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The Dynamic Linkages between Islamic Index and the Major Stock Markets: New Evidence from Wavelet time-scale decomposition Analysis

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Abstract

The increase of globalization and financial liberalization along with the recurrence of the financial crises have made the issue of global stock market integration crucial particularly from the view of portfolio diversification. Moreover, an empirical time-scale-varying analysis from the perspective of Islamic stock is still lacking. The Islamic stocks are expected to be theoretically different from the conventional stocks in view of the Shariah-compliant restrictions, smaller and less diversified market. Therefore, this paper makes the first attempt to test the time-scale analysis of the linkages between the international Islamic stock index and six major international stock markets such as, the United States, United Kingdom, Europe, Japan, China, and Malaysia. The paper analyzes the cross volatility, comovement, and estimates the Granger causality between the stock markets using the recently applied continuous wavelet transform and maximal overlap discrete wavelet transform. The findings tend to suggest strong linkage between Islamic index and the western markets as compared to the Asian markets. The volatility and comovements between stock indices are higher and unstable during the financial crises. Furthermore, the results indicate the existence of inefficient market, spillover effect of financial crisis, strong causality effects and bi-directional causality between Islamic index and other international indices. As for the policy implications, the international investors should include the Asian market in their investment portfolio, however, the instability and high comovement especially during the crises will limit the investors' ability to exploit international diversification. Additionally, the inefficient markets might suggest an arbitrage opportunity for the investors.

Keywords: Islamic index, volatility, cross-volatility, comovement, and causality.

JEL Classification: C22, G11, G15

1. Introduction

The process of globalization and financial liberalization have made international stock markets become more integrated. The rapid expansion of international trade in commodities, services, and financial assets play important roles in this issue. In addition, the links between international markets are becoming closer not only because of growing international trade and investment flows, but also in terms of international financial transactions (Rezayat and Yavas, 2006). The pace of activity in financial markets has grown faster than real output in the major industrial countries, but this has been accompanied by even faster growth in offshore financial market activity (Lucey and Kearney 2004). As a result, correlation between stock indices across countries had gone up overtime. Intuitively, Islamic stock index that was developed and traded in the same environment would also be affected by the current situation. However, empirical research concerning Islamic stock investment is still lacking.

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Besides, an analysis of stock market linkages has become more crucial due to the recurring financial crisis. Among the recent study in this line are Loh (2013), Mandeleno and Pinho (2012), and Horvath and Petrovski (2013). These papers report that in the event of financial crisis, the behavior of stock markets change and the correlation between the markets becomes more integrated. Recent studies also suggest a strong but transient market contagion effect during this crisis (Huyghebaert and Wang, 2010) The recent financial crises has shown that dramatic movements in one market can have a powerful impact on other markets, even when the underlying economic fundamentals are different (Ahlgren and Antell, 2010). Correlation structure has experienced dramatic changes before and after the crisis, suggesting that cross-market linkage has been significantly reshaped in the recent global financial crisis (Ding and Pu, 2012).

The analysis of stock market linkages is important for the investors for the purpose of portfolio diversification and risk management. Understanding the interaction among the various international markets is important to diversify risk and to derive high return. In the perspective of Islamic principles, Islam promotes the creation of wealth through permissible way and encourages the people to protect it from harm. Investment in permissible stock and managing the risk is in line with the fifth *maqasid of shariah* (the objective of Islamic law) which is "the protection of wealth". Intuitively, a rich Muslim can contribute to zakat and sadaqah (obligatory and voluntary giving part of wealth to the poor), thus increase the economic conditions of Muslim society as a whole. Beside this, the development of Islamic stock and index has also provided an alternative of investment and portfolio diversification opportunity for the non-Muslims investors.

The lack of empirical research for Islamic stock had put investors at a disadvantage in this competitive environment. As compared to the conventional stocks, Islamic stocks possess some unique characteristics. In general, Islamic stocks need to pass through all the screening criteria set by regulatory body such as Security Commission in Malaysia, the international organization such as Dow Jones. According to Dow Jones report, the screens are designed to exclude companies with financial ratios or lines of business that are typically viewed as incompatible with Shariah investment guidelines. Among the prohibited line of business are businesses dealing with the production or serving of alcohol, tobacco, pork-related products, conventional financial services (banking and insurance), weapons and defense, and entertainment (hotels, casinos/gambling, cinema, pornography, and music). *The Islamic stocks are different from the conventional stocks not only because of the Shariah-compliant restrictions but also because of the smaller and less diversified market.* These unique characteristics of Islamic stocks call for a specific analysis to it, as conclusions derived from the analysis of conventional stocks may not be applicable.

The line of empirical research on financial market linkages, may suffer from several drawbacks. First, the focus on comparative statics misses the important element of time variation in equity risk. Recent studies have pointed out that the relationship among stock markets are time-scale varying (Huyghebaert and Wang, 2010; Rezayat and Yavas, 2006; Mandeleno and Pinho, 2012) Thus, any attempt to model the integration of markets without taking account of the time variation may yield confusing and partial results (Huyghebaert and Wang, 2010). By considering the element of time variation, the distinction between the short and long-term investors who have different objectives could be pointed out. As discussed in Madaleno and Pinho (2012), short-term investors naturally are more interested in the comovement of stock returns at higher frequencies, that is, short term fluctuations, but the long-term investor focus on the relationship at lower frequency. Additionally, denying the time-varying nature of international stock market relationships may result in mixed result (Awokuse et al., 2009).

The next essential gap of the past study is in terms of the method of analysis. As discussed by Menezes et al. (2012), among the main drawbacks are the use of linear models and the computation of stock return by taking first log difference. Linear models may not be able to capture the complex relationship of international markets. Secondly, the computation of return data will

remove the long-run information contained in the original price data. Thus, using prices along with returns as this paper tends to provide, may give a better framework for the analysis of market globalization. Moreover, the past studies usually focus on one particular issue such as, short-run linkages, long-run linkages, volatility linkages or comovement of stock prices. Studies that provide a more comprehensive view as this study attempts to deliver is still lacking.

Accordingly, as another contribution to this line of literature, this paper will make an attempt to examine the linkages of international Islamic stock index with the six major international stock markets in the world. The analyzed stock markets are United States, United Kingdom, Europe, Japan, China, and additionally Malaysia as one of the major Islamic financial markets in the world. Even though Malaysia is not a dominant economy in the world, it is included in the study because it is one of the major Islamic markets in the world. Specifically, this paper tries to address the international stock linkages from the point of view of Islamic index in a more comprehensive approach. The comprehensive approach was captured through the analyses of volatility, cross volatility, comovement and Granger causality. In addition, the analyses will try to capture the time-scale varying behavior of stock markets through the application of the recently applied Continuous Wavelet Transform (CWT) and Maximal Overlap Discrete Wavelet Transform (MODWT).

Overall, our analyses reveal that the interaction among the stock indices are indeed time-scale varying as the findings tend to change across the time scales. We found strong linkage between Islamic index and the western markets as compared to the Asian markets. During the global financial crisis, the comovements between stock indices are higher and unstable. Furthermore, the results indicate the existence of inefficient market, spillover effect of financial crisis, strong causality effects and bi-directional causality between Islamic index and other international indices. Consequently, international investors should include the Asian markets in their investment portfolio, and the inefficient market might suggest an arbitrage opportunity. However, the international diversification opportunities decrease especially during the crises as the volatility and comovements increase.

This paper extends the previous literature in the following aspects. First, as empirical research for Islamic equity investment is still lacking, the main focus of the paper is to analyze the international stock linkages from the perspective of Islamic market in view of its unique characteristics in a more comprehensive approach. This will provide some beneficial insights to the Islamic investors particularly for the purpose of portfolio diversification. Second, the paper explores the potential Granger causality of the stock markets at different time-scales in that the analysis will also take into account the time-scale varying behavior of long run stock market relationships. Consequently, the implication of the results could capture the information flow in the market and might satisfy the heterogeneous investors holding stocks for different periods with different objectives.

