000]
lambda1_Emerging Market	0.90268	79.5720[.000]	0.9164	77.0396[.000]
lambda1_Fortune 500	0.85635	56.2895[.000]	0.8712	51.7859[.000]
lambda1_European	0.90703	73.7791[.000]	0.9166	72.9764[.000]
lambda2_Oil	0.051443	7.7025[.000]	0.0507	6.3856[.000]
lambda2_Emergin Market	0.091772	8.9114[.000]	0.078	7.2820[.000]
lambda2_Fortune 500	0.13412	9.8213[.000]	0.12	7.9632[.000]
lambda2_European	0.085161	7.9776[.000]	0.0763	6.9509[.000]
delta1	0.97738	339.2469[.000]	0.9782	302.8706[.000]
delta2	0.016461	9.4223[.000]	0.0152	8.3981[.000]
df			7.676	12.6997[.000]
Maximized Log-Likelihood		25581.3		25727.9

From table 1, the estimates of the volatility decay parameters show highly significant values. Comparing between the normal and t distributions, we find that the normal distribution gives a maximized log-likelihood of 25581.3 while that of t distribution gives a value of 25727.9 which is larger than that of the normal. Also, we find the degree of freedom for the t distribution is below 30, which together with the previous statement suggest that the t distribution is more appropriate for the case in this study. Therefore, the following computation will be based on the t-distribution estimates.

Following this, we find the estimated unconditional volatilities through the diagonal elements in the matrix and the unconditional correlations through the off-diagonal elements for the three stock markets. The following table shows these estimates:

Table 3: Estimated Unconditional Volatility and Correlation Matrix for the Oil price with three stock markets

	Oil	Emerging Market	Fortune 500	European
Oil	0.020838	0.49976	0.31165	0.51244
Emerging Market	0.49976	0.01433	0.5165	0.73187
Fortune 500	0.31165	0.5165	0.0128	0.59063
European	0.51244	0.73187	0.59063	0.014761

The on-diagonals in table 6 explain the unconditional volatilities of the indices. If the unconditional volatility is near to zero, it can be implied that the particular index has the least volatility whereas if the unconditional volatility is near to 1, it indicates higher volatility levels. The values highlighted show the diagonal elements which gives the value of the unconditional volatility of the variables on its own. Other values off the diagonal line give the unconditional correlations between oil price and three other stock indices. From the diagonal elements, we summarize the volatility ranking of currencies in oil prices from lowest to highest as below:

1. Oil price (0.020838)
2. S&P Europe 350 (0.014761)
3. FTSE Shariah Emerging Index (0.01433)
4. S&P 500 Shariah (0.0128)

With regards to the off-diagonal elements showing the unconditional correlations as presented in table 3, it is observed that correlation between returns of FTSE Shariah Emerging Market index and returns with European 350 Shariah index returns to be the highest among the other returns of the three shariah indices which is +0.73187.

All our investigation so far has only dealt with the unconditional volatilities and correlations. We have not come yet to the conditional basis. That is, we only looked into the average volatility and correlation in the sample period which seems quite contradictory to real economic intuition. It is much safer to base our prediction and conclusion through a dynamic aspect of investigation

which will be through the Dynamic Correlation Coefficient (DCC).

Figure 1: Conditional Volatility – all stock markets in relation to oil price

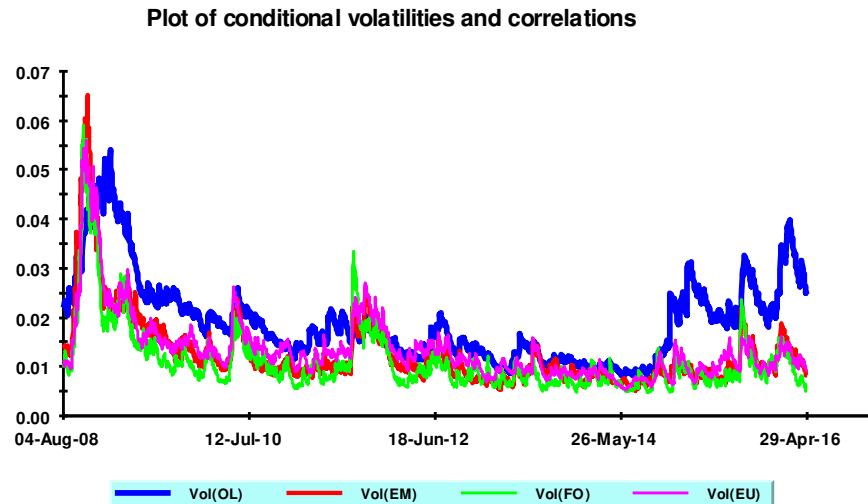Plot of conditional volatilities and correlations

