Investigating International Portfolio Diversification Opportunities for the Asian Islamic Stock Market Investors

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ABSTRACT

The purpose of this chapter is to analyze the possible portfolio diversification opportunities between Asian Islamic market and other regions' Islamic markets; namely USA, Europe, and BRIC. This study makes the initial attempt to fill in the gaps of previous studies by focusing on the proxies of global Islamic markets to identify the correlations among those selected markets by employing the recent econometric methodologies such as multivariate generalized autoregressive conditional heteroscedastic–dynamic conditional correlations (MGARCH–DCC), maximum overlap discrete wavelet transform (MODWT), and the continuous wavelet transform (CWT). By utilizing the MGARCHDCC, this chapter tries to identify the strength of the time-varying correlation among the markets. However, to see the time-scale-dependent nature of these mentioned correlations, the authors utilized CWT. For robustness, the authors have applied MODWT methodology as well. The findings tend to indicate that the Asian investors have better portfolio diversification opportunities with the US markets, followed by the European markets. BRIC markets do not offer any portfolio diversification benefits, which may be explained partly by the fact that the Asian markets cover partially the same countries of BRIC markets, namely India and China. Considering the time horizon dimension, the results narrow down the portfolio diversification opportunities only to the short-term investment horizons. The very short-run investors (up to eight days only) can benefit through portfolio diversification, especially in the US and European markets. The above-mentioned results have policy implications for the Asian Islamic investors (e.g., Portfolio Management and Strategic Investment Management).

Keywords: Multivariate generalized autoregressive conditional heteroscedastic–dynamic conditional correlations; maximal overlap discrete wavelet transform; continuous wavelet transform; contagion; volatility spillover; Shari'ah indices

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1 INTRODUCTION

The economic integration of international stock markets has become especially relevant over the last two decades. The substantial development of technology and the increased flow of capital between countries are the main factors for this globalization process. Thus, understanding the linkages between different financial markets is of great importance for portfolio managers and financial institutions. Volatility, as measured by the standard deviation or variance of returns, is often used as a crude measure of the total risk of financial assets (Brooks, 2002). Hence, when referring to international equity markets integration, researchers not only investigate the return causality linkages, but also measure volatility spillover effects. Information about volatility spillover effects is very useful for the application of value at risk and hedging strategies.

Recently, with the role of the emerging markets becoming more important, economists not only focus on developed countries, for example, United States, the United Kingdom, and Japan, but also pay great attention to the emerging markets. For example, in the equity markets, the extent of the linkages of the emerging stock market exchanges with developed stock market exchanges has important implications for both the developing and the developed countries' investors. If the emerging market stock exchange is only weakly integrated with the developed market, it has the implication that there would be portfolio diversification possibilities for developed countries' investors through including the emerging market stocks in their portfolio as this diversification should reduce risk, and vice versa. On the contrary, if the emerging stock markets were fully integrated with the developed stock markets, there would not be any portfolio diversification benefit for either developed and/or emerging countries' investors.

Several researches such as Kumar and Mukhopadhyay (2002) and Wong, Agarwal, and Du (2005) support the notion that there is a correlation between the various markets globally. Furthermore, Yang (2005) inspected the international stock exchange correlations between Japan and the Asian Four Tigers (Hong Kong, Singapore, South Korea, and Taiwan) and found that stock exchange correlations vary widely over time and volatilities seem to be contagious across the markets. The importance of these studies was also confirmed by Levy and Sarnat (1970), in which they have shown how the correlations between developed and developing countries provide a paramount risk-reduction benefit.

More recently, the focus of the studies of these topics shifted to the contagion effect of financial crisis. For example, Lucia and Bernadette's (2010) analysis show the evidence that the global financial crisis in 2007–2009 has been affecting differently the world economic regions. In the same year, Charles, Pop, and Darne (2011) discovered that during the crisis, both Islamic and conventional indices were affected to the same degree by variance changes. However, in terms of portfolio diversification, Achsani, Effendi, and Abidin (2007), in general, find that the interdependence of the Islamic stock markets tends to be asymmetric across a wide geographical area. While there are strong correlations between the Islamic stock indices of Indonesia and Malaysia, the US and Canada, and Japan and Asia Pacific, this is not exactly the case across the region.

In Grubel's fundamental work in 1968, the idea of international portfolio diversification resulting in lower portfolio risks is still broadly acknowledged and accepted in the literature. International stock market relations are very important to international investors and fund managers to identify a set of international stocks that form best-diversified portfolios with the lowest possible risks (Dacjman, Festic, & Kavkler, 2012). The substance of lower risks from international diversification is significantly reliant upon low correlations across cross-border markets (Grubel & Fadner, 1971). Therefore, an increase in co-movements between asset returns of international stock market can subsequently reduce the advantage of international diversified investment portfolios (Ling & Dhesi, 2010). It has been further accepted in the literature that correlations among markets are raising through time due to changes in interdependence across markets (Engle, 2002). Likewise, market returns are not only time-varying, but may also be reliant on time scales highlighting the importance of investment horizons (Gencay et al., 2001).

Over the past decade, the global financial markets have observed the fast-growing "Islamic Financial Sector." According to DeLorenzo (2000), the Islamic financial system is founded around the fundamentals of Shari'ah (Islamic Law) that requires profits from investment to be earned in an ethical and socially responsible way following the teachings of Islam. Equities traded under Shari'ah indices run through a screening procedure to guarantee they are free from the prohibited elements as commanded by Shari'ah. The common screening elements comprise riba (interest rates), gharar (uncertain outcomes), maysir (gambling), prohibited commodities (liquor, pork, etc.), and fulfillment of contractual requirements as required in Islamic Law of Contracts (Rosly, 2005). Over the past decade, the average annual growth rate of the Islamic financial sector ranges between 15% and 20% per annum (International Islamic Financial Market, 2010). This fact invites researchers and investors to study and analyze the volatilities and co-movement of asset returns among Shari'ah compliant indices across regions to provide Islamic investors and fund managers an idea on riskiness and potential international portfolio diversifications benefits.

In spite of the fact that there are enormous number of studies in portfolio diversification issues focusing on different regions, the concentrations of the studies were based on the conventional (Shari'ah non-compliant) stock indices. Thus, this chapter attempts to study the portfolio diversification aspect with the focus only on the Shari'ah indices of the selected regional financial markets. We concentrate in our study on four regional Islamic financial markets; those are BRIC, European, USA, and Asian, with the Asian being selected as the focus market. These markets represent a global picture of the potential possibilities of portfolio diversification benefits. Hence, the specific research questions of this study are as follows:

1. Should the Asian Islamic stock market investors invest in USA, European, or BRIC markets to gain international portfolio diversification benefits?
2. Given the answer from the previous research question, how would the international portfolio diversification strategy change given different investor stockholding periods (e.g., 2–4 Days, 4–8 Days, 8–16 Days, etc.)?

The results from each of the research questions are expected to have significant implications for the regional Islamic market, specifically for the Asian Islamic stock market investors and fund managers in their decisions concerning portfolio allocations and investment horizons.

This study contributes to the literature by empirically testing the 'time-varying' and 'scale dependent' volatilities and correlations of the selected regional financial markets. Particularly, by integrating scale dependence, this study is able to identify unique portfolio diversification opportunities for different type of investors with different investment horizons or holding periods of stocks (e.g., weekly, monthly, quarterly, etc.). The ability to do this is achieved by applying the modern empirical research techniques: multivariate generalized autoregressive conditional heteroscedastic–dynamic conditional correlations (MGARCH–DCC) model of Engle (2002) and the continuous wavelet transform (CWT) analysis of volatility and correlations, and the maximal overlap discrete wavelet transform (MODWT) analysis.

The first part of our findings shows that the Asian Islamic Index is least correlated with the US, followed by the European Islamic Index, which indicates that Asian Islamic investors who have allocated their investment on other regions (i.e., US and European markets) may enjoy portfolio diversification benefits. However, the same results cannot be attributed when the same investors extend their investments to BRIC Islamic markets. The high correlation between both, the Asian market and BRIC market, can be explained by the fact that the Asian markets cover partially the same countries of BRIC market, namely India and China. The second part of our findings considers the time-horizon dimension and the results narrow down the portfolio diversification opportunities only to the short-term investment horizons, that is, 2–8 days. Overall, excepting the very short-run, the markets are all highly correlated yielding minimal portfolio diversification benefits. As a result, the Asian investors are advised to consistently re-asses their stock exposures and holding positions within a period of one year and ideally every month or two.

Our findings would help fund managers or Islamic investors to play their role in diversifying their portfolio internationally. It also would help the potential investors to make decisions through the economic outlook and anticipating changes in investment returns. The findings of this research would be of particular interest to an investor limited to Islamic equity investment in the Asian market and those investors with different holding appetite (time horizon).

The following sections of this chapter are organized as follows. Section 2 discusses the existing literature and it is followed by the theoretical underpinnings and the very recent methodology used in Sections 3 and 4, respectively. Data and empirical results are dealt with in Section 5. Finally, this chapter ends with the conclusion followed by the future research suggestions in Section 6.

2 LITERATURE REVIEW

2.1 Co-movement among the Financial Markets

Acknowledging the rapid growth of Islamic financial industries during the last three decades, researchers have started shifting their focus to the integration of both Islamic and conventional stock markets. However, in comparison with the studies on the conventional stock markets, efforts devoted to the Islamic stock markets are still trivial. Hence, it is the opinion of the author that there is not sufficient research conducted on the unity of global Islamic indices using the wavelet technique.

Lucia and Bernadette's (2010) analysis, in regards to the contagion effects in a worldwide framework, shows the evidence that the current global financial crisis has been affecting the world economic regions differently. In general terms, there is no evidence that supports the existence of world market or across regional market contagion effects. Further, they claim that instead of contagion, markets suffered mostly from spillover effects, originating from the US economy and that were transmitted and propagated by some key countries into the different regions (Singapore in Asia, UK in Europe) (Lucia & Bernadette, 2010). According to Arshad and Rizvi (2013), the ripples of the financial crisis are still being felt over different parts of the world causing much distress to the real economy. The capital market, in particular, took a massive hit during the crisis declined to all-time lows. However in the pace of globalization, a financial shock to the US capital market can cause a spillover effect to other markets; including the Islamic capital market.

Charles et al. (2011) discovered that during the crisis, both Islamic and conventional indexes were affected to the same degree by variance changes. Conversely, when they tested the indices over other periods, it was found that the variance was not the same, where Islamic indices showed a slightly higher volatility as compared to their financial counterpart. However on the contrary, Al-Zoubi and

Maghyereh (2007) found Islamic indices to be less risky than the benchmark, accrediting it to the profit- and loss-sharing principle in Islamic finance.

While studying the correlation between indices, Arshad and Rizvi (2013) suggest a low-moving correlation between the conventional and Islamic indices substantiating that Islamic Index may provide a better alternative for hedging against crisis.