The paper is organized as follows. The next section presents the theoretical framework objective of this paper. Section 3 provides a brief literature review about stock market linkages. Section 4 discusses the methods employed in this paper. Data overview, descriptive statistics are provided in Section 5. In Section 6, empirical results, applying the tools described in Section 4 for the six stock market indices are discussed. Section 7 discusses the policy implications and point out directions for future research. Finally, Section 8 provides some concluding remarks.

2. Theoretical Framework

The area of this research is related to the theory of international financial market integration and portfolio diversification. Market integration can be defined as the intensity of association and causality that occurs in price and return's transmission over time (Menezes et al., 2012). Generally

in finance, diversification means reducing risk by investing in variety of assets. The theory of finance suggested a security's standalone risk can be eliminated through proper diversification by combining different assets with negative correlation. The theory of portfolio diversification has long being discuss by Markowitz (1959). Portfolio selection is based on the theory that investors should focus on selecting optimal portfolios as opposed to optimal assets. To reduce risk, it is necessary to avoid a portfolio whose securities are all highly correlated with each other. Correlation is typically being used to represent relationships between assets. It is the tendency of two variables to move together. When stock are perfectly negative correlated, all risk can be diversify away; but when stocks are positively correlated, diversification does not good. In reality, most stocks are positively correlated but not perfectly so.

In the perspective of international finance, the means of diversification can be achieved by investing at different markets of the world. International diversification allows for reduced total risk without sacrificing expected returns as the stock returns display much higher positive correlation within a country than across countries (Rezayat and Yavas, 2006). However, because national and overseas residents, whether households, corporations, or financial institutions, can increasingly decide whether to hold domestic assets such as bills, bonds, equity, or other assets in foreign countries, financial assets linkage arises. Based on the Law of One Price (LOP), market integration occurs when the price of some asset tends to uniformity across different geographical markets after allowing for different opportunity costs (Menezes et al., 2012). Based on this view, the price variable provides a suitable framework to test for market linkages by looking at the price relationship of assets over time (Menezes et al., 2012). The price will represent the long-run market integration and price changes over time or asset returns is the measure of short-run market integration.

Rezayat and Yavas, (2006) listed out five factors contributing to an increased general level of correlation among markets and markets integration that include the following: (1) the development of global and multinational companies and organizations; (2) advances in information technology; (3) deregulation of the financial systems of the major industrialized countries; (4) explosive growth in international capital flows; and (5) the abolishment of foreign exchange controls.

Lucey and Kearney (2004) discuss three basic approaches to defining the extent to which international financial markets are integrated. These fall into two broad categories of direct and indirect measures. The first approach, a direct measure, is couched in terms of the extent to which the rates of return on financial assets with similar risk characteristics and maturity are equalized across political jurisdictions. It is a direct measure, because it invokes the law of one price and related to the theory of equalization of rates of return, whereby assets with identical cash flows should command the same return. The second approach invokes the concept of international capital market completeness. Asserts that financial integration is perfect when there exists a complete set of international financial markets that allows economic and financial market participants to insure against the full set of anticipated states of nature. This obviously requires the efficient operation of a more complete set of markets than presently exists. The third approach is based on the extent to which domestic investment is financed from world savings rather than from domestic savings. Both these latter measures can be called indirect.

Furthermore, from a compilation of literatures, Lucey and Kearney (2004) list out three main measurement of stock market integration. First, *CAPM*; models typically assumes that all the world's capital markets are in fact perfectly integrated, and therefore the source of asset risk can be associated purely with the covariance of the local returns with the world market portfolio. The key weakness of this approach, however, is that the degree of segmentation is assumed to remain constant over time. Second, *correlation and cointegration;* if the correlation structure demonstrates instability over time, then, assuming that the trend is towards increased correlation, this indicates

greater integration. Third, *time varying analysis;* recent measurement techniques that might capture the changes of integration in equities markets over time. Consequently, these are all theoretical views which provide the fundamental ground for investors and policy makers. However they are still inconclusive without an empirical test to give an answer of what really happened in reality.

3. Literature Review

International stock market linkages can be address through several approaches either by looking at the correlation, cointegration, causality, or comovement. As mentioned before, research in this line of literature had received more attention due to the occurrence of financial crisis. Financial crisis can create contagion or structural break in the movement of stock prices, and thus affect the correlation between international stocks.

In the event of Asian financial crisis, Fernandez (2006) detects short-term breakpoints in stock price. Loh (2013) reports that the behavior of stock market change and the correlation between the markets has become more integrated. Similarly, Ding and Pu (2012) found that market linkage become stronger in crisis as a result of increasing volatility and deteriorating funding liquidity. In Ahlgren and Antell (2010) the linkages among stock prices was evidenced in the short term. However, in contrast, Xu and Hamori, (2012) suggest that on account of the 2008–09 US financial crisis, international transmission of stock prices weakened in both the mean and variance. This is supported by Horvath and Petrovski (2013) that suggest weaker stock market integration in the event of crisis is might be due to the decrease in market capitalization. Awokuse et al., (2009) also suggest that the significant increase in market linkages due to the wave of financial liberalization policies have later weakened during the 1997 Asian financial crisis.

The mixed results in the above study were argued due to the time-varying nature of international stock market relationships. Awokuse et al., (2009) found time-varying cointegration relationships exist among these stock markets. Mandeleno and Pinho (2012) suggested that the relation among analyzed indices was reported to have changed and evolved through time as financial crisis occurred at different time periods. Supporting this view, Loh (2013) uncover the evidence of a wide variation in co-movement across the time scales of the financial crises, they provide evidence that there are time-variation and scale-variation in co-movements between the analyzed stock markets.

Despite the financial crisis, shift in stock prices movement could be the result of major event or news that creates shock in the market. Charles and Darne (2006) found that the international stock markets experienced large permanent and temporary shocks in response to the terrorist attacks and its aftermath. International market correlations also change after an exogenous shock such as the introduction of European Union (Rezayat and Yavas (2006).

Another prominent analysis of stock market linkages is analyzing the direction of causality among international indexes. Besslet and Yang, (2003); Huyghebaert and Wang, (2010); Menezes et. al (2012); Fujii (2005); Azdemir and Cakan (2007); Gooijera and Sivarajasingham (2008) are among the studies that focus on this objective. Generally the analyses indicate that stock markets are closely linked both in terms of price level and returns. The causalities vary overtime and tend to strengthen particularly at the time and after major financial crises (Fujii, 2005; Gooijera and Sivarajasingham, 2008). In addition, Azdemir and Cakan (2007) found a strong bi-directional and non-linear causal relationship among the stock indices.

Significant linkages among international stock markets could create spillover effect to other market. In the case of China, due to the implementation of liberalization policies, Chinese stock market is linked to the overseas markets and the reforms permit spillovers from China to the international markets (Li, 2012). For dominant markets such as United States and European, the

direction of spillover could be bidirectional (Savva, 2009). Ding and Pu (2012) also found evidence of spillover across markets.

The strength of linkage and dependency between markets is much related to the geographical factor. For instance, Chinese market has been reported to have the highest level of dependence with Japan and Pacific countries. The similar finding also evidence between United States and United Kingdom (Ozdemir, 2009). Moreover, in addition to standard analyses of stock linkages, recent studies also tend to focus on contemporaneous interactions between stock markets. Contemporaneous interactions would consider the effect of exchange rate variable into the estimation. Lee (2006) found contemporaneous interactions exist between the stock markets of the U.S., Japan, and Hong Kong.

As mentioned, the main rational for analyzing stock linkages is for the purpose of international portfolio diversification. Based on Diamandis (2009), although cointegration exists there are small long run benefits from international portfolio diversification since the stock prices adjust very slowly to these common trends. Also supported by Rezayat and Yavas (2006), despite the significant interdependencies across markets, there is still room for international portfolio diversification. Lucy and Muckley (2011) also suggested that the European stock markets provide a superior long-term diversification opportunity relative to that provided by the Asian stock markets despite positive correlation style.