Figure 1 that illustrates the conditional volatilities of all shariah index returns tend to move more or less simultaneously except during the 2008 global financial crisis on which there seems to be high convergence of volatility among shariah stock index returns of oil price, emerging market index and Shariah 350 European index during the period of the 2008 crisis and earlier part of 2016 being another shock in oil prices. These results very much confirm the result shown in Table 3 on which returns on Shariah 500 index are least volatile. This is mainly due to the 2008 whereby US stock indices were badly affected but Islamic indices are relatively stronger to the shocks.

Figure 2: Conditional Correlations – all stock markets in relation to oil price

Plot of conditional volatilities and correlations
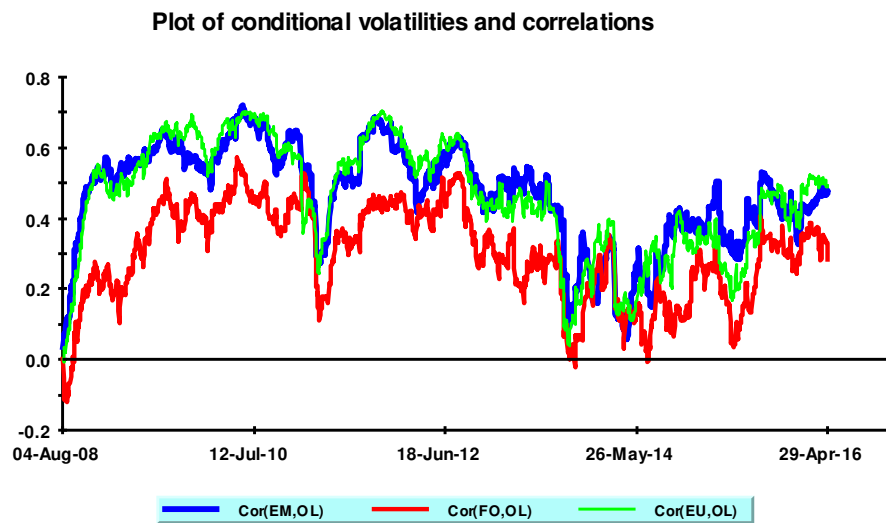
Next, we plot the conditional correlations in Figure 2 and again it consistently confirms with the results of the unconditional correlations in Table 3 showing that the Shariah 500 index having the least unconditional correlations with respect to the oil price. It can be suggested from here that investors who are looking for portfolio diversification and the comovement of stock price against oil prices are better off investing in US shariah stock markets to gain more portfolio diversification compared to other shariah stock markets of the major trading partners.

Comovement of Crude Oil and Stock Markets:

1. **Continuous Wavelet Transform**

Under the CWT, the original time series is mapped and represents a function of just one variable time separate into the function of two different variables such as time and frequency. The number of wavelets time scales is not required to be defined in CWT. since it generates itself based on the data length. The series correlations in a two dimensional figure is mapped by the CWT which enables easy identification and interpretation of patterns. For this study, the least asymmetric wavelet filter by Daubechies (1992) of length L=8 which is denoted by LA(8) based on eight non-zero coefficients. The length filter of L=8 is shown as a moderate length by previous studies which is adeuqte to deal with the characteristics of time series data (Gencay et. al 2001, In & Kim 2013). It has also been argued that a more smooth wavelet coefficient compared to other filters such as

Haar wavelet filter is generated by the LA(8) (In & Kim 2013).

The research on comovement of commodities and stock markets has been discussed in several papers. One paper written by Reboredo (2014) stating that wavelet decomposition of the original time series is useful in characterizing the oil–stock price relationship at different time scales, in revealing contagion and interdependence between oil and stock prices (as in the recent global financial crisis) and in analyzing oil lead and lag effects on stock prices through wavelet cross-correlation.

He further explains that empirical evidence for the period June 2000 to July 2011 indicates that oil price changes had no effect on stock market returns in the pre-crisis period at either the aggregate or sectoral level (with the exception of oil and gas company stock).