Several researches such as Kumar and Mukhopadhyay (2002) and Wong et al. (2005) support the notion that there is a correlation between the various markets globally. They further emphasize that dramatic movements in one equity market can have a powerful impact on different markets. The same applies to Islamic indices, where any volatility in major global markets is very likely to influence Islamic indices (Majid, Meera, & Omar, 2008; Rahman & Sidek, 2011; Siskawati, 2011). Kassim and Arip (2010) and Yusof and Majid (2007) contradict this, as they failed to find any empirical existence of co-integration among the Islamic indices.

With the abovementioned studies, this chapter attempts to contribute to the literature on the Islamic stock market by undertaking a unique study of how the regional Islamic stock markets are correlated to each other by employment of the new econometric technique like MGARCH–DCC, Wavelet, etc.

2.2 International Portfolio Diversification

International stock index diversification studies date from the 1970s, when globalization and international investing became paramount (see, e.g., Black & Litterman, 1992; Jankus, 1998; Levy & Sarnat, 1970; Solnik, 1974). The fundamental focus of such research is to examine the size of the constant correlations in order to determine the relative diversification benefits of constructing international stock portfolios. For example, Levy and Sarnat (1970) show how the correlations between developed and developing countries provide a paramount risk-reduction benefit, while Solnik (1974) provides evidence that combining stocks from US and European countries generates portfolios that are only half as risky as domestically well-diversified portfolios of US stocks. Nevertheless, several studies in the past concentrate on constant correlations and the profits of diversification to US investors, consequently other attributes of international stock portfolios and the diversification benefits to foreign investors are regularly disregarded. New insight about the financial market interdependence raised in later studies after the stock market crash in 1987 partially contradicted the previous theories and empirical results. Using seven months of daily data before and after October 1987, Dwyer and Hafer (1988) confirm that changes in the stock price indices in USA, Germany, and Japan are generally related. Further studies, for example, by Eun and Shim (1989), Von Furstenberg and Jeon (1989), and

Bertera and Mayer (1990), likewise examined different stock price indices around stock markets crash of 1987 and discovered significant correlations among national stock markets.

Later, inconsistencies in the empirical finding appeared in the literature, finding strong correlation among markets – for instance, the studies in Becker, Finnerty, and Gupta (1990), Hamao, Masulis, and Ng (1990), and Kasa (1992) find strong correlation between USA and Japan stock markets with an asymmetric spillover effects from the US to the Japanese stock market. Different other studies found contradicting results for the same market samples – for instance, Smith, Brocato, and Rogers (1993) recommending that the US equity prices do not lead Japanese equity prices. Furthermore, Rezayat and Yavas (2006), Flavin, Panopoulou, and Unalmis (2008), Middleton, Fifield, and Power (2008), and Mansourfar, Mohamad, and Hassan (2010) are the latest studies with the same objective of international portfolio diversification opportunities.

In short, studies on the stock market linkages and its resulting impact on international portfolio diversification strategies have remained inconclusive with results reporting contradicting evidence. Subsequently, this subject needs further investigation.

2.3 Time-varying and Time-scale-dependent Correlations

Numerous later studies have empirically tested and given proof that the correlation crosswise over national markets may not be consistent and are developing through time. For example, Longin and Solnik (1995) study the correlation and covariance of monthly excess returns for seven significant nations over the period 1960–1990 and find that both correlations and covariances are volatile over time. Yang (2005) inspected the international stock exchange correlations between Japan and the Asian Four Tigers (Hong Kong, Singapore, South Korea, and Taiwan) and found that stock exchange correlations vary widely over time and volatilities seem to be contagious across the markets. Also, correlation increase during periods of high market volatilities when risk diversification is required most and that is bad news for international diversification. Most recently, Dacjman et al. (2012) find that co-movement dynamics between the developed European stock markets of the United Kingdom, Germany, France, and Austria are not constant and returns are time-varying. Subsequently, when modeling volatilities and correlations, it is more proper to utilize time-varying correlations models as contrasted with constant connections model.

Additionally, studies have likewise found that investment holding periods (e.g., 2 days, 6 days, 30 days, etc.) also have an effect on the volatilities and correlations dynamics of stock market returns. This kind of research is relatively new and there are a couple of empirical papers that incorporated time-scaling in examining volatilities and correlations. Gencay et al. (2001) were one of the earliest supporters of the time-scaled dependence of returns and correlations in financial markets. In and Kim (2013) have grouped a cluster of their papers using wavelet time-scaling in finance to produce a book simply called *An Introduction to Wavelet Theory in Finance*. Dacjman et al. (2012), in their late study on co-movement dynamics between the developed European stock markets of the United Kingdom, Germany, France, and Austria also find evidence in favor of scale dependence for stock market returns. Subsequently, future studies are recommended to consider the time-scale properties in modeling volatilities and correlations.

2.4 Islamic Stocks and Portfolio Diversification

Shari'ah advocates socially responsible investments including profit-sharing, partnership, leasing, and sale-based contracts, in contrast to fixed interest earnings (Girard & Hassan, 2008). Consequently, conventional debt-based instruments such as treasury bills, corporate bonds, certificates of deposits, and preferred stocks are prohibited to be used as means of incomes or source of funds (Merdad, Hassan, & Alhenawi, 2010). In addition, conventional insurance products are prohibited as they involve uncertainties in outcomes, which are contingent on insured events occurring and Islamic principles require commercial transactions to be free from ambiguity. Consequently, several derivative products such as trading of futures, warrants, options, as well as short-selling and anything speculative is prohibited (El-Gamal, 2000). Investments in nonproductive and/or potentially harmful activities such as pure games of chance, prostitution, production and/or distribution of nonpermissible products such as alcohol, tobacco, pork, pornography, and arms are also prohibited according to Shari'ah (Hassan, 2001).

Empirical studies on stock market integration among Islamic stock markets worldwide are relatively scarce compared to the extensive numbers of studies on integration and performances among conventional stock markets both in the West and Islamic countries (Moeljadi, 2012). Hakim and Rashidian (2004) endeavored to study the returns performances of the Dow Jones Islamic Market Index (DJIM), Dow Jones World Index (DJW), and Dow Jones Supportability World Index (DJS). Utilizing a capital asset pricing model (CAPM) framework, they found that DJIM has performed well compared to DJW, however has failed compared to DJS. Hussein (2005) broke down the DJIM returns for the period 1996–2003 and found that Islamic indices provide investors with positive unusual returns throughout the bull market period, but they fail in performance against their counterpart non-Islamic indices during the bear market period.

Abderrezak (2008) studies 46 Islamic Equity Funds (IEFs) during January 1997 to August 2002. Applying Fama's 3-factor model, he found that Islamic funds performed poorly against their respective indices. The co-movement of IEFs returns with the market, measured by the betas, was low and poor evidence was found for selectivity. Small cap firms and growth preference stocks significantly affect IEFs and IEFs do suffer from lower diversification.

Achsani et al.'s (2007) study finds in terms of portfolio diversification that the interdependence of the Islamic stock markets tends to be asymmetric across a wide geographical area. More specifically, there are strong correlations between the Islamic stock indices of Indonesia and Malaysia, the US and Canada, and Japan and Asia Pacific, but this is not exactly the case for across the region basis. Additionally, the study finds that while the Islamic stock market in the US has a strong influence on the other Islamic stock markets, the reverse is not true. In particular, the Indonesian, Malaysian, Canadian, and Asia Pacific stock markets have smaller effects on the US' Islamic stock market. However in an earlier study, Aziz and Kurniawan (2007) conclude that there are potential diversification benefits for investors considering the Islamic stock markets in Indonesia and Malaysia. In particular, detailed empirical investigation using recent econometric analysis finds that the Jakarta Islamic Index and the Kuala Lumpur Shariah Index have significant leverage and asymmetric effects. Other studies such as Kamil, Bacha, and Masih (2012) and so on also find mixed results in their analysis.

As evident from the review above, there are inconsistencies in empirical literature analyzing the portfolio diversification properties of the Islamic indices across the globe. While some studies find evidence of strong correlations across Islamic stock indices, others have found Islamic stocks to be weakly correlated allowing investors to gain international diversification opportunities.

3 THEORETICAL FRAMEWORK AND LITERATURE REVIEW

3.1 Theoretical Framework

The academic underpinnings expected in this chapter draw upon the fundamental works of Markowitz's (1959) "Modern Portfolio Theory" and Grubel's (1968) "Internationally Diversified Portfolios." Markowitz formed the contemporary portfolio hypothesis where the volatility of a portfolio is less than the weighted average of the volatilities of the securities it holds, given that the portfolio comprises assets that are not completely correlated in returns. The variance of the expected return on a portfolio might be estimated as:

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

where the sums are over all the securities in the portfolio, Wi is the proportion of the portfolio in security i, σi is the standard deviation of expected returns of security i, and Covij is the covariance of expected returns of securities of *i* and *j*. Assuming that the covariance is less than one (which is always true), this will be less than the weighted average of the standard deviation of the expected returns of the securities. This is why diversification reduces risk.

Drawing from Markowitz's model, Grubel (1968) applied the modern portfolio theory to explore the potential benefits of holding long-term international assets. Grubel modeled international portfolio diversification benefits between two countries A and B as follows:

$$E(r_{a,b}) = W_a R_a + W_b R_b$$

$$V(r_{a,b}) = W_a^2 \sigma_a^2 + W_b^2 \sigma_b^2 + 2 W_a W_b Cov_{ab}$$

where *E*(*ra,b*) is the expected returns on portfolio invested in Country A and B with investment weights of *Wa* and *Wb*, and *V*(*ra,b*) measures the variance on the portfolio. The crucial factor here is the Cov*ab* and the lower the covariance between countries A and B, the greater would be diversification benefits. Grubel found that if US investors allocate a part of capital to foreign stock markets, they could achieve a significant reduction in portfolio risk and better portfolio return opportunities.

Subsequent to these seminal papers, various writers have attempted to empirically test the covariance of asset returns among cross-border stock markets in order to identify international portfolio diversification opportunities. A higher covariance between asset returns can therefore diminish the advantage of internationally diversified investment portfolios (Ling & Dhesi, 2010). This chapter drawing upon such theoretical foundations also studies the volatilities and cross-correlations among sample Islamic stock indices to answer the research questions albeit using recent empirical methodologies.

One of the criticisms of the earlier models of modern portfolio theory was the assumption that the portfolio variances are normally distributed. Markowitz himself thought normally distributed variances are inadequate measure of risk. However, subsequent models have been developed that use asymmetric and fat-tailed distributions that are closer to real-world data. The methodology to be adopted in this chapter, MGARCH–DCC, has the ability to adopt a student-*t* distribution of variances, which is more appropriate in capturing the fat-tailed nature of the distribution of index returns (Pesaran & Pesaran, 2009). Furthermore, the use of wavelet transform methodologies makes no assumptions and is tantamount to produce more realistic results (In & Kim, 2013). The chapter elaborates the methodologies to be adopted in achieving the research objectives in the following section.