From the above review of literatures, the results of the analyses are important to the investors and policy makers. However, none of them address the analysis in the context of Islamic stock market. The lack of empirical research focusing in this area has made the issue remained unresolved and put Islamic investors at disadvantages. Therefore, this paper would like to make an attempt at addressing the issue with a view to filling up the gap in the literatures.

4. Empirical answer: Method

Analysis of this paper is divided into two main estimations. Utilizing wavelet techniques as the main method, the first estimation is using continuous wavelet transformation (CWT), and the second estimation is using maximal overlap discrete wavelet transformation (MODWT). According to Mandeleno and Pinho (2012), wavelet is interesting and useful because the window can be continuously resized. By looking at a signal with a small window only fine features can be viewed, whereas by looking at the same signal with a large window, the coarse features will be viewed. Thus, by using wavelets we could see both fine details and approximations. The temporal analysis by wavelets is performed with a contracted, high-frequency version of the wavelet, while frequency analysis is performed with a dilated, low-frequency version of the same wavelet.

4.1 Continuous wavelet transformation (CWT)

In CWT, the main purpose is to capture (i) individual stock index volatility, (ii) cross volatility, and (iii) co-movement between stock indices. CWT will generate graphical output for the whole time period at different frequencies of the indices.

As discussed by In and Kim (2013), CWT is defined as the integral over all the time of the signal multiplied by scaled, shifted version of the wavelet function ψ (scale, position and time):

$$C(scale, position) = \int_{-\infty}^{\infty} x_t \, \psi(scale, position, t) dt$$

The results of CWT are many wavelet coefficients C, which are a function of scale and position. The scale and position can take on any values compatible with the region of the time series x_t. Multiplying each coefficient by the appropriately scaled (dilated) and shifted wavelet yields the constituent wavelet of the original signal. To capture the high and low frequency of the signal, the wavelet transform utilities a basic function (mother wavelet) that is stretched (scaled) and shifted.

4.2 Maximal overlap discrete wavelet transformation (MODWT)

The main purpose of MODWT in this study is to decompose the time series data which are the stock prices indices into five time scales plus the long scale. The new decomposed series of data will be used to estimate the linear and non-linear causality between the stock indices. From this, the causality relationships can be found out at different time scales. Besides using MODWT, the same objective could also be achieved by DWT. However there are several advantages of MODWT over DWT.

MODWT essentially to define a transform that acts as much as possible like DWT, it does not suffer from the DWT's sensitivity to the choice of a starting point for a time series. Non-redundancy of the DWT is achieved by down-sampling the filtered output at each scale. Importantly, the zero-phasing property of MODWT permits meaningful interpretation of "timing" regarding the wavelet details. With this property, we can align perfectly the details from decomposition with the original time series. In comparison with the DWT, no phase shift will result in the MODWT. MODWT provide smoother coefficient compared to DWT.

The MODWT of level J for a time series x_t is highly redundant non-orthogonal transforming yielding the column vectors $D_1, D_2, \ldots.. D_j$ and S_j, each of dimension N. The vector D_j contains the MODWT coefficients associated with changes in x_t between scale $j - 1$ and j, while S_j contains the MODWT scaling coefficient associated with the smooth of x_t at scale $J + 1$ and higher. The MODWT also follows the same pyramid algorithm as the DWT, while it utilized the rescaled filters, instead of the wavelet and scaling filters in the DWT. These rescaled wavelet and scaling filters can be expressed as follows:

$$\widetilde{h_j} = \frac{h_j}{2^j} \; and \; \tilde{g}_j = \frac{g_j}{2^j}$$

Utilizing its filtered output at each scale, a time series x_t can also be decomposed into its wavelet details and smooth as follows:

$$x_t = \sum_{j=1}^{j} \widetilde{D_j} + \tilde{S_j}$$

The wavelet coefficients are calculated using wavelet filters. Wavelet filter was chosen based on length of data, complexity of the spectral density function, and the underlying shape of features in the data.

4.2.1 Granger causality

Conducting Granger-causality test is important to fulfill the objectives of this paper since correlation does not necessarily imply causation in any meaningful sense of that word. The econometric graveyard is full of magnificent correlations, which are simply spurious or meaningless. The Granger (1969) approach to the question of whether x causes y is to see how much of the current y can be explained by past values of y and then to see whether adding lagged values of x can improve the explanation. y is said to be Granger-caused by x if it helps in the

prediction of *y*, or equivalently if the coefficients on the lagged 's are statistically significant. Note that two-way causation is frequently the case; *x* Granger causes *y* and *y* Granger causes *x*.

It is important to note that the statement " *x* Granger causes *y*" does not imply that *y* is the effect or the result of *x*. Granger causality measures precedence and information content but does not by itself indicate causality in the more common use of the term. The bivariate regressions for all possible pairs of *(x, y)* series in the group are based on the following form:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \ldots + \alpha_l y_{t-l} + \beta_1 x_{t-1} + \ldots + \beta_l x_{t-l} + \epsilon_t$$

$$x_t = \alpha_0 + \alpha_1 x_{t-1} + \ldots + \alpha_l x_{t-l} + \beta_1 x_{t-1} + \ldots + \beta_l y_{t-l} + u_t$$

The reported F-statistics are the Wald statistics for the joint hypothesis for each equation are:

$$\beta_1 = \beta_2 = \ldots = \beta_l = 0$$

The null hypothesis is that *x* does not Granger-cause *y* in the first regression and that *y* does not Granger-cause *x* in the second regression.

5. Data Description

This paper use seven daily prices of stock market indices, namely Dow Jones Islamic World as the main index, S&P500 of United States, FTSE100 of United Kingdom, Nikkei225 of Japan, S&P Euro representing the European market, Shanghai SE Composite of China (SSEC), and KLCI of Malaysia. The ranges of data are from January 1996 to February 2013, and were collected from Datastream. Japan, U.K and U.S are chosen because these markets rank the highest in term of their transaction volume and capitalize value (Ozdemir, 2009). China on the other hand had increased its global influences due to the new stock markets reforms. Finally, Malaysia is included in the analysis because it is one of the major Islamic markets in the world. Referring to Securities Commission of Malaysia, 92 percent of the total stocks listed in Bursa Malaysia are Shariah compliant stocks. In addition to that, Malaysia is the largest Sukuk (Islamic debt certificates) issuer in the world.

The stock market indices are analyzed in levels, as discussed by Madaleno and Pinho (2012), daily prices instead of returns are used since the main advantage of wavelet analysis is its ability to decompose time series, and data in general, into their time scale components. Due to the translation and scale properties, non-stationarity in the data is not a problem when using wavelets, and pre-filtering is not needed. The price variable provides a suitable framework to test for market linkages in the long-run and price changes over time or asset returns is the measure of short-run market integration (Menezes et al., 2012). Therefore, for the purpose of comparison, we estimate Granger causality for both in their levels and returns.

Summary of descriptive statistics of daily prices for each indices are presented in Table 1. It is clear that all indices are against normal distribution, evidence by the significant in the p-value of Jarque-Bera which translated from the excess of kurtosis and skewness. These indicate the existing of typical phenomena of volatility clustering in stock prices. Japanese market shows the highest variability as measured by standard deviation of prices. The S&P 500 of United States displays less volatility evidence by lowest standard deviation than other markets. On the other hand, Islamic Index present average volatility compared to the others. The negative (positive) values for skewness indicate that the series distributions are skewed to the left (right).

Table 2 presents the correlation matrix between all seven stock market indices under analysis. Islamic Index is positively more correlated with US market, and less correlated with

European market. Islamic Index indicates negative correlation only with Japanese market. Results for the simple cross-correlation analysis of stock index prices indicate that these stock markets do exhibit a significant degree of integration with each other (Madaleno and Pinho, 2012).