Following figures depict the wavelet coherence into a contour plot. The time domain is represented by x-axis and the frequency by y-axis. In addition, the frequency is represented by the period, i.e. the higher frequency the lower the period. We focus on the comovement between each of stock indices and crude oil. The interpretation of the figures is based on the color of regions; blue color means that there is low or even no comovement. On the other hand, red regions with a thick black outline mean that there is a significant comovement between time series.

As a result of this we can obtain very detailed results based on the time domain and the frequency domain at the same time. Another thing that helps us to interpret results are so called phase arrows, which show the relative phasing of time series at given scale. If arrows are pointing to the right that means that time series are in phase, opposite direction means anti-phase. If they are pointing down, then the first variable is leading the second one and if they are pointing up then the second variable is leading the first one.

Figure 3: Wavelet Coherence Analysis: Comovement of Brent Crude Oil and S&P Shariah 500 Index,
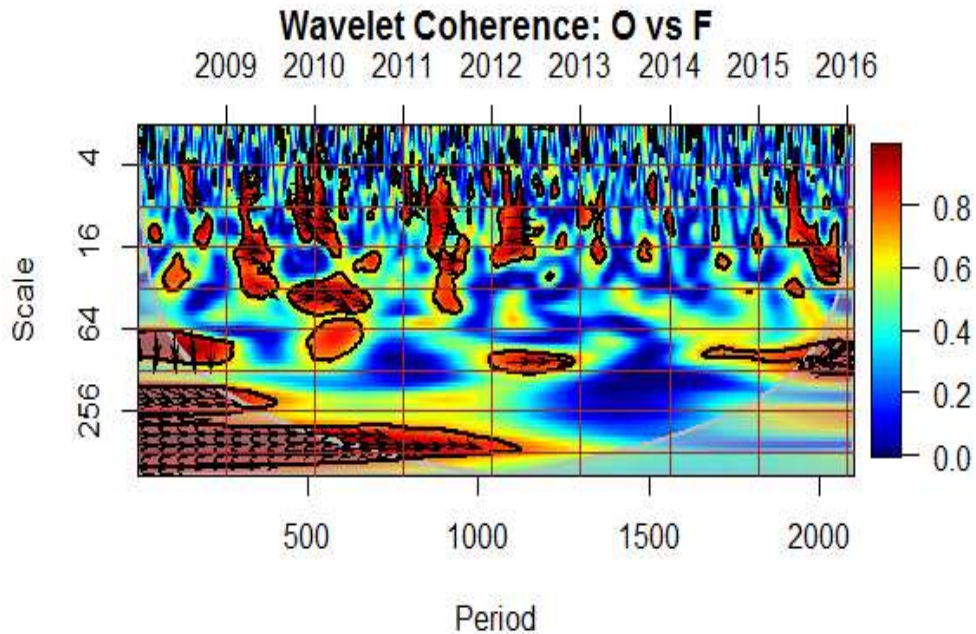

Based on the wavelet coherence, we analyze the interdependence of crude oil and stock market indices. Starting with S&P Shariah 500 and its comovement with crude oil, we observe that S&P Shariah 500 co-move with crude oil significantly from 2008-2012 as it shows the interdependence of crude oil and S&P Shariah 500 became significant. As a result, we can see a very strong comovement at almost all frequencies for the whole year 2011. As we can see the Crude Oil Brend is the leader between the two.