4 Methodology

4.1 MGARCH and DCC

One of the earliest volatility models, autoregressive conditional heteroscedastic (ARCH), was proposed by Engle (1982), which captured the time-varying conditional variances of time series based on past information. This model was then enhanced by Bollerslev (1986) who proposed a generalized ARCH (GARCH), which took into account both past error terms and conditional variances into its variance equation simultaneously to avoid the problem that the number of parameters to be estimated becomes too large as the number of lagging periods to be considered increases in the ARCH model. Bollerslev (1990) further extended the GARCH model in a multivariate sense to propose a MGARCH–constant conditional correlation (MGARCH–CCC) model where the conditional correlation among different variables was assumed to be constant. The MGARCH–CCC model only allows the variances of each variable to be time-varying while keeping the correlation coefficient among them constant. However, while the CCC assumption makes estimation simple, it may be inconsistent with reality (Longin & Solnik, 1995). Therefore, Engle (2002) finally proposed an MGARCH–DCC model where the conditional correlations among variables were allowed to be dynamic and this chapter makes use of this model in answering parts of the research questions. It can be stated as follows:

$$\mathbf{r}_t = \boldsymbol{\beta}_0 + \sum_{i=1}^{k} \boldsymbol{\beta}_i \mathbf{r}_{t-i} + \mathbf{u}_t = \boldsymbol{\mu}_t + \mathbf{u}_t$$

$$\boldsymbol{\mu}_t = E[\mathbf{r}_t | \Omega_{t-1}]$$

$$\mathbf{u}_t | \Omega_{t-1} \sim N(0, \mathbf{H}_t)$$

$$\mathbf{H}_t = \mathbf{G}_t \mathbf{R}_t \mathbf{G}_t$$

$$\mathbf{G}_t = \mathrm{diag}\{\sqrt{h_{ii,t}}\}$$

$$\mathbf{z}_t = \mathbf{G}_t^{-1} \mathbf{u}_i$$

Source: Ku (2008).

where $h_{ii,t}$ is the estimated conditional variance from the individual univariate GARCH models, $\boldsymbol{G}_t$ is the diagonal matric of conditional standard deviations, $\boldsymbol{R}_t$ is the time-varying conditional correlation coefficient matrix of returns, and z_t is the standardized residuals vector with mean zero and variance one. Furthermore' the dynamic correlation coefficient matrix of the DCC model can be specified as:

$$\mathbf{R}_t = (\text{diag}(\mathbf{Q}_t))^{-1/2}\mathbf{Q}_t(\text{diag}(\mathbf{Q}_t))^{-1/2}$$

$$\mathbf{Q}_t = (q_{ij,t})$$

$$(\text{diag}(\mathbf{Q}_t))^{-1/2} = \text{diag}(\frac{1}{\sqrt{q_{11,t}}}, \dots, \frac{1}{\sqrt{q_{nn,t}}})$$

$$q_{ij,t} = \bar{p}_{ij} + \alpha(z_{i,t-1}z_{j,t-1} - \bar{p}_{ij}) + \beta(q_{ij,t-1} - \bar{p}_{ij})$$

Source: Ku (2008)

where $\bar{p}_{ij}$ is the unconditional correlation coefficient and the new time-varying conditional correlation coefficient is $p_{i,j,t} = q_{i,j,t}/\sqrt{q_{ii,t}\, q_{jj,t}}$. Meanwhile, the returns on financial assets have often been documented to be fat-tailed or leptokurtic where a normal distribution assumption is not appropriate. One possible remedy for such is to use a Student-*t* distribution setting. That is, the conditional distribution $\mathbf{u}_t|\Omega_{t-1}\sim N(0,\mathbf{H}_t)$ is replaced by $\mathbf{u}_t|\Omega_{t-1}\sim f_{Student-t}(\mathbf{u}_t;v)$ where v is the degree of freedom parameter.

4.2 Maximum Overlap Discrete Wavelet Transformation

Co-movements between stock market returns may not only be time-varying, but also scale-dependent (Gencay et al., 2001), and can be analyzed with wavelet tools. A maximum overlap discrete wavelet transformation (MODWT)-based estimator has been shown to be superior to the earlier discrete wavelet transform (DWT)- based estimators (Percival, 1995). The MODWT is a variant of the DWT that, unlike the classical DWT, can handle any sample size and not just those that are multiples of 2*x*. The MODWT is highly redundant, nonorthogonal transform – this enables alignment of the decomposed wavelet and scaling coefficients at each level with the original time series, thus allowing a ready comparison between the series and its decompositions. This feature is not in DWT. The MODWT variance estimator is also asymptotically more efficient than the same estimator based on the DWT. MODWT is generally known as stationary wavelet transform, shift or translation invariant DWT, time-invariant DWT, and nondecimated DWT. Hence, this research makes use of the MODWT method, which can be described as follows.

Let ***X*** be an *N*-dimensional vector whose elements represent the real-valued time series $\{X_t: t = 0, \dots, N-1\}$. For any positive integer, J_0, the level J_0 MODWT of ***X*** is a transform consisting of the $J_0 + 1$ vectors $\tilde{w}_{J_0}, \dots, \tilde{w}_{J_0}$ and $\tilde{v}_{J_0}$, all of which have dimension ***N***. The vector $\tilde{w}_J$ contains the MODWT wavelet coefficients associated with changes on scale $\tau_j = 2^{j-1}$ (for $j = 1,\dots.J_0$) while $\tilde{v}_{J_0}$ contains

MODWT scaling coefficients association with averages on scale $\lambda_{J_0} = 2^{J_0}$. Based on the definition of MODWT coefficients we can write (Percival & Walden, 2000, p. 200):

$$\widetilde{w}_J = \widetilde{w}_J x \text{ and } \tilde{v}_J^0 = \tilde{v}_J^0 x$$

where $\widetilde{w}_J$ and $\tilde{v}_{J_0}$are *N x N* matrices. Vectors are denoted by bold italics. By definition, elements of $\widetilde{W}_J$ and $\tilde{V}_{J_0}$are outputs obtained by filtering ***X***, namely:

$$\widetilde{W}_{j,t} = \sum_{l=0}^{L_{j-1}} \tilde{h}_{j,l} X_{t-1\, modN}$$

and

$$\tilde{V}_{j,t} = \sum_{l=0}^{L_{j=1}} \tilde{g}_{j,l} X_{t-1\, modN}$$

For t = 0, ……, N – 1, where $\tilde{h}_{j,l}$ and $\tilde{g}_{j,l}$ are *j*th MODWT wavelet and scaling filters.

The MODWT treats the series as if it were periodic, whereby the unobserved samples of the real-valued time series $X_{-1}, X_{-2}, \dots, X_{-N}$ are assigned the observed values at $X_{N-1}, X_{N-2}, \dots, X_0$. The MODWT coefficients are thus given by:

$$\widetilde{W}_{j,t} = \sum_{l=0}^{N-1} \tilde{h}^{\circ}_{j,l} X_{t-l\, modN}$$

and

$$\tilde{V}_{j,t} = \sum_{l=0}^{N-1} \tilde{g}^{\circ}_{j,l} X_{t-l\, modN}$$

(for $t = 0, \dots, N-1$; $\tilde{h}^{\circ}_{j,l}$ and $\tilde{g}^{\circ}_{j,l}$ are periodization of $\tilde{h}^{\circ}_{j,l}$ and $\tilde{g}^{\circ}_{j,l}$ to circular filters of length *N*)

Wavelet variance is defined for stationary and non-stationary processes with stationary backward differences. Considering only the non-boundary wavelet coefficient, obtained by filtering stationary series with MODWT, the wavelet variance $v_X^2(\tau_j)$ is defined as the expected value of $\widetilde{W}_{j,t}^2$. In this case $v_X^2(\tau_j)$ represents the contribution to the (possibly infinite) variance of $\{X_t\}$ at the scale $\tau_j = 2^{j-1}$ and can be estimated by the unbiased estimator (Percival & Walden, 2000, p. 306):

$$\hat{v}_X^2(\tau_j) = \frac{1}{M_j} \sum_{t=L_j-1}^{N-1} \widetilde{W}_{j,t}^2$$

where $M_j \equiv N - L_j + 1 > 0$ is the number of non-boundary coefficients at the *j*th level.

The MODWT correlation estimator for scale τ_j is obtained by making use of the wavelet cross-covariance and the square root of wavelet variances:

$$\hat{p}_{X,Y}(\tau_j) = \frac{\hat{v}_{X,Y}\ (\tau_j)}{\hat{v}_X(\tau_j)\hat{v}_Y(\tau_j)}$$

where $|\hat{p}_{X,Y}(\tau_j)| \leq 1$ the wavelet correlation is analogous to its Fourier equivalent, the complex coherency (Gencay et al., 2001, p. 258).

4.3 CWT and Wavelet Coherence

There has been a general practice to utilize Fourier analysis to expose relations at different frequencies between interest variables. However, the shortcomings of the use of Fourier transform for analysis has been well established. A big argument against the use of Fourier transform is the total loss of time information, thus making it difficult to discriminate ephemeral relations or to identify structural changes, which is very much important for time series macro-economic variables for policy purposes. Another strong argument against the use of Fourier transform is the reliability of the results. It is strongly recommended (i.e., it is based on assumptions such as) that this technique is appropriate only when time series is stationary, which is not so usual as in the case with macro-economic variables. The time series of macro-economic variables are mostly noisy, complex, and rarely stationary. To overcome such situation and have the time dimensions within Fourier transform, Gabor (1946) introduced a specific transformation of Fourier transform. It is known as the short-time Fourier transformation. Within the short-time Fourier transformation, a time series is broken into smaller subsamples and then the Fourier transform is applied to each subsample. However, the short-time Fourier transformation approach was also criticized on the basis of its efficiency as it takes equal frequency resolution across all dissimilar frequencies (see, for details, Raihan et al., 2005). Hence, as solution to the above-mentioned problems, wavelet transform took birth. It offers a major advantage in terms of its ability to perform "*natural local analysis of a time-series in the sense that the length of wavelets varies endogenously: it stretches into a long wavelet function to measure the lowfrequency movements; and it compresses into a short wavelet function to measure the high-frequency movements*." (Aguiar-Conraria & Soares, 2011, p. 646). Wavelet possesses interesting features of conduction analysis of a time series variable in spectral framework but as function of time. In other words, it shows the evolution of change in the time series over time and at different periodic components, that is, frequency bands. However, it is worthy to mention that the application of wavelet analysis in the economics and finance is mostly limited to the use of one or other variants of DWT. There are various things to consider while applying discrete wavelet analysis such as up to what level we should decompose. Further, it is also difficult to understand the DWT results appropriately. The variation in the time series data, what we may get by utilizing any method of DWT at each scale, can be obtained and more easily with continuous transformation. Even if wavelets possess very interesting features, it has not become much popular among economists because of two important reasons as pointed out by Aguiar-Conraria et al. (2008). In Aguiar-Conraria et al. (2008, p. 2865) the authors point out that "*first, in most economic applications the (discrete) wavelet transform has mainly been used as a low and high pass filter, it being hard to convince an economist that the same could not be learned from the data using the more traditional, in economics, band pass-filtering methods. The second reason is related to the difficulty of analyzing simultaneously two (or more) time series. In economics, these techniques have either been applied to analyze individual time series or used to individually analyze several time series (one each time), whose decompositions are then studied using traditional time-domain methods, such as correlation analysis or Granger causality*."