Table 1: Descriptive statistics of daily prices for the stock market indices under analysis

	DJ ISLAMIC	SSEC	S&P EURO	S&P 500	NIKKEI225	KLCI	FTSE100
Mean	1514.194	1968.389	1215.917	1156.592	13336.88	1002.874	5293.731
Median	1467.805	1673.221	1158.639	1179.365	12260.44	921.9150	5410.435
Maximum	2467.970	6092.055	1957.951	1570.900	22666.80	1694.160	6930.200
Minimum	806.9800	516.4600	577.5940	599.4000	7054.980	262.7000	3287.040
Std. Dev.	421.5164	943.9805	321.3510	223.5553	3872.705	326.8283	842.5576
Skewness	0.179005	1.505965	0.321912	-0.496640	0.460773	0.344773	-0.333789
Kurtosis	1.851265	5.835004	2.436997	2.538554	2.032429	2.125432	1.990774
Jarque-Bera	270.0078	3190.824	136.4212	223.7139	332.9845	231.3238	273.0725
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	4476	4476	4476	4476	4476	4476	4476

Table 2: Cross-correlation analysis among the stock market index prices under analysis

	SSEC	S&P EURO	S&P 500	NIKKEI 225	KLCI	FTSE 100	DJ ISLAMIC
SSEC	1.000000						
S&P EURO	0.433660	1.000000					
S&P500	0.509175	0.819203	1.000000				
NIKKEI225	-0.227843	0.226614	-0.038767	1.000000			
KLCI	0.554453	-0.100426	0.267347	-0.141647	1.000000		
FTSE100	0.445157	0.834014	0.906365	0.198250	0.196594	1.000000	
DJ ISLAMIC	0.759335	0.621906	0.827669	-0.101886	0.640019	0.748833	1.000000

6. Empirical Results and Discussion

6.1 Volatility

Figure 1 shows the continuous wavelet power spectrum that illustrates individual volatility for the DJ Islamic, S&P500, FTSE100, Nikkei225, S&P Euro, SSEC and FBMKLCI stock market indices. As explained by Madaleno and Pinho (2012) in the wavelet power spectrum, the black contour in regions with energy indices designates the 5% significance level (95% confidence level) estimated from Monte Carlo simulations using phase randomized surrogate series, assuming the bottom red noise defined by the variance and the number of points of the original time series. The cone of influence, indicating the region affected by edge effects, is shown with a line. The periods outside the cone of influence must be neglected since they do not possess statistical confidence. The color code for power ranges from blue (low frequency) to red (high frequency). In short, low frequency refer to high scales that represent the long term structure of the data, in contrast, high frequency refer to low scales that represent the short term structure of the data.

The time scale decomposition of these variables reveals some interesting facts. DJ Islamic shows a huge significant volatility in the period from 2006 to 2011 in the daily time scale of 256 to 1024 days, and small significant volatility in year 2000 in the daily scale of 512 days. SSEC and FBMKLCI depict almost similar pattern which experience large volatility from 2006 to 2011 in the daily time scale of 256 to 1024 days, but for China the volatility is longer that start since 2003. S&P Euro experience small significant volatility during 1998 to 2009 at high scale.

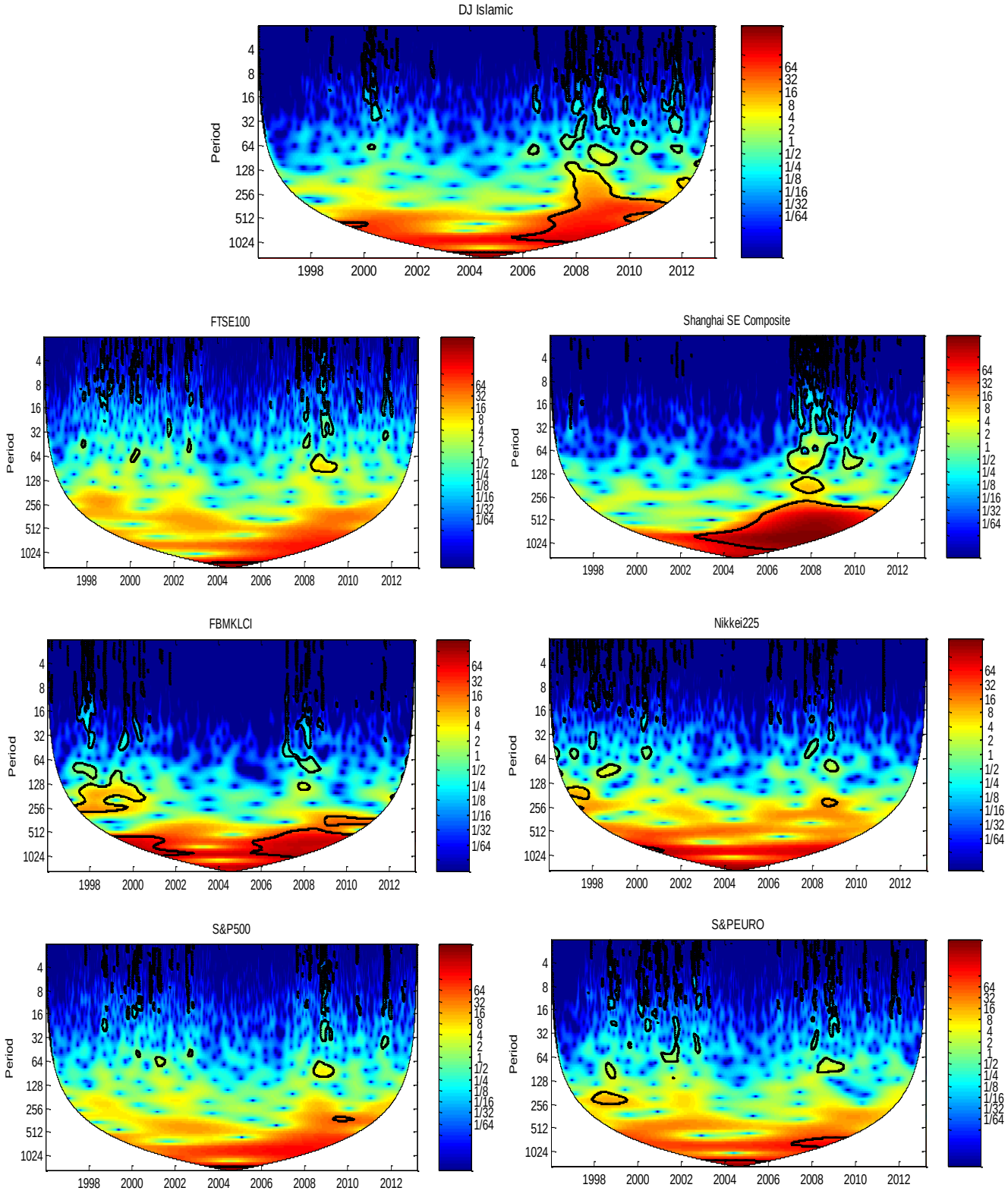

Figure 1: Wavelet power spectrum of stock market indices (illustrate individual volatilities); (a) DJ Islamic, (b) FTSE100, (c) SSEC, (d) KLCI, (e) NIKKEI225, (f) S&P500, (g) S&P EURO.

Despite of these, all of the analyzed indices appear to have similar pattern where the significant volatility occur during 1998 to 2003 and 2007 to 2011, the difference between them are the time scales. This might be due to the two major crises of Asian financial crisis and global financial crisis that occurs during that time. The Asian crisis affects the stock market more at the short term except for Malaysia. In contrast, the global crisis affect Islamic index, China and Malaysia at both long and short term. This is intuitive since among the analyses indices, Malaysia is

the most affected to the Asian crisis. The findings indicate that the volatility of stock prices increase during financial crisis. In addition, the volatility was somehow continue after a few years that might signal the existing of inefficient market where it took a long time for the stock to return back to equilibrium after a shock. In addition to Asian financial crisis in 1998, the continuation of indices volatility might be caused by the terrorist attack on 11th September 2001 which latter lead to controversial war against Muslims.