Figure 4: Wavelet Coherence Analysis: Comovement of Brent Crude Oil and FTSE Shariah Emerging Market Index
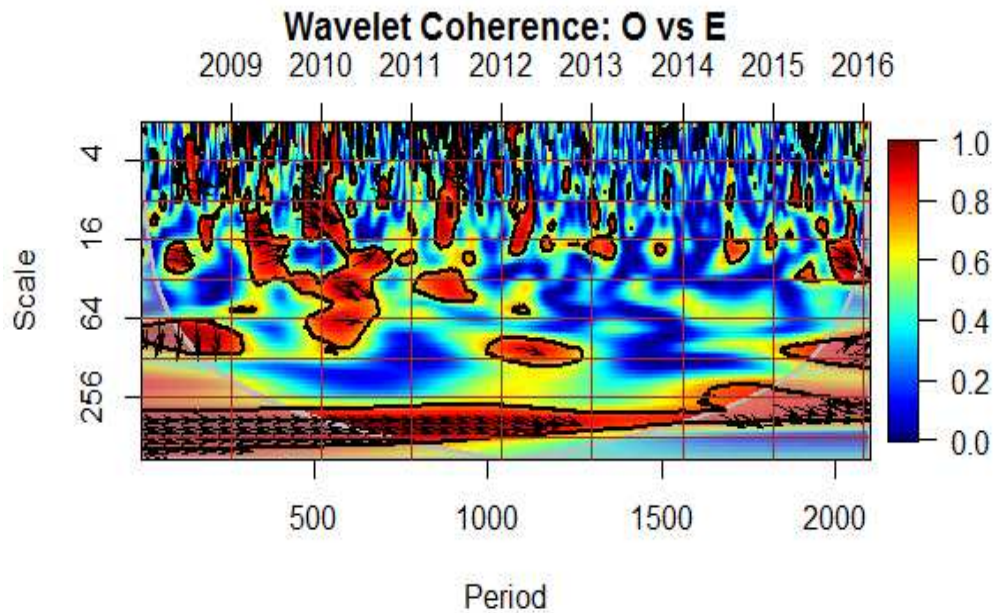
We continue with FTSE Shariah Emerging Market Index and crude oil as the wavelet coherence revealed very similar patterns as in case of S&P Shariah 500. However, we observe that similar to the earlier findings, crude oil co-moved with the stock market index in different periods and only on certain frequencies. A very significant comovement is in the second half 2009 as there was a strong comovement at higher frequency. In 2010 we observed a comovement starting at the lower frequencies starting from 2008 to early 2012. As the same with S&P Shariah 500 Index, crude oil brent is again the leader in this observation.

Figure 5: Wavelet Coherence Analysis: Comovement of Brent Crude Oil and S&P Shariah 350 European Index
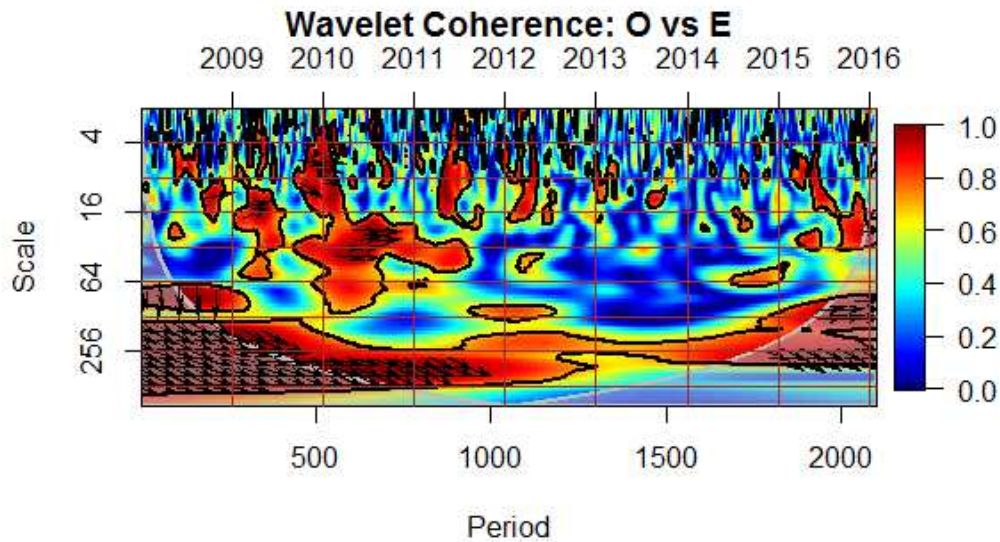
For FTSE Shariah 350 European Market Index and crude oil as the wavelet coherence revealed very similar patterns as in case of S&P Shariah 500 and FTSE Shariah Emerging Market Index. However, we observe that similar to the earlier findings, crude oil co-moved with the stock market index in different periods and only on certain frequencies. A very significant comovement starting at the beginning of the 2008 until early 2016. There are several comovements for the 16-64 days' scale in 2010 towards 2011. As the same with S&P Shariah 500 Index, crude oil brent is again the leader in this observation.