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

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

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

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

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

where *S* is a smoothing operator, *s* is a wavelet scale, $W_n^x(s)$ is the CWT of the time series X, $W_n^y(s)$ is the CWT of the time series Y, $W_n^{xy}(s)$ is a cross wavelet transform of the two time series, *X* and *Y* (Madaleno & Pinho, 2012). For brevity, we omit further detailed mathematical equations and interested readers may refer to Gencay et al. (2001, 2002) and In and Kim (2013) for full methodological models.

5 DATA ANALYSIS AND EMPIRICAL RESULTS

5.1 Descriptive Statistics

In addressing our research question, we utilize four indices for the empirical investigation as listed in Table 1. First, the S&P ASIA PAC X JAPAN BMI Shariah Index is used as a focus variable where the stocks for this index are drawn from the Asian country indices in the S&P Global BMI Index, excluding Australia, Japan, and New Zealand. Second, the S&P 500 Shariah Index, which is widely regarded as the best single gauge of the U.S. equities market. This world-renowned index includes 500 leading companies in leading industries of the US economy. Third, the S&P EUROPE 350 Shariah Index, which combines the benefits of representation with replication for the Europe region, spanning 17 exchanges and, fourth, the S&P BRIC Shariah Index, designed to provide exposure to the leading companies from the emerging markets of Brazil, Russia, India, and China, while at the same time complying with the Shari'ah law. These mentioned Islamic indices were selected to represent a global picture, the potential possibilities of portfolio diversification benefits.

All the sample indices are from Standard & Poor's Indices family. Primarily, two reasons contribute toward sticking with Standard & Poor's Indices: first, for the purpose of uniformity' in the underlying universe of stocks and index pricing computation; second, in order to have a harmonized Shari'ah screening criterion applied on these Islamic indices. All index providers follow roughly a similar criterion, but with slight variations in cut-offs for different ratios. Sticking with Standard & Poor's Islamic indices family provides us this consistency.

We have taken daily values of indices, transformed to daily returns for an extended time period of six years starting from April 7, 2008 to March 14, 2014; covering 1,549 daily observations.

Preliminary observation of graphs from Fig. 1 suggests that the variables are of random walk in nature. At the first glance, it can be seen that BRIC represents high volatility (ASIA least volatile) over the last six years.

From now onwards we are going to answer the questions of this study by employing MGARCH–DCC, CWT, and MODWT (for robustness), respectively.

Table 1 Selected Indices for Research

#	Code	Description
1	**ASIA**	S&P ASIA PAC X JAPAN BMI Shariah Index
2	**USAM**	S&P 500 Shariah Index
3	**EURO**	S&P EUROPE 350 Shariah Index
4	**BRIC**	S&P BRIC Shariah Index

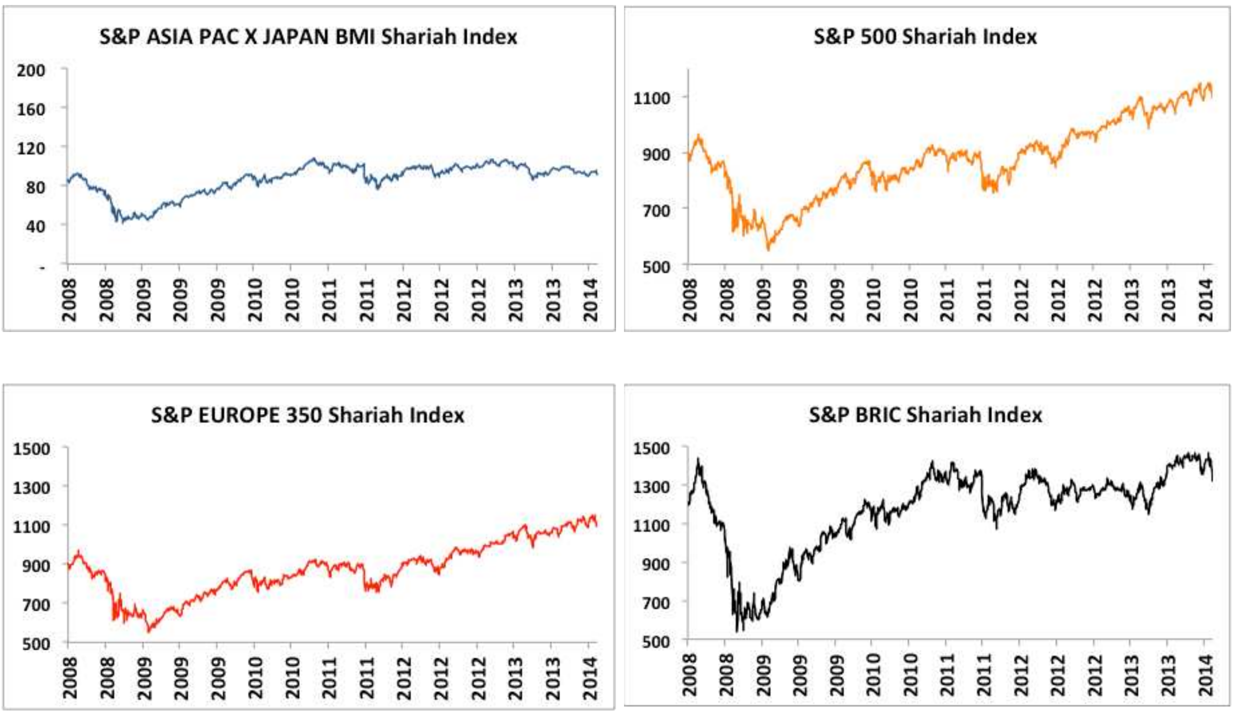

Figure 1: Graphs based on the raw data

Table 2: Descriptive Statistics of Indices Returns Series

#	Code	Mean	Median	Minimum	Maximum	Std. Dev.	Skewness	Kurtosis	Obs
1	ASIA	0.00006	0.00030	-0.14770	0.14800	0.01862	0.17720	15.10362	1549
2	USAM	0.00012	0.00050	-0.07390	0.09910	0.01259	0.11440	9.63846	1549
3	EURO	0.00004	0.00050	-0.12920	0.13740	0.01620	-0.51633	9.73948	1549
4	BRIC	0.00032	0.00030	-0.08630	0.11540	0.01267	0.02240	11.17960	1549

5.2 Research Question 1: Should the Asian Islamic Stock Market Investors Invest in USA, European, or BRIC Markets to Gain International Portfolio Diversification Benefits?

We ran a MGARCH–DCC analysis on the S&P ASIA PAC X JAPAN BMI Shariah Index returns, S&P BRIC Shariah Index returns, S&P EUROPE 350 Shariah Index returns, and S&P 500 Shariah Index returns. First, we look at the unconditional volatilities and correlations and the results are illustrated in Table 3.[1]

The diagonal elements in *italics* represent the volatilities of the returns while the off-diagonal elements illustrate the unconditional correlations between returns. Based on the unconditional results, we find that European Shariah Index returns are least volatile (0.01263) followed by USA Shariah

Table 3: Unconditional volatility and correlations – ASIA, BRIC, EURO and USAM

	ASIA	BRIC	EURO	USAM
ASIA	*0.01626*	0.64358	0.43442	0.27356
BRIC	0.64358	*0.01871*	0.66249	0.61934
EURO	0.43442	0.66249	*0.01263*	0.55622
USAM	0.27356	0.61934	0.55622	*0.01269*

Index returns (0.01269), Asian Shariah Index returns (0.01626), and BRIC Shariah Index returns (0.01871). Furthermore, it appears that an Asian investor is better off by investing in US market followed by the European market to gain portfolio diversification benefits as opposed to the BRIC market as the correlations in returns are much lower for US market (0.27) and European market (0.43442) as compared to BRIC market (0.64358). We proceed to examine the DCCs, which capture the time-varying properties in volatilities and correlations. Figs. 2 and 3 illustrate the results.

Figs. 2 and 3 confirm the time-varying properties of volatilities and correlations. Fig. 2 illustrates a stable volatility nature of all markets prior to the financial crisis of 2008. However, the BRIC market returns hits the highest volatility in a very short time during the financial crisis followed by the Asian market returns. This can be explained by the Asian market covers, partially the same countries of BRIC market, namely India and China. US and European markets' returns face similar volatility magnitude and being the least volatile among those selected markets. Post-financial crisis however, the volatilities of all markets more or less move together and are similar. Fig. 3 confirms that consistently, the Asian returns are less correlated with US market return as compared to the European and BRIC market returns. However, post-financial crisis, the correlation between Asian and European market returns follow the same pattern as the Asian and US market returns. Hence, it suggests that Asian investors are better off by investing in US markets followed by the European markets to gain portfolio diversification benefits.

We suspected that the BRIC returns maybe highly correlated with Asian returns since BRIC countries, India and China, are a component of the S&P ASIA PAC X JAPAN BMI Shariah Index.