6.2 Cross volatility

For cross volatility, Figure 2 shows the continuous wavelet power spectrum that illustrates cross volatility between DJ Islamic and other six indices (S&P500, FTSE100, Nikkei225, S&P Euro, SSEC and FBMKLCI). The arrows in the figures indicate the movement of the volatility between two indices. Analyzing the figures in detail, the cross volatility between Islamic and SSEC are observed to have high and long statically significant volatility from 2002 until 2011, and the arrow appear to indicate that the china market is leading Islamic index with positive correlation. The significant events also occur at all time scales that majorly concentrate during 2007 to 2010. For Islamic index and FTSE100, high and medium shorter significant volatility exist during 2007 to 2011 which also appear to lead Islamic Index.

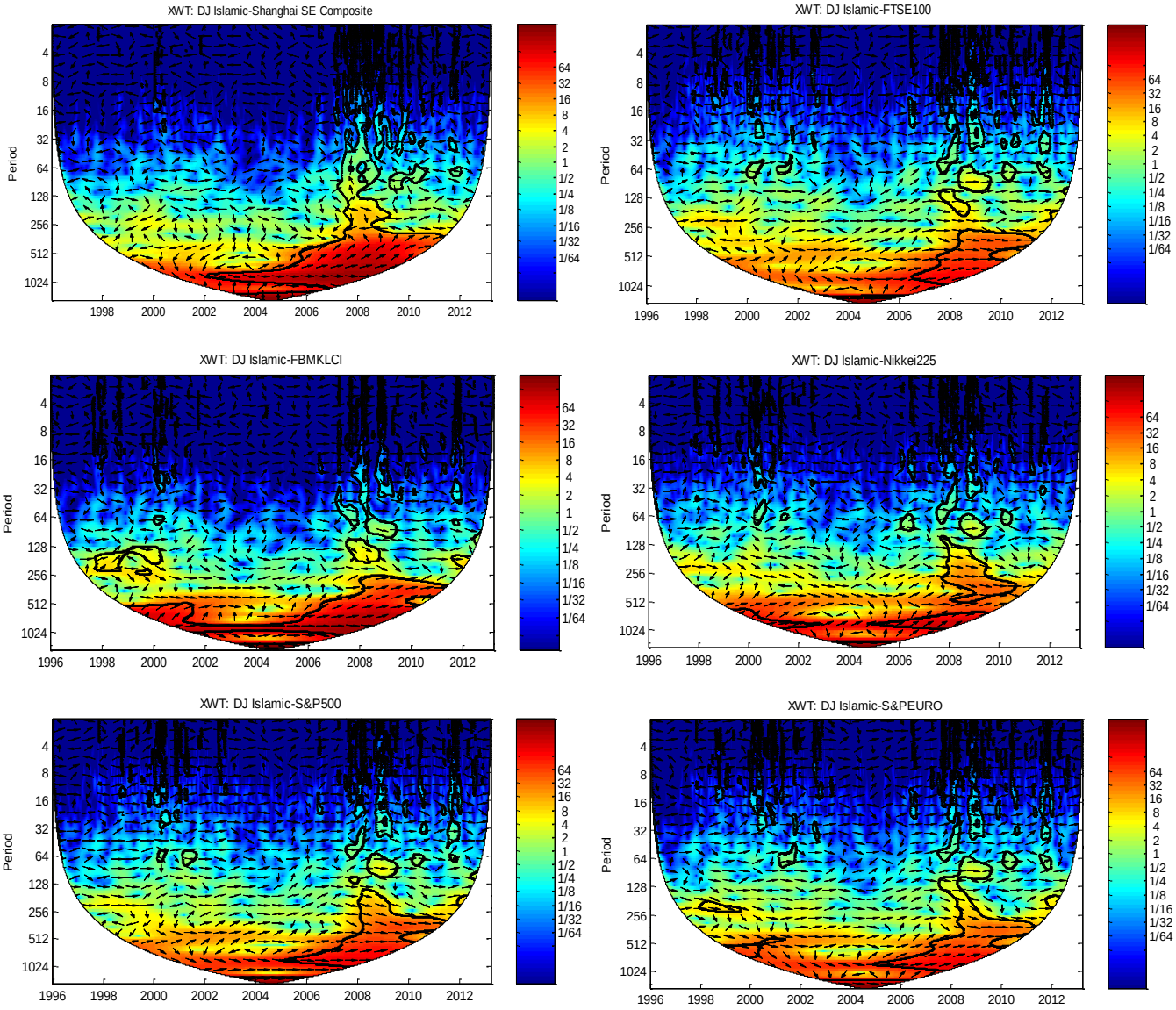

Figure 2: Cross-volatilities between stock market indices: (a) DJ Islamic – SSEC, (b) DJ Islamic – FTSE100, (c) DJ Islamic – KLCI, (d) DJ Islamic – Nikkei 225, (e) DJ Islamic – S&P500, (f) DJ Islamic – S&P EURO.

Cross volatility with other indices (FBMKLCI, NIKKEI225, S&P500, and S&PEURO) also depict almost similar pattern. For FBMKLCI, the appearance of high significant cross volatility at low scale is longer that start from 1999 to 2011 which is almost across all the period of analysis. The interesting part is although Malaysia is a small market, it still appeared to positively lead Islamic index during this period and time scale. Scanning through all the figures, in general we can see that Islamic index was led by other indices, and high significant cross volatility at high scale occur during global financial crisis period which between 2007 and 2011.

6.3 Comovement

Figure 3 presents the estimated wavelet coherency or comovement and phase difference between the seven indices. Values for significance were obtained from Monte Carlo simulations. Contours denote wavelet-squared coherency, the thick black contour is the 5% significance level and outside of the thin line is the boundary affected zone. In the cross-wavelet power pictures, color code for power ranges from blue (low coherency) to red (high coherency). Vectors indicate the phase difference between the two series.

Looking at the figures in detail, starting with China market, DJ Islamic seems to have strong comovement with SSEC on 2004 until 2011 between 512 to 1024 days. During this period SSEC positively leading DJ Islamic, but the two indices start to move in the same direction as the scale get higher. Also observed, small significant high comovement island scatted over the periods at difference time scales, where DJ Islamic lagging with the mix of positive and negative relationship. For Malaysia, DJ Islamic show a straight line of significant strong comovement from 1999 until 2011, that begins at scale of 512 days in the early period, but the scale start to get wider until reaching to scale of 256 to 1024 days. Small and medium significant high comovement island scatted over the periods at difference time scale, where FBMKLCI leading with mix of positive and negative relationship. Looking at Japan figure, DJ Islamic seems to have high comovement with Nikkei 225 at lower time scale which between 256 days to less than that especially during 2007 to 2010. Nikkei 225 also appears to lead DJ Islamic with the mix of positive and negative relationship.

For UK market, DJ Islamic appeared to have very strong comovement with FTSE100 at almost all over the period and time scale except during 1998 to 2004 at scale 256 to 1024 days. FTSE100 positively lead DJ Islamic between 2002 and 2007, the arrow change slightly indicating negative relationship in 2008 between scale 256 to 512 days, but most of the time the indices move in the same direction. Almost similar picture also depicted in US market that indicated very significant strong comovement across all the period and scale, except between 1998 to 2003 at scale less than 246 day to 1024 days. Most of the time these two indices move in the same direction, but S&P500 appear to lead DJ Islamic with the mix of positive and negative relationship and not the vice versa. The existence of low comovement between DJ Islamic with US and UK markets at almost the same period and scale might signal the effect of slow market movement due to the terrorist attract in US and spillover effect of Asian financial crisis. Shifting to the last index, DJ Islamic also has strong comovement with S&P Euro across all period and scales. At scale 256 to 1024 days, S&P Euro negatively lead DJ Islamic in 1998 until 2001, however the arrow change in 2005 until 2008 at scale 512 to 1024 days indicating positive relationship.