2. **Robustness and Validation of results-MODWT**

To further reassure ourselves regarding the results from the previous methodologies, we applied Maximum Overlap Discrete Wavelet Transform (MODWT) to our original returns series. Unlike CWT, the MODWT requires the researcher to specify time-scales for the returns and we specified a total of seven scales (2-4 days, 4-8 days, 8-16 days, 32-64 days, 64-128 days, and 128-256 days). Using the newly generated MODWT returns series, we examined the correlations between the oil price movement and stock market returns. The results are presented below:

Table 4: Correlations of Crude Oil Brent vis a vis Emerging Market, Shariah 500 and Shariah 350 European Index Equity Market Returns

MODWT/Scaling	Emerging Market	Shariah 500	Shariah 350 European
2-4 Days	0.4308573	0.18552516	0.51369172
4-8 Days	0.5043759	0.36526201	0.46560257
8-16 Days	0.5565600	0.46069537	0.50508511
16-32 Days	**0.6088150**	0.54400603	0.58607359
32-64 Days	0.4416264	0.44535001	0.40111429
64-128 Days	0.3986855	0.44608617	0.51811701
128-256 Days	**0.6419735**	0.57109195	0.58973711
256-512 Days	**0.8647371**	0.43439669	**0.90790415**
512- beyond	-0.4690726	0.08999716	0.03341153

Note: *Correlations more than 0.6 is arbitrarily considered to be strong (Najeeb&Masih forthcoming) and are indicated by the values highlighted in bold. The values not highlighted in bold and are between 0.44 to 0.6 indicate moderate correlation. The rest indicate low correlation.*

The results are found to be very much consistent with earlier CWT analysis. Crude Oil Brent and FTSE Shariah Emerging Market are highly correlated. The MODWT result shows that for the time scale as 16-32 days, 128-256 days and 256-512 days, the correlations are strong which as the number shows more than 0.6.

The correlation results between crude oil prices and S&P Shariah 500 are moderately correlated as most of correlations are in the range of 0.44 to 0.60. However, correlations between crude oil and S&P Shariah 350 index having the highest correlations with 0.90790415 at the scale of 256-512 days.

Conclusions

This study examines the comovements of crude oil prices with the selected Shariah stock indices. Daily data from Datastream database spanning from April 2008 to April 2016 was used for the wavelet techniques with CWT and MODWT analysis have been applied.

Our findings from wavelet CWT and MODWT analysis provide us the information of the comovement between crude oil prices and three stock market indices. The correlations between the crude oil prices and these stock markets are strong especially in the lower frequencies and very much consistent between the two methods.

This paper tries to answer its objective questions as the following:

1. *Should the Shariah Investors invest in USA, European or Emerging markets to gain international portfolio diversification benefits with respect to the oil price shocks?*

From our analysis by using MGARCH-DCC method, we can see that the conditional volatilities of all shariah index returns tend to move more or less simultaneously except during the 2008 global financial crisis on which there seems to be high convergence of volatility among shariah stock index returns of oil price, emerging market index and Shariah 350 European index during the period of the 2008 crisis and earlier part of 2016 being another shock in oil prices.

Results from the conditional correlations showing that the Shariah 500 index having the least unconditional correlations with respect to the oil price. It can be suggested from here that investors who are looking for portfolio diversification and the comovement of stock price against oil prices are better off investing in US shariah stock markets to gain more portfolio diversification compared to other shariah stock markets of the major trading partners

2. *Given the answer from the previous research question, how would the international portfolio diversification strategy change given different investor stock holding periods (e.g. 2-4 Days, 4-8 Days, 8-16 Days, etc*

Refer to the multiscale analysis, results show a low degree of comovement crude oil prices and Crude Oil Brent and FTSE Shariah Emerging Market are highly correlated. The MODWT result shows that for the time scale as 16-32 days, 128-256 days and 256-512 days, the correlations are strong which as the number shows more than 0.6.

The correlation results between crude oil prices and S&P Shariah 500 are moderately correlated as most of correlations are in the range of 0.44 to 0.60. However, correlations between crude oil

and S&P Shariah 350 index having the highest correlations with 0.90790415 at the scale of 256-512 days. It shows that there is a significant comovement between the crude oil prices and stock markets. This result indicated that for long term forecast, when crude oil markets become volatile, the stock markets indices will positively correlated

The results reported in this present analysis is not limited to the comovement between oil prices and stock market indices only as it can be extended in several ways in future research. One interesting area is in the field of macroeconomic such as the causality relationship between oil prices to inflation rate, interest rate in the monetary policy as well as the impact on the GDP of a country or countries. This can be expanded to other variables such as unemployment rate or consumer prices.

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