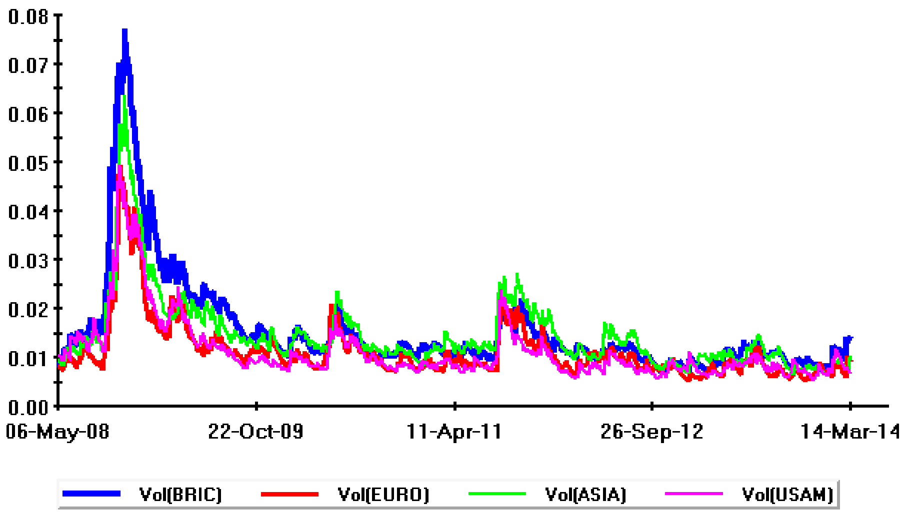

Figure 2: Conditional Volatilities – ASIA, BRIC, EURO and USAM

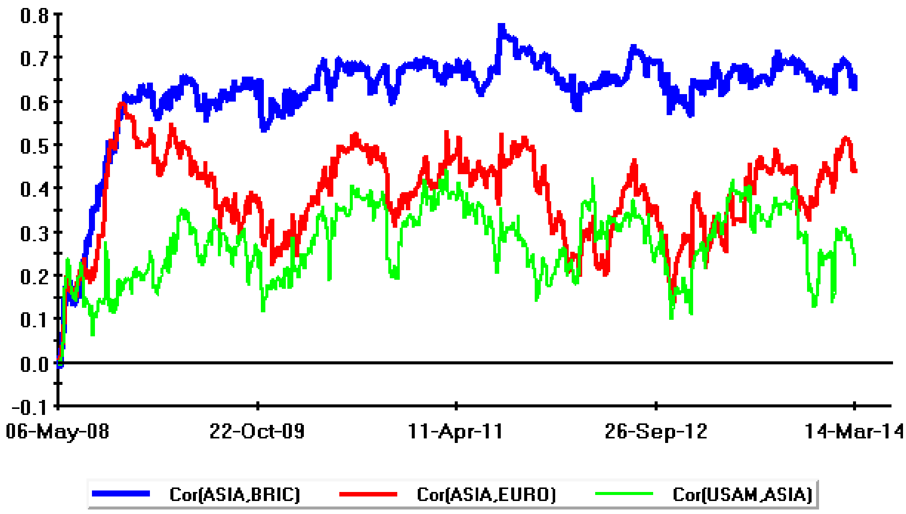

Figure 3: Conditional Correlations – ASIA with BRIC, EURO and USAM

5.3 Research Question 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.)?

Earlier using MGARCH–DCC analysis, we observed how the Asian investors can gain portfolio diversification benefits by investing in US markets followed by European markets. However, the previous analysis ignored investor stock-holding periods and the results were based on daily volatilities in indices. In this section, we use modern wavelet transformations to analyze the impact on portfolio diversification benefits given different investment horizons. Figs. 4–6 present the estimated CWT and phase difference of Asian Market returns with US Market returns, European Market returns, and BRIC Markets returns from scale 1 (one day) up to scale of 9 (approximately two market years, 512 days). Time is shown on the horizontal axis in terms of number of trading days, while the vertical axis refers to the investment horizon. The curved line below shows the 5% significance level, which is estimated using Monte Carlo simulations. The figure follows a color code as illustrated on the right with power ranges from blue (low correlations) to red (high correlations). A first layman glance instantly confirms the lower correlations of the Asian markets returns with the US and European markets returns as evident by the greater number of blue spots on the coherence diagram compared to the BRIC market returns. More specifically, we find that for very short holding periods consisting of 2–4 days and 4–8 days, the US market returns and European market returns are consistently weakly correlated to Asian returns over the past six years, thus offering effective portfolio diversification opportunities. However, temporary higher correlation between Asian and US market returns can be seen during the Global Financial Crisis in 2008/2009 and between Asian and European market returns during the Euro-Sovereign Debt crisis in 2011/2012. The same is not true for BRIC markets where particularly during Global Financial Crisis 2008/2009 and Euro-Sovereign Debt crisis 2011/2012, the correlations become very high, thus effectively eliminating any diversification opportunities.

For the short investment horizon consisting of 8–16, 16–32, and 32–64 days holding periods, once again we find US market correlations to be lower correlated as compared to European and BRIC markets, which exhibit very strong levels of interdependence in returns. Thus, investors have international portfolio diversification opportunities in US markets. However, moving toward medium investment horizons consisting of 64–128 and 128–256 days, we observe post-financial crisis higher correlations for both European and BRIC markets suggesting that investors with such holding periods are unable to exploit international portfolio diversification opportunities, except with the US markets.

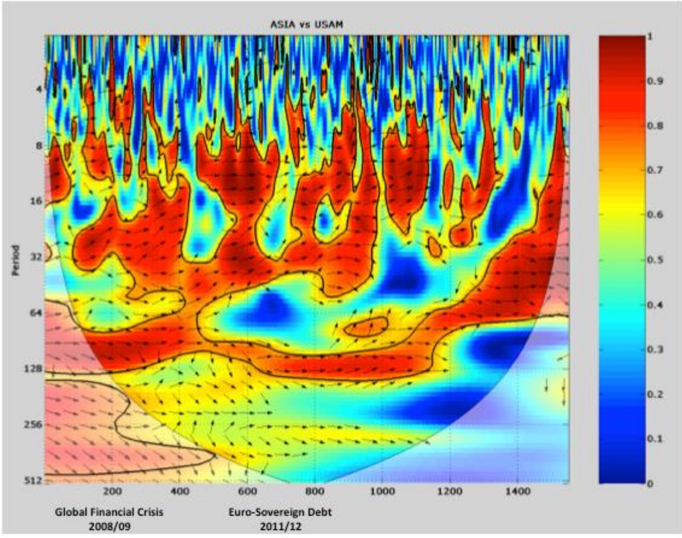

Figure 4: Continuous Wavelet Transform ASIA and USAM

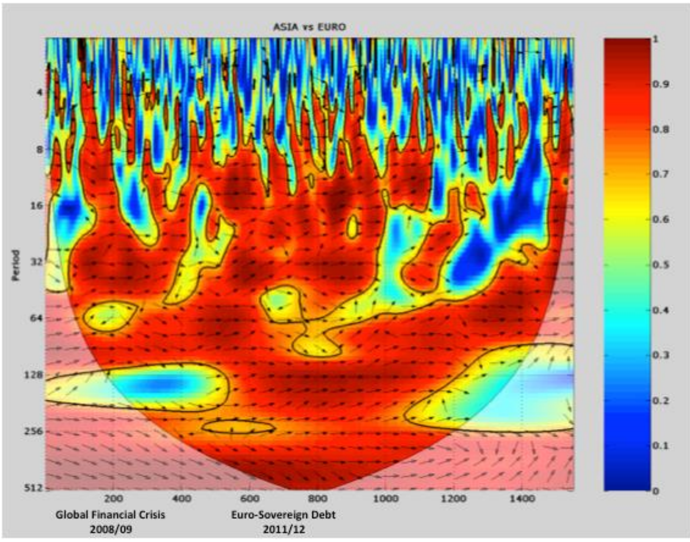

Figure 5: Continuous Wavelet Transform ASIA and EURO

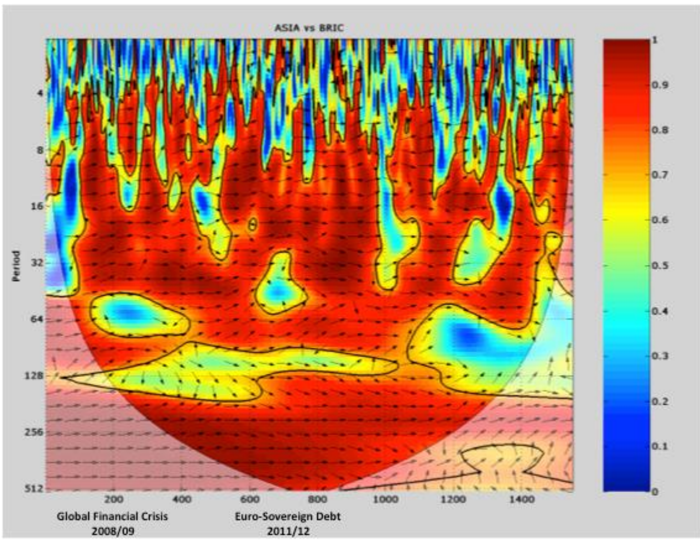

Figure 6: Continuous Wavelet Transform ASIA and BRIC

For long-term investors as well, consisting of 256–512 days holding periods, there are very strong correlations in returns for both European and BRIC markets that eliminate potential international portfolio diversification opportunities. However, US markets still remain less correlated and therefore offer potential opportunities for international portfolio diversification. We can clearly see the contributions of the wavelet transformations in helping us understand international portfolio diversification opportunities for investors with different investment horizons.

5.4 Robustness and Validation of Results – Application of MODWT

To further reassure ourselves regarding results from previous methodologies, we applied a MODWT to our original returns series for all the four indices. Unlike CWT, an 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, 16–32 days, 32–64 days, 64–128 days, and 128–256 days). Using the newly generated MODWT returns series, we examined the correlations between the Asian Islamic stock market returns and the other index returns and the results are presented in Table 4.[2]

Table 4: Correlations of Asian Islamic Stock Market Returns Vis-à-Vis Other Sample Market Returns – MODWT Transformations

MODWT Scaling (days)	BRIC	EURO	USAM
2-4	0.45	0.17	0.01
4-8	0.73	0.58	0.45
8-16	0.86	0.80	0.72
16-32	0.88	0.80	0.71
32-64	0.90	0.88	0.75
64-128	0.79	0.87	0.74
128-256	0.91	0.96	0.78

Note: Green shades indicate portfolio diversification opportunity due to having lower correlations with Asian returns relative to the other index and red shades are vice versa. *Correlations exceeding the 0.6 level are arbitrarily considered to be strong* and hence not effective for portfolio diversification.

The results are partially consistent with the results obtained from the earlier CWT analysis. The results driven from the CWT are more transparent and accurate compared to MODWT. Therefore, we rely on the CWT results. For a very short holding period of time (up to 2–4 days) all Islamic stock market returns and up to 4–8 days holding period even the European and US market returns offer effective portfolio diversification opportunities to the Asian investors.

However, for investment horizons longer than that, the correlations are quite high thus eliminating any potential portfolio diversification opportunities for the Asian investors.

5.5 Summary of the Empirical Results

Table 5 summarizes the empirical results from this section concerning the international portfolio diversification opportunities for Asian Islamic Stock Market investors. The table clearly highlights the objectives of this study and provides the results in the form of whether any international portfolio diversification opportunity exists with the Islamic indices from the regions under study. Furthermore, the differing investment horizons of various investors (e.g., 2–4 days, 4–8 days, etc.) are considered and an appropriate international portfolio diversification opportunity is identified based on such stock-holding periods. This contribution is most probably the first of its kind for Asian Islamic investors. Several researches such as Kumar and Mukhopadhyay (2002) and Wong et al. (2005) support the notion that there is a correlation between the various markets globally. They further emphasis that dramatic movements in one equity market can have a powerful impact on different market. The same applies for Islamic indices, where any volatility in major global markets is very likely to influence Islamic indices (Majid et al., 2008; Rahman & Sidek, 2011; Siskawati, 2011).

Table 5: Summary of the Overall Study in a Categorized Form

		Objective 1: Region-based		
		BRIC	EURO	USAM
	MGARCH-DCC	N	Y	Y
	CWT			
Objective 2: Time Scaled	2-4	Y/N	Y	Y
	4-8	Y/N	Y	Y
	8-16	N	Y/N	Y/N
	16-32	N	Y/N	Y/N
	32-64	N	N	Y/N
	64-128	N	N	Y/N
	128-256	N	N	Y
	Long Term	N	N	Y/N

Note: Since the results differ based on the different year, there is no unique answer; hence we use Y/N (Yes/No) to indicate this situation.