In summary, the figures reveal very interesting results. Islamic index appear to have very high comovement with US, UK and Euro markets, intermediately affected by Malaysia and Japan markets, and having low comovement with Chinese market. China appeared to have the weakest comovement with Islamic Index. This is consistent with Li (2012), however, the correlation is expected to increase due to the implementation of China's the liberalization policies and institutional reforms. Dividing the markets into regions, it is clear that Islamic index have high and strong comovement with the western market as compared to Asian markets. This might be due to the fact that event though the Dow Jones Islamic world index is international index that exclude US

market in its index component, it is still being develop and traded in US market which highly correlated with the western world. This has been discussed in Mandeleno and Pinho (2012) and also supported by Odzemir (2009) that geographically and economically closer countries exhibit higher levels of market linkages as suggested also suggested by other researches. Rezayat and Yavas (2006) suggest the lap of time might be the possible reason behind this. Therefore, as a suggestion, international investors of Islamic index should include Asian market in their investment portfolio as it is less correlated with the international Islamic index.

Moreover, in the event global crisis, the comovements between markets becomes higher, and thus decrease the opportunities for international diversification at the most crucial time. The finding is consistent with Ahlgren and Antell (2010); Ding and Pu (2012) and Wang et al. (2011). International diversifications also become a limitation to the investors due to the changing in the lid-lag of positive and negative relationship across period and scales, thus, indicating the existence of instability in various aspects of market comovements.

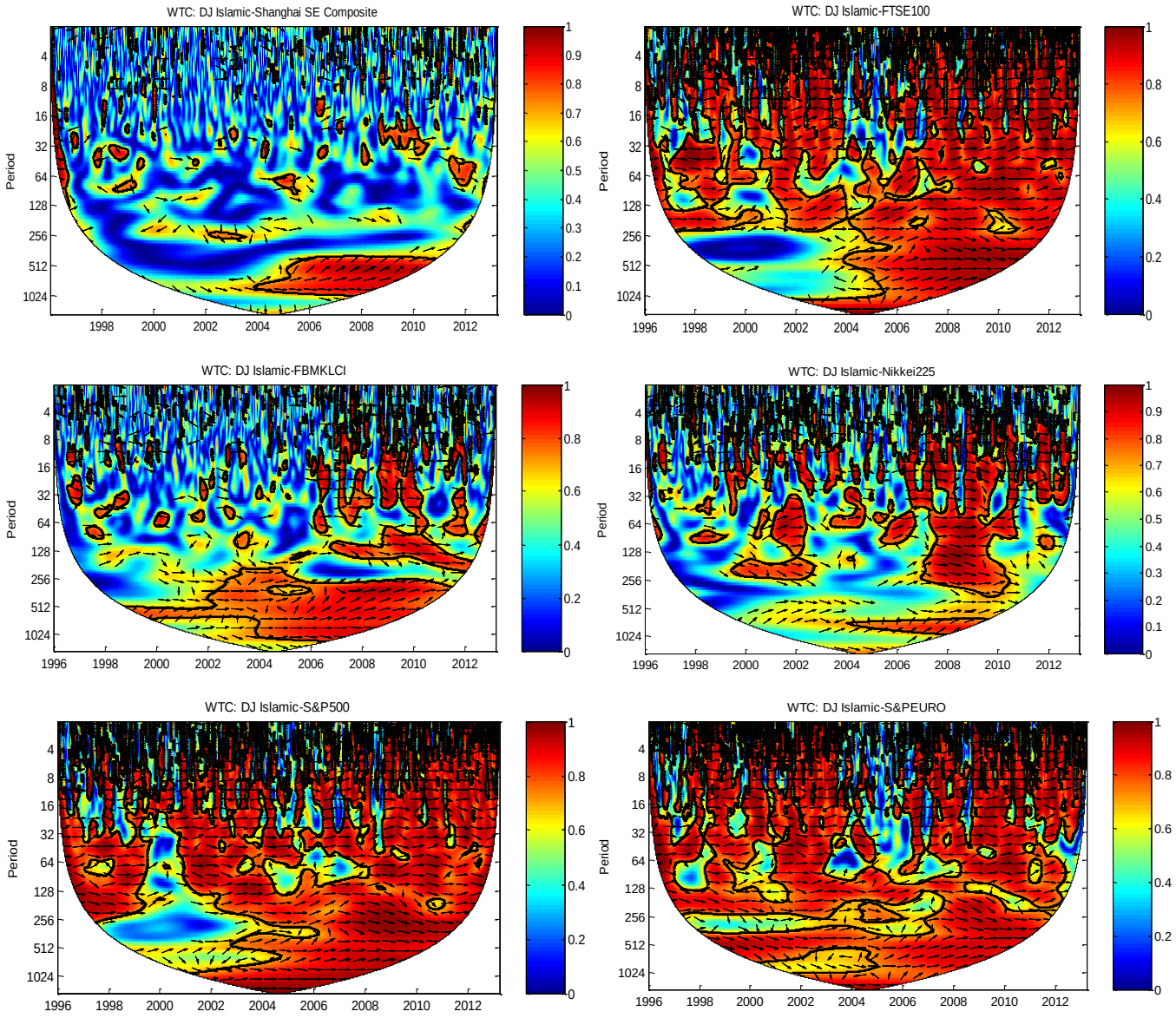

Figure 3: Cross-wavelet coherency or comovement between stock market indices: (a) DJ Islamic – SSEC, (b) DJ Islamic – FTSE100, (c) DJ Islamic – KLCI, (d) DJ Islamic – Nikkei 225, (e) DJ Islamic – S&P500, (f) DJ Islamic – S&P EURO.

6.4 Granger Causality

MODWT multiresolution analysis was performed before testing Granger-causality in order to capture the causality between the indices at different time scales. Since this analysis use daily data, the wavelet scales of D1, D2, D3, D4, D5, and scale long are associated with oscillation of period 2-4, 4-8, 8-16, 16-32, 32-64, and above 64 days, respectively. Table 3 and 4 report the Granger-causality test of indices price and return respectively. For the purpose of simplicity and fulfilling the objectives of the study the presented result are the causality of DJ Islamic index to other indices and the causality of other indices to DJ Islamic index. The Granger-causality among other indices is not presented, but available in the appendices section for reference. As noticed, the presented tables are divided into two parts as:

1. *Ho_1: DJ Islamic does not Granger-cause other indices*
2. *Ho_2: Other indices do not Granger-cause DJ Islamic*

With the reference to the significance of the F-statistics, the results reported in the tables show that there are strong causality effects of Islamic index with other international indices. The strong causality exists in the level form and across different time scale even in the first layer, which represent the period of 2 days. Overall, however, the causality effects slightly changing at different scales. This signifies that the linkages of Islamic index with other international indices are changing relative to the time scales. For example, Table 3 shows that the Granger-causality of DJ Islamic and SSCE is strong across all scale except in scale 5. This also evidence in the causation relationship of DJ Islamic with FTSE 100 and S&P EURO where the causality are insignificant at level form and scale four.

Table 3: Granger-causality test of stock market indices price on the wavelet domain

		Level	D1	D 2	D 3	D 4	D 5	Scale
DJ Islamic	→ SSCE	13.7848* [0.000]	11.508* [0.000]	10.263* [0.000]	5.0326* [0.0018]	20.869* [0.000]	1.18796 [0.3127]	2.87457* [0.0349]
DJ Islamic	→ NIKKEI225	190.986* [0.000]	152.791* [0.000]	65.5758* [0.000]	16.2638* [0.000]	25.395* [0.000]	26.2266* [0.000]	7.02092* [0.0001]
DJ Islamic	→ KLCI	35.8964* [0.000]	7.99127* [0.000]	21.7214* [0.000]	22.5537* [0.000]	11.8408* [0.000]	14.9289* [0.000]	17.302* [0.000]
DJ Islamic	→ FTSE100	0.70608 [0.5483]	15.6414* [0.000]	35.6786* [0.000]	25.7979* [0.000]	7.17685* [0.000]	36.6613* [0.000]	54.6163* [0.000]
DJ Islamic	→ S&P500	25.8668* [0.000]	4.78113* [0.0025]	9.10159* [0.000]	10.368* [0.000]	7.5659* [0.000]	11.7177* [0.000]	42.3744* [0.000]
DJ Islamic	→ S&P EURO	0.41117* [0.000]	15.1705* [0.000]	35.0898* [0.000]	13.862* [0.000]	0.96063 [0.4103]	14.4955* [0.000]	38.1639* [0.000]
SSCE	→ DJ Islamic	3.25877* [0.0207]	25.9953* [0.000]	21.2284* [0.000]	3.77721* [0.0101]	15.705* [0.000]	7.26319* [0.000]	1.28062 [0.2792]
NIKKEI225	→ DJ Islamic	24.0876* [0.000]	34.4033* [0.000]	62.294* [0.000]	17.3257* [0.000]	32.0105* [0.000]	29.0801* [0.000]	8.93519* [0.000]
KLCI	→ DJ Islamic	2.74957* [0.0413]	4.803* [0.0024]	16.3237* [0.000]	19.4096* [0.000]	13.0582* [0.000]	11.6743* [0.000]	22.7762* [0.000]
FTSE100	→ DJ Islamic	7.47266* [0.000]	27.5843* [0.000]	36.2331* [0.000]	21.435* [0.000]	10.6617* [0.000]	37.9707* [0.000]	46.946* [0.000]
S&P500	→ DJ Islamic	0.37683 [0.7697]	1.35958 [0.2532]	7.06013* [0.0001]	7.9236* [0.000]	11.9018* [0.000]	19.6879* [0.000]	42.4118* [0.000]
S&P EURO	→ DJ Islamic	10.1954* [0.000]	34.4033* [0.000]	28.1827* [0.000]	10.0587* [0.000]	0.92076 [0.4298]	12.8727* [0.000]	36.3666* [0.000]

Note: The P-value of F statistics are given in parentheses, * indicates significant at 5% and ** indicates significant at 10%. Data used are daily closing stock index price for the period January 1996 to February 2013. Data were collected from Datastream. The column heading (level, scale 1 to scale long) refer to original stock index closing price and wavelet scales of 1, 2, 3, 4, 5, and scale long are associated with oscillation of period 2-4, 4-8, 8-16, 16-32, 32-64, and above 64 days, respectively.

The second main finding that can be observed from the results is the existence of bi-directional causality, whereby Islamic index significantly Granger-cause other indices and vice versa. Granger causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another. For instance, if a time series X is said to Granger-cause Y, it indicates that the X values provide statistically significant information about future values of Y. In this case, DJ Islamic is statically significant providing information about future value of Nikkei225 and Nikkei225 also statically significant providing information about future value of DJ Islamic regardless of the time scale. This is also applicable to KLCI. For other indices (SSEC, FTSE100, S&P500 and S&P EURO), the bi-directional causality also exist, but the causality effects slightly changing at different scales. The existence of bi-directional Granger-causality relationship imply a degree of market inefficiency in the sense that the lagged information from one stock market price can be used to forecast changes in another stock market price (Azdemir and Cakan, 2007).

For the purpose of comparison, we also estimate Granger-causality test to the index return at different time scales as presented in Table 4. In general, the depicted results are quite consistence with the index price estimation, the reported results show that there are strong causality effects of Islamic index return with other international indices return. The bi-directional causality also exists, thus the overall findings slightly change at different scales. In addition, DJ Islamic to FTSE 100 and S&P Euro to DJ Islamic report identical results, whereby the point of significant and insignificant are the same. Referring to the two tables, DJ Islamic to FTSE 100 is insignificant at level form but significant in the others, and S&P Euro is insignificant at level form and scale 1 but significant in the others. However, the Granger-causality effects in the indices returns are stronger as only four points of insignificant appear in the result as compared to six insignificant points in the price estimation.

Table 4: Granger-causality test of stock market indices return on the wavelet domain

		Level	D 1	D 2	D 3	D 4	D 5	Scale
DJ Islamic	→ SSCE	12.2221* [0.000]	23.5940* [0.000]	15.2663* [0.000]	15.3433* [0.000]	47.2039* [0.000]	26.1537* [0.000]	0.51404 [0.6726]
DJ Islamic	→ NIKKEI225	189.106* [0.000]	171.106* [0.000]	219.484* [0.000]	148.15* [0.000]	109.365* [0.000]	40.7929* [0.000]	13.7557* [0.000]
DJ Islamic	→ KLCI	37.4958* [0.000]	32.0186* [0.000]	50.3938* [0.000]	51.1803* [0.000]	38.136* [0.000]	28.4425* [0.000]	1.45085 [0.226]
DJ Islamic	→ FTSE100	1.10473 0.3458	30.7680* [0.000]	65.9918* [0.000]	29.5969* [0.000]	8.50303* [0.000]	29.0091* [0.000]	17.587* [0.000]
DJ Islamic	→ S&P500	25.6760* [0.000]	16.3763* [0.000]	13.0892* [0.000]	8.34557* [0.000]	3.85527* [0.0091]	11.4324* [0.000]	15.6885* [0.000]
DJ Islamic	→ S&P EURO	0.53282 [0.6598]	25.2354* [0.000]	51.7676* [0.000]	10.2576* [0.000]	3.71484* [0.011]	11.0839* [0.000]	7.38780* [0.000]
SSCE	→ DJ Islamic	3.64401* [0.0122]	23.5940* [0.000]	18.611* [0.000]	13.2863* [0.000]	45.8455* [0.000]	21.9201* [0.000]	1.42182 [0.2343]
NIKKEI225	→ DJ Islamic	24.2198* [0.000]	49.8741* [0.000]	182.245* [0.000]	125.248* [0.000]	110.452* [0.000]	32.5666* [0.000]	15.5733* [0.000]
KLCI	→ DJ Islamic	2.59594** [0.0507]	6.88163* [0.0001]	36.3697* [0.000]	39.0618* [0.000]	34.7267* [0.000]	31.4398* [0.000]	8.67052* [0.000]
FTSE100	→ DJ Islamic	11.6556* [0.000]	36.7637* [0.000]	82.2513* [0.000]	32.7955* [0.000]	11.3637* [0.000]	29.3465* [0.000]	25.9047* [0.000]
S&P500	→ DJ Islamic	1.16816 [0.3203]	1.74753 [0.155]	11.1232* [0.000]	7.71518* [0.000]	4.13918* [0.0061]	9.42721* [0.000]	12.5937* [0.000]
S&P EURO	→ DJ Islamic	10.835* [0.000]	21.9827* [0.000]	60.0314* [0.000]	12.7508* [0.000]	5.35214* [0.0011]	10.2293* [0.000]	8.53485* [0.000]

***Note*:** The P-value of F statistics are given in parentheses, * indicates significant at 5% and ** indicates significant at 10%. Data used are stock index return for the period January 1996 to February 2013, calculated by taking the first difference of the daily stock index price (for example: the return of DJ ISLAMIC = log(DJ ISLAMIC) – log(DJ ISLAMIC)t-1) . Data were collected from Datastream. The column heading (level, scale 1 to scale long) refer to original stock index return and wavelet scales of 1, 2, 3, 4, 5, and scale long are associated with oscillation of period 2-4, 4-8, 8-16, 16-32, 32-64, and above 64 days, respectively.

7. Policy Implications

From the findings, several policy implications could be pointed out. In general, the analyses of volatility, cross-volatility, comovement and causality, the results evidence the increase in international integration between Islamic Index and the major international markets in the long-run and during the crises. Lucey and Kearney (2004) discussed that increasing integration of equity and capital markets, in general, can be expected to have three broad sets of implications. First, the attractiveness of international portfolio diversification will weaken as returns are equalised across countries. Second, the more complete are the world's capital markets, the more robust will be the economies of the individual states. Third, household savings rates will consequently change over time. The former two elements are likely to have positive effects on economic growth while the latter is more uncertain.

The findings also support that geographically and economically closer countries exhibit higher levels of market linkages. As an implication, international Islamic investors should include Asian market in their investment portfolio as it is less correlated with the international Islamic index. However, the changing in the lead-lag of positive and negative relationship across period and scales indicates the existence of instability in various aspects of market comovements, this does imply serious limitations to the investor's ability to exploit potential benefits of international diversification (Madaleno and Pinho, 2012).