6 CONCLUSION

Understanding the linkages between different financial markets is of great importance for portfolio managers. Volatility, as measured by the standard deviation or variance of returns, is often used as a crude measure of the total risk of financial assets (Brooks, 2002), so when referring to international equity markets integration, researchers not only investigate the return causality linkages, but also measure volatility spillover effects.

Recently, with the role of the emerging markets becoming more important, economists not only focus on developed countries, for example, United States, the United Kingdom, and Japan, but also pay great attention to the emerging markets. For example, in the equity markets, the extent of the linkages of the emerging stock market exchanges with developed stock market exchanges has important implications for both the developing and the developed countries' investors. If the emerging market stock exchange is only weakly integrated with the developed market, it has the implication that there would be portfolio diversification possibilities for developed countries' investors through including the emerging market stocks in their portfolio as this diversification should reduce risk, and vice versa. On the contrary, if the emerging stock markets were fully integrated with the developed stock markets, there would not be any portfolio diversification benefit for either the developed and/or the emerging countries' investors.

More recently, the focus of the studies of these topics shifted to the contagion effect of Financial Crisis. For example, Morales and Andreosso-O'Callaghan (2010) analysis show the evidence that the current global financial crisis has been affecting the world economic regions differently. In the same year, Charles et al. (2011) discovered that during the crisis, both Islamic and conventional indexes were affected to the same degree by variance changes. However, in terms of portfolio diversification, Achsani et al. (2007), in general, find that the interdependence of the Islamic stock markets tends to be asymmetric across a wide geographical area. While there are strong correlations between the Islamic stock indices of Indonesia and Malaysia, the US and Canada, and Japan and Asia Pacific, this is not exactly the case across the region.

In a nutshell, our findings suggest that Asian investors have better portfolio diversification opportunities with the US markets followed by the European markets. BRIC markets do not offer any portfolio diversification benefits, which can be explained partly by the fact that the Asian market covers partially the same countries of BRIC market, namely India and China. Furthermore, considering the time horizon dimension, the results narrow down the portfolio diversification opportunities only to the short-term investment horizons, that is, up to 8 days. Excepting the very short-run, the markets are all highly correlated yielding minimal portfolio diversification benefits. As a result, Asian investors are advised to consistently re-asses their stock exposures and holding positions within a period of one year and ideally every month or two.

Our analysis in this chapter was performed on broad-market indices in order to recommend international portfolio diversification opportunities for the Asian Islamic investors. As a result, future studies are recommended considering a sector-based analysis where sectors of the specific Islamic stock index (e.g., Automobile, Manufacturing, Finance, etc.) is compared with the sectors of the other regions' Islamic stock index in order to identify portfolio diversification benefits between sectors. Such studies have great importance and value for international investors and fund managers who need to take portfolio allocation decisions that could maximize investments returns while minimizing associated risks.

NOTES

1. Refer to Appendix 1 to see the underlying data driven from the Micro-fit upon which the results are shown in this part of the study and the necessary tests applied regarding MGARCH–DCC methodology.
2. Refer to Appendix 2 to see the underlying wavelet correlation tables and charts driven from the Matlab upon which the results are shown in this part of the study regarding MODWT methodology.

References

Abderrezak, F. (2008). The performance of Islamic equity funds: A comparison to conventional, Islamic and ethical benchmarks. Master Thesis, Department of Finance: 87. University of Maastricht.

Achsani, N., Effendi, J., & Abidin, Z. (2007). Dynamic interdependence among international Islamic stock market indices: Evidence from 2000–2007. Proceedings of the international conference of the Islamic capital markets, Jakarta, Indonesia.

Aguiar-Conraria, L., Azevedo, N., & Soares, M. J. (2008). Using wavelets to decompose the time–frequency effects of monetary policy. Physica A: Statistical Mechanics and its Applications, 387(12), 2863–2878.

Aguiar-Conraria, L., & Soares, M. (2011). Oil and the macroeconomy: Using wavelets to analyze old issues, Empirical Economics, 40(3), 645–655.

Al-Zoubi & Maghyereh (2007). The relative risk performance of Islamic finance: A new guide to less risky investments. International Journal of Theoretical and Applied Finance, 10(2), 235–249.

Arshad, S., & Rizvi, A. (2013). The impact of global financial shocks to Islamic indices: Speculative influence or fundamental changes? Journal of Islamic Finance, 2(1), 001–011.

Aziz, H., & Kurniawan, T. (2007). Modelling the volatility of the Sharia index: Evidence from the Kuala Lumpur Sharia index and Jakarta Islamic index. Proceedings of the international conference of the Islamic capital markets, Jakarta, Indonesia.

Becker, K., Finnerty, J., & Gupta, M. (1990). The intertemporal relation between the US and Japanese stock markets. Journal of Finance, 45, 1297–1306.

Bertera, E., & Mayer, C. (1990). Structure and performance: Global interdependence of stock markets around the crash of 1987. European Economic Review, 34, 1155–1180.

Black, F., & Litterman, R. (1992). Global portfolio optimization. Financial Analysts Journal, 48(5), 28–43.

Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. Journal of Econometrics, 31, 307–327.

Bollerslev, T. (1990). Modeling the coherence in short-run nominal exchange rates: A multivariate generalized ARCH model. Review of Economic and Statistics, 72, 498–505.

Brooks, C. (2002). Introductory econometrics for finance. New York: Cambridge University Press.

Charles, A., & Pop, A., & Darné, O. (2011). Is the Islamic finance model more resilient than the conventional finance model? Evidence from Sudden Changes in the Volatility of Dow Jones Indexes. SSRN Electronic Journal.

Dacjman, S., Festic, M., & Kavkler, A. (2012). European stock market comovement dynamics during some major financial market turmoils in the period 1997 to 2010 – A comparative DCC–

GARCH and wavelet correlation analysis. Applied Economic Letters, 19 (13), 1249–1256.

Daubechies, I. (1992). Ten lectures on wavelets. CBMS-NSF Regional Conference Series in Applied Mathematics (Vol. 61). Philadelphia, PA: Society for Industrial and Applied Mathematics.

DeLorenzo, Y. (2000). Shariah supervision of Islamic mutual funds. In 4th annual Harvard forum on Islamic finance. Cambridge, MA: Harvard University.

Dwyer, G., & Hafer, R. (1988). Are national stock markets linked? Federal Reserve Bank of St. Louis Review, 70, 3–14.

El-Gamal, M. (2000). A basic guide to contemporary Islamic banking and finance. Unpublished paper. Rice University.

Engle, R. (1982). Autoregressive conditional heteroskedasticity with estimates of the variance of the United Kingdom inflation. Econometrica, 50, 987–1007.

Engle, R. (2002). Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. Journal of Business and Economic Statistics, 20, 339–350.

Eun, C., & Shim, S. (1989). International transmission of stock market movements. Journal of Financial and Quantitative Analysis, 24, 241–256.

Flavin, T., Panopoulou, E., & Unalmis, D. (2008). On the stability of domestic financial market linkages in the presence of time-varying volatility. Emerging Markets Review, 9(4), 280–301.

Gabor, D. (1946). Theory of Communication. Journal of the Institution of Electrical Engineers, 93 Part III, 429–457.

Gencay, R., Selcuk, F., & Whitcher, B. (2001). Differentiating intraday seasonalities through wavelet multi-scaling. Physica A, 289, 543–556.

Gencay, R., Selcuk, F., & Whitcher, B. (2002). An introduction to wavelets and other filtering methods in finance and economics. Academic press, San Diego, CA.

Girard, E., & Hassan, K. (2008). Is there a cost to faith-based investing? Evidence from FTSE indices. Journal of Investing, 17(4), 112–121.

Grubel, H. (1968). Internationally diversified portfolios: Welfare gains and capital flows. American Economic Review, 58, 1299–1314.

Grubel, H., & Fadner, K. (1971). The interdependence of international equity markets. Journal of Finance, 26(1), 89–94.

Hakim, S., & Rashidian, M. (2004). How costly is investor's compliance to Sharia? Paper presented at the 11th Economic Research Forum Annual Conference, Beirut, Lebanon.

Hamao, Y., Masulis, R., & Ng, V. (1990). Correlations in price changes and volatility across international stock markets. The Review of Financial Studies, 3, 281–307.

Hassan, M. (2001). Nuances of Islamic mutual funds. Islamic Horizon, 30(3), 16–18.

Hussein, K. (2005). Islamic investment: Evidence from Dow Jones and FTSE Indices. Paper presented at the 6th international conference on Islamic Banking and Finance, Jakarta, Indonesia, November, 21–14.

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

International Islamic Financial Market. (2010). The state of the Islamic capital market and future prospects. The World Islamic Capital Markets Conference, IIFM, Bahrain.

Jankus, J. C. (1998). The recent history of international diversification. The Journal of Investing, 7(2), 67–76.

Kamil, N., Bacha, O., & Masih, M. (2012). Do 'Sin Stocks' deprive Islamic stock portfolios of diversification? Some Insights from the Use of MGARCH–DCC. Capital Markets Review, 20(1–2), 1–20.

Kasa, K. (1992). Common stochastic trends in international stock markets. Journal of Monetary Economics, 29, 95–124.

Kassim & Arip, M. A. (2010). The subprime crisis and Islamic stock markets integration. International Journal of Islamic and Middle Eastern Finance and Management, 3(4), 363–371.

Ku, Y. H. (2008). Student-t distribution based VAR-MGARCH: An application of the DCC model on international portfolio risk management. Applied Economics, 40(13), 1685–1697.

Kumar K., & Mukhopadhyay C. (2002). Equity Market Interlinkages: Transmission of Volatility – A Case of US and India. Working Paper No.16. Indian Institute of Science - Department of Management Studies.

Levy H., & Sarnat, M. (1970). International diversification of investment portfolios. American Economic Review, 60, 668–675.

Ling, X., & Dhesi, G. (2010). Volatility spillover and time-varying conditional correlation between the European and US stock markets. Global Economy and Finance Journal, 3, 148–164.

Longin, F., & Solnik, B. (1995). Is the correlation in international equity returns constant: 1960–1990. Journal of International Money and Finance, 14, 3–26.

Lucia M., & Bernadette A.-O. (2010). The global financial crisis: World market or regional contagion effects? Conference Paper, Dublin Institute of Technology.

Madaleno, M., & Pinho, C. (2012), International stock market indices comovements: A new look. International Journal of Finance & Economics, 17, 89–102.

Majid, M., Meera, A., & Omar, M. (2008). Interdependence of ASEAN-5 stock markets from the US and Japan. Global Economic Review, 37(2), 201–225.