During the two major crises of Asian financial crisis and global financial crisis, the volatilities of indices are high, and somehow continued for a few years. High volatilities indicate the increase in trading frequency as the result of increase in uncertainty of stock prices. In general, the Asian financial crisis affected the stock market more in the short term, in contrast, the global financial crisis affected in both long and short term. From this, two possibilities could be derived, first, the existence of inefficient market where it took a long time for the stock to return back to equilibrium after a shock. Yet, for arbitrager this might be an opportunity since the innovations in the stock markets do not rapidly get transmitted to other market. Second, the volatilities mark spillover effect of the Asian financial crisis. As known, the Asian financial crisis occurred only in several Asian countries such as Malaysia, but the volatilities in the stock indices appeared in all analyzed indices including the western market. In addition, the existence of bi-directional Granger-causality relationship implies a degree of market inefficiency in the sense that the lagged information from one stock market price can be used to forecast changes in another stock market price (Azdemir and Cakan, 2007).

8. Conclusions

This study attempts to analyze the linkages of international Islamic stock index with the six major international stock markets in the world, particularly United States, United Kingdom, Europe, Japan, China and Malaysia. To realize this, wavelet techniques has been utilized as the main method, the first estimation is using continuous wavelet transformation (CWT), and the second estimation is using maximal overlap discrete wavelet transformation (MODWT). The main objective is to address the international stock linkages from the view of Islamic index by analyzing indices volatility, cross volatility, comovement; and estimating the Granger-causality between the stock markets at different time scales.

The study suggests a few insights, first, in terms of volatility, the analyzed indices appear to have similar pattern where the significant volatility occurred during 1998 to 2003 and 2007 to 2011, and the difference between them are the time scales. This might be due to the two major crises of Asian financial crisis and global financial crisis that occurred during that time, and the volatility somehow continued after a few years. Second, in cross volatility, Islamic index was led by other

indices, and high significant cross volatility at high scale occurred during global financial crisis period between 2007 and 2011. Third, Islamic index appears to have very high comovement with US, UK and Euro markets, moderately affected by the Malaysia and Japan markets, and having low comovement with the Chinese market. It is clear that Islamic index have high and strong coherence with the western market as compared to the Asian markets.

In addition to the above, evidence from Granger-causality test, the linkages of Islamic index with other international indices are changing relative to the time scales. The result also indicated the existence of bi-directional causality, whereby Islamic index significantly Granger-cause other indices and vice versa. The Granger-causality effects for indices price and return appear to depict identical results, however, the effect is stronger for the indices return. In short, the analysis of international stock market linkages from the view of Islamic index provides beneficial insights into the behavior of the investors, more importantly, our findings support the changing behavior of stock index as time-scale varying.

This work contains some limitations and can be extended in several ways. This paper being limited to only seven international stock market indices, further analysis of other stock market indices could be conducted. The analysis of this paper being only from the perspective of Dow Jones Islamic World index as a proxy for Islamic index, other Islamic indices (such as FTSE Bursa Malaysia Emas Shariah index) could direct to different inferences. Finally, the findings of this study suggested the existence of inefficient market and spillover effect that led to arbitrage opportunity and suggestion for portfolio diversification. These deductions deserve a more careful attention.

References

Ahlgren, N. and Antell, J. (2010), 'Stock market linkages and financial contagion: A cobreaking analysis,' *The Quarterly Review of Economics and Finance 50,* 157–166.

Awokuse, T. O., Chopra, A. &. Bessler, D. A. (2009), 'Structural change and international stock market interdependence: Evidence from Asian emerging markets,' *Economic Modelling 26,* 549–559.

Bessler, D. A. and Yang, J. (2003), 'The structure of interdependence in international stock markets,' *Journal of International Money and Finance 22,* 261–287.

Cifarelli, G. and Paladino, G. (2005), 'Volatility linkages across three major equity markets: A financial arbitrage approach,' *Journal of International Money and Finance 24,* 413e439.

Charles, A. and Darné, O. (2006), 'Large shocks and the September 11th terrorist attacks on international stock markets,' *Economic Modelling 23,* 683–698.

Diamandis, P. F. (2009), 'International stock market linkages: Evidence from Latin America,' *Global Finance Journal 20,* 13–30.

Ding, L. and Pu, X. (2012), 'Market linkage and information spillover: Evidence from pre-crisis, crisis, and recovery periods,' *Journal of Economics and Business 64,* 145– 159.

Fernandez, V. (2006), The impact of major global events on volatility shifts: Evidence from the Asian crisis and 9/11. Economic Systems 30, 79–97.

Fujii. (2005), 'Intra and inter-regional causal linkages of emerging stock markets: evidence from Asia and Latin America in and out of crises,' *International Financial Markets, Institutions and Money 15,* 315–342.

Gooijera, J. G. D. and Sivarajasinghamb, S. (2008), 'Parametric and nonparametric Granger causality testing: Linkages between international stock markets,' *Physica A 387,* 2547–2560.

Horvath, R. and Petrovski, D. (2013), 'International stock market integration: Central and South Eastern Europe compared,' *Economic Systems xxx,* xxx–xxx.

Huyghebaert, N. and Wang, L. (2010), 'The co-movement of stock markets in East Asia Did the 1997–1998 Asian financial crisis really strengthen stock market integration?,' *China Economic Review 21,* 98–112.

In, F. and Kim, S. (2013), 'An Introduction to Wavelet Theory in Finance: A Wavelet Multiscale Approach,' Singapore. World Scientific Publishing Co. Pte. Ltd.

Kearney, C. and Lucey, B. M. (2004), 'International equity market integration: Theory, evidence and implications,' *International Review of Financial Analysis 13,* 571– 583.

Lee, K. Y. (2006), 'The contemporaneous interactions between the U.S., Japan, and Hong Kong stock markets,' *Economics Letters 90,* 21–27.

Li, H. (2012), 'The impact of China's stock market reforms on its international stock market linkages,' *The Quarterly Review of Economics and Finance 52,* 358– 368.

Liu. (2013), 'International stock market interdependence: Are developing markets the same as developed markets?' *International Financial Markets, Institutions and Money 26,* 226– 238.

Loh, L., (2010), 'Co-movement of Asia-Pacific with European and US stock market returns: A cross-time-frequency analysis,' *Research in International Business and Finance,* doi:10.1016/j.ribaf.2013.01.001.

Lucey, B. M. and Muckley, C. (2011), 'Robust global stock market interdependencies,' *International Review of Financial Analysis 20,* 215–224.

Madaleno, M. and Pinho, C. (2012), 'International stock market indices Comovements: A new look,' *International Journal of Finance and Economy 17,* 89–102.

Menezes, R., Dionísio, A. & Hassani, H. (2012), 'On the globalization of stock markets: An application of vector error correction model, mutual information and singular spectrum analysis to the G7 countries,' *The Quarterly Review of Economics and Finance 52,* 369– 384.

Ozdemira, Z. A. and Cakan, E. (2007), 'Non-linear dynamic linkages in the international stock markets,' *Physica A 377,* 173–180.

Ozdemir, Z. A. (2009), 'Linkages between international stock markets: A multivariate long-memory approach,' *Physica A 388,* 24612468.

Rezayat, F. and Yavas, B. F. (2006), 'International portfolio diversification: A study of linkages among the U.S., European and Japanese equity markets,' *Journal of Multinational Financial Management 16,* 440–458.

Savva, C. S. (2009), 'International stock markets interactions and conditional correlations' *International Financial Markets, Institutions and Money 19,* 645–661.

Wang, K., Chen, Y. H. and Huang, S. W. (2011), *'The dynamic dependence between the Chinese market and other international stock markets: A time-varying copula approach,' International Review of Economics and Finance 20,* 654–664.

Xu, H. and Hamori, S. (2012), 'Dynamic linkages of stock prices between the BRICs and the United States: Effects of the 2008–09 financial crisis,' *Journal of Asian Economics 23,* 344–352.