Mansourfar, G., Mohamad, S., & Hassan, T. (2010). A review on international portfolio diversification: The Middle East and North African region. African Journal of Business and Management, 19(4), 4167–4173.

Merdad, H., Hassan, M., & Alhenawi, Y. (2010). Islamic versus conventional mutual funds performance in Saudi Arabia: A case study. Journal of King Abdul Aziz University – Islamic Economics, 23(2), 157–193.

Middleton, C., Fifield, S., & Power, D. (2008). An investigation of the benefits of portfolio investment in Central and Eastern European stock markets. International Business Finance, 22(2), 162–174.

Moeljadi, (2012). Resilience of Islamic and conventional stock markets during the 2007 global financial crisis: A comparative empirical examination. Asia-Pacific Management and Business Application, 1(1), 81–102.

Morales, L., & Andreosso-O'Callaghan, B. (2010). The global financial crisis: World market or regional contagion effects? MFA (Midwest Finance Association) Annual Meeting, February 24th –27th February, 2010, Las Vegas, Nevada, USA.

Percival, D. (1995). On the estimation of the wavelet variance. Biometrika, 82, 619–631.

Percival, D., & Walden, A. (2000). Wavelet methods for time series analysis. New York, NY: Cambridge University Press.

Pesaran, B., & Pesaran, H. (2009). Time series econometrics using Microfit 5.0. Oxford: Oxford University Press.

Rahman, A. A., & Sidek, N. Z. M. (2011). Spill-over effect of US sub-prime crisis on ASEAN-5 stock markets. Business and social science research conference. Dubai: World Business Institute Australia, 334.

Raihan, S., Wen, Y., & Zeng, B. (2005). Wavelet: A new tool for business cycle analysis. Working Paper 2005-050A, Federal Reserve Bank of St. Louis.

Rezayat, F., & Yavas, B. (2006). International portfolio diversification: A study of linkages among the U.S., European and Japanese equity markets. Journal of Multinational Finance Management, 16 (4), 440–458.

Rosly, S. (2005). Islamic banking: Doing things right and doing right things. Malaysian Journal of Economic Studies, 42(1–2), 31–40.

Saiti, B. (2012). Testing the contagion between conventional and Shariah compliant stock indices: Evidence from wavelet analysis. Ph.D. thesis, INCEIF, Kuala Lumpur, Malaysia.

Siskawati, E. (2011). Islamic capital market interconnection: Evidence from Jakarta Islamic index. The Regional Islamic Market and Global Islamic Market.

Smith, K., Brocato, J., & Rogers, J. (1993). Regularities in the data between major equity markets: Evidence from Granger causality tests. Applied Financial Economics, 3, 55–60.

Solnik, B. (1974). Why not diversify internationally? Financial Analyst Journal, 30(4), 48–54.

Vacha, L., & Barunik, J. (2012). Co-movement of energy commodities revisited: Evidence from wavelet coherence analysis. Energy Economics, 34(1), 241–247.

Von Furstenberg, G., & Jeon, B. (1990). Growing international comovements in stock price indexes. Quarterly Review of Economics and Business, 30, 15–30.

Wong W. K., Agarwal, A., & Du, J. (2005). Financial integration for India Stock Market, a fractional cointegration approach. Working Paper No. WP 0501, National University of Singapore.

Yang, S. Y. (2005). A DCC analysis of international stock market correlations: The role of Japan on the Asian Four Tigers. Applied Financial Economics Letters, 1(2), 89–93.

Yusof, R. M., & Shabri, A. M. M. (2007). Stock market volatility transmission in Malaysia: Islamic versus conventional stock market. Journal of King Abdulaziz University: Islamic Economics, 20(2), 17–35.

APPENDIX 1. MGARCH/DCC APPLIED TESTS AND RESULTS

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     Multivariate GARCH with underlying multivariate Normal distribution
                        Converged after 24 iterations
*******************************************************************************
 Based on  1529 observations from 06-May-08 to 14-Mar-14.
 The variables (asset returns) in the multivariate GARCH model are:
 BRIC EURO ASIA USAM
 Volatility decay factors unrestricted, different for each variable.
 Correlation decay factors unrestricted, same for all variables.
*******************************************************************************
 Parameter                 Estimate       Standard Error          T-Ratio[Prob]
 lambda1_BRIC                .92238           .0097808           94.3049[.000]
 lambda1_EURO                .88918            .015562           57.1371[.000]
 lambda1_ASIA                .90584            .012985           69.7614[.000]
 lambda1_USAM                .89297            .016136           55.3413[.000]
 lambda2_BRIC               .073974           .0090224            8.1989[.000]
 lambda2_EURO                .10066            .013399            7.5124[.000]
 lambda2_ASIA               .087949            .011576            7.5974[.000]
 lambda2_USAM               .099147            .014301            6.9331[.000]
 delta1                      .97407           .0042665          228.3044[.000]
 delta2                     .014532           .0020535            7.0768[.000]
*******************************************************************************
 Maximized Log-Likelihood =    19833.3
*******************************************************************************


                  Estimated Unconditional Volatility Matrix
      1529 observations used for estimation from 06-May-08 to 14-Mar-14
    Unconditional Volatilities (Standard Errors) on the Diagonal Elements
           Unconditional Correlations on the Off-Diagonal Elements
*******************************************************************************
               BRIC       EURO       ASIA       USAM
 BRIC        .018705     .66249     .64358     .61934

 EURO         .66249    .012631     .43442     .55622

 ASIA         .64358     .43442    .016261     .27356

 USAM         .61934     .55622     .27356    .012690

*******************************************************************************
 For the time-varying conditional volatilities and correlations see the Post
 Estimation Menu.

                                   Page 1
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A1-1: MGARCH - Estimates (Normal Distribution)

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Multivariate GARCH with underlying multivariate t-distribution
Converged after 26 iterations

****

Based on 1529 observations from 06-May-08 to 14-Mar-14.
The variables (asset returns) in the multivariate GARCH model are:
BRIC EURO ASIA USAM
Volatility decay factors unrestricted, different for each variable.
Correlation decay factors unrestricted, same for all variables.

Parameter	Estimate	Standard Error	T-Ratio[Prob]
lambda1_BRIC	.92937	.011164	83.2478[.000]
lambda1_EURO	.89855	.016931	53.0727[.000]
lambda1_ASIA	.91631	.012977	70.6121[.000]
lambda1_USAM	.91093	.016022	56.8533[.000]
lambda2_BRIC	.066958	.010255	6.5295[.000]
lambda2_EURO	.091741	.014566	6.2984[.000]
lambda2_ASIA	.077395	.011463	6.7519[.000]
lambda2_USAM	.082193	.014136	5.8146[.000]
delta1	.97310	.0047699	204.0077[.000]
delta2	.016524	.0024319	6.7948[.000]
df	10.1614	1.2188	8.3373[.000]

Maximized Log-Likelihood = 19890.0

df is the degrees of freedom of the multivariate t distribution

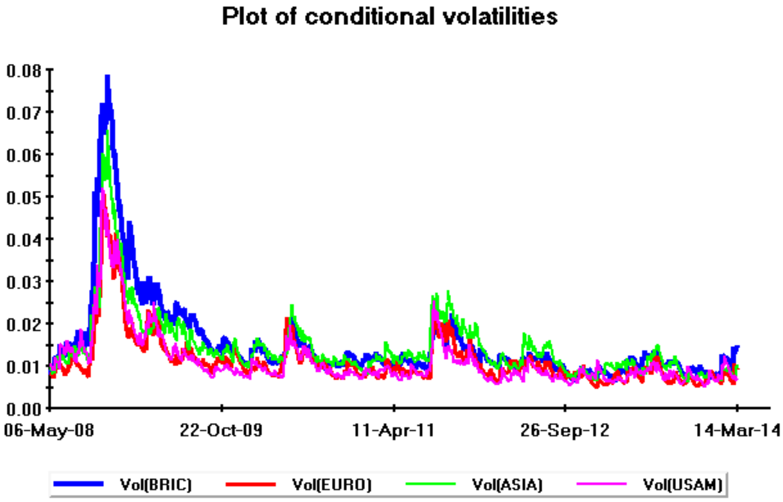
Estimated Unconditional Volatility Matrix
1529 observations used for estimation from 06-May-08 to 14-Mar-14
Unconditional Volatilities (Standard Errors) on the Diagonal Elements
Unconditional Correlations on the Off-Diagonal Elements

	BRIC	EURO	ASIA	USAM
BRIC	.018705	.66249	.64358	.61934
EURO	.66249	.012631	.43442	.55622
ASIA	.64358	.43442	.016261	.27356
USAM	.61934	.55622	.27356	.012690

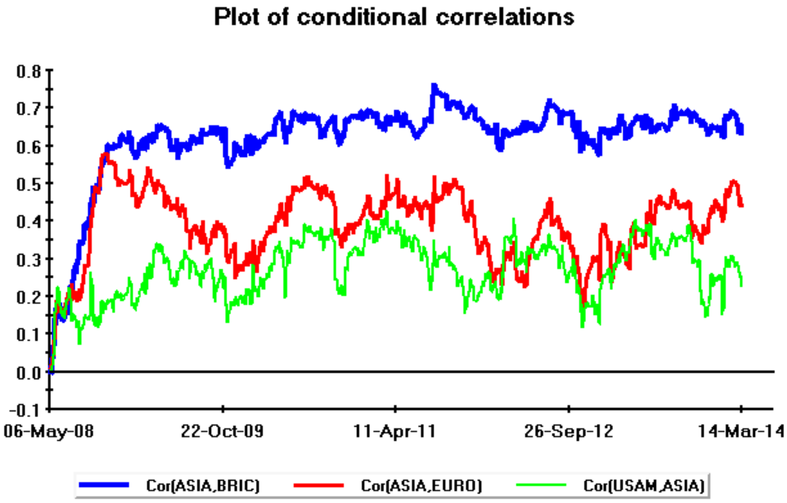
For the time-varying conditional volatilities and correlations see the Post Estimation Menu.

Page 2

A1-2: MGARCH - Estimates (t-Distribution)



A1-3: MGARCH - Plot of Conditional Volatilities (Normal Distribution)



A1-4: MGARCH - Plot of Conditional Correlations (Normal-Distribution)

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Analysis of Function(s) of Parameter(s)

The variables (asset returns) in the multivariate GARCH model are:
BRIC EURO ASIA USAM
Volatility decay factors unrestricted, different for each variable.
Correlation decay factors unrestricted, same for all variables.
1529 observations used for estimation from 06-May-08 to 14-Mar-14

List of specified functional relationship(s):
ZERO = 1 - LAMBDA1_BRIC - LAMBDA2_BRIC

Function	Estimate	Standard Error	T-Ratio[Prob]
ZERO	.0036735	.0011620	3.1613[.002]

Estimated Variance Matrix of the Function(s) of the Parameters
1529 observations used for estimation from 06-May-08 to 14-Mar-14

	ZERO
ZERO	.1350E-5

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Analysis of Function(s) of Parameter(s)

The variables (asset returns) in the multivariate GARCH model are:
BRIC EURO ASIA USAM
Volatility decay factors unrestricted, different for each variable.
Correlation decay factors unrestricted, same for all variables.
1529 observations used for estimation from 06-May-08 to 14-Mar-14

List of specified functional relationship(s):
ZERO = 1 - LAMBDA1_EURO - LAMBDA2_EURO

Function	Estimate	Standard Error	T-Ratio[Prob]
ZERO	.0097067	.0029497	3.2908[.001]

Estimated Variance Matrix of the Function(s) of the Parameters
1529 observations used for estimation from 06-May-08 to 14-Mar-14

	ZERO
ZERO	.8701E-5

```
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              Analysis of Function(s) of Parameter(s)
*****************************************************************
The variables (asset returns) in the multivariate GARCH model are:
BRIC EURO ASIA USAM
Volatility decay factors unrestricted, different for each variable.
Correlation decay factors unrestricted, same for all variables.
1529 observations used for estimation from 06-May-08 to 14-Mar-14
*****************************************************************

List of specified functional relationship(s):
ZERO = 1 - LAMBDA1_ASIA - LAMBDA2_ASIA
*****************************************************************
Function          Estimate     Standard Error     T-Ratio[Prob]
ZERO              .0062907       .0021090          2.9828[.003]
*****************************************************************

     Estimated Variance Matrix of the Function(s) of the Parameters
   1529 observations used for estimation from 06-May-08 to 14-Mar-14
*****************************************************************
            ZERO
ZERO      .4448E-5

*****************************************************************
```

```
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              Analysis of Function(s) of Parameter(s)
*****************************************************************
The variables (asset returns) in the multivariate GARCH model are:
BRIC EURO ASIA USAM
Volatility decay factors unrestricted, different for each variable.
Correlation decay factors unrestricted, same for all variables.
1529 observations used for estimation from 06-May-08 to 14-Mar-14
*****************************************************************

List of specified functional relationship(s):
ZERO = 1 - LAMBDA1_USAM - LAMBDA2_USAM
*****************************************************************
Function          Estimate     Standard Error     T-Ratio[Prob]
ZERO              .0068759       .0023067          2.9808[.003]
*****************************************************************

     Estimated Variance Matrix of the Function(s) of the Parameters
   1529 observations used for estimation from 06-May-08 to 14-Mar-14
*****************************************************************
            ZERO
ZERO      .5321E-5

*****************************************************************
```

Indices	$1-\lambda1-\lambda2$	Std. Errors	t-ratio
BRIC	0.00367	0.00116	3.16130
EURO	0.00971	0.00295	3.29080
ASIA	0.00629	0.00211	2.98280
USAM	0.00688	0.00231	2.98080

A1-5: MGARCH – Testing Linear Restrictions

The above results suggest very slow but statistically significant mean-reverting volatility for all indices.

```
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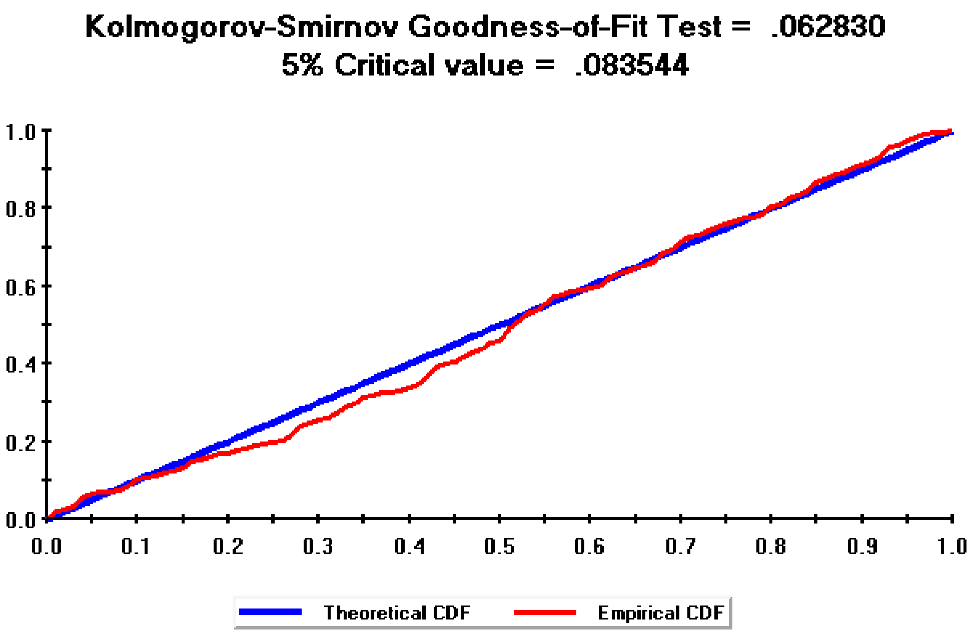
                Test of Serial Correlation of Residuals (OLS case)
******************************************************************************
 Dependent variable is U-Hat
 List of variables in OLS regression:
 Intercept
 265 observations used for estimation from 11-Mar-13 to 14-Mar-14
******************************************************************************
 Regressor              Coefficient       Standard Error         T-Ratio[Prob]
 OLS RES(-1)               .22037            .062730             3.5130[.001]
 OLS RES(-2)             -.026760            .064287            -.41625[.678]
 OLS RES(-3)             .0091304            .064642             .14125[.888]
 OLS RES(-4)             -.081163            .064518            -1.2580[.210]
 OLS RES(-5)              .038435            .064927             .59198[.554]
 OLS RES(-6)              .031605            .065046             .48588[.627]
 OLS RES(-7)             .0021067            .065053            .032384[.974]
 OLS RES(-8)             -.011754            .065044            -.18071[.857]
 OLS RES(-9)              .073538            .065318             1.1258[.261]
 OLS RES(-10)            -.017810            .065970            -.26997[.787]
 OLS RES(-11)             .023591            .066074             .35703[.721]
 OLS RES(-12)             -.11938            .064758            -1.8434[.066]
******************************************************************************
 Lagrange Multiplier Statistic    CHSQ(12)=  18.8576[.092]
 F Statistic                      F(12,252)=    1.6089[.089]
******************************************************************************
 U-Hat denotes the probability integral transform.
 Under the null hypothesis, U-Hat should not display any serial correlation.
******************************************************************************
```

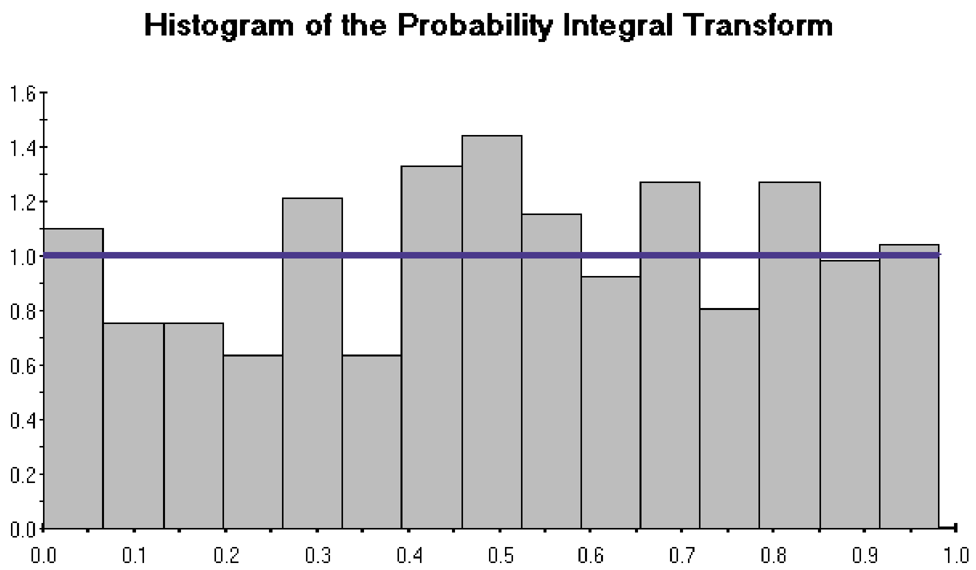
A1-6: MGARCH – Test of Serial Correlation of Residuals (OLS case)

The LM test equal to 18.8576 (p-value=0.092) which is not statistically significant at 5% significant level and we cannot reject the null hypothesis and we conclude that t-DCC model is correctly specified.

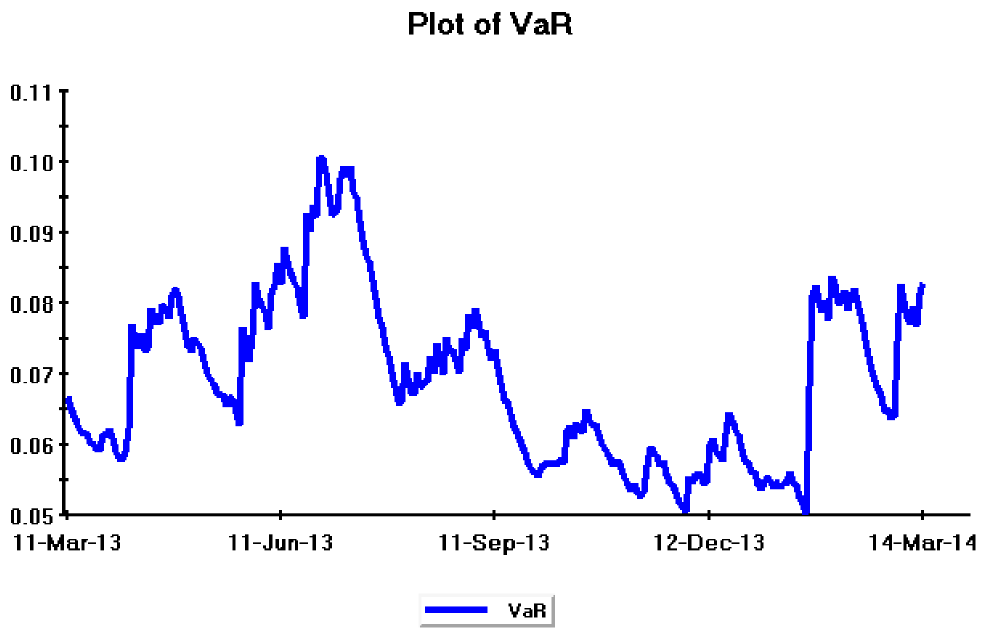


A1-7: MGARCH – Kolmogorov-Smirnov Goodness-of-Fit

The above graph compares the empirical cumulative distribution function of the probability integral transform variable with that of a uniform. In the above figure, we can see that the Kolmogorov-Smirnov test statistic is 0.63, which is lower than the 5% critical value of 0.84. Therefore, we cannot reject the null hypothesis that the probability integral transforms are uniformly distributed.



A1-8: MGARCH - Histogram of the Probability Integral Transform



A1-9: MGARCH - Plot of VaR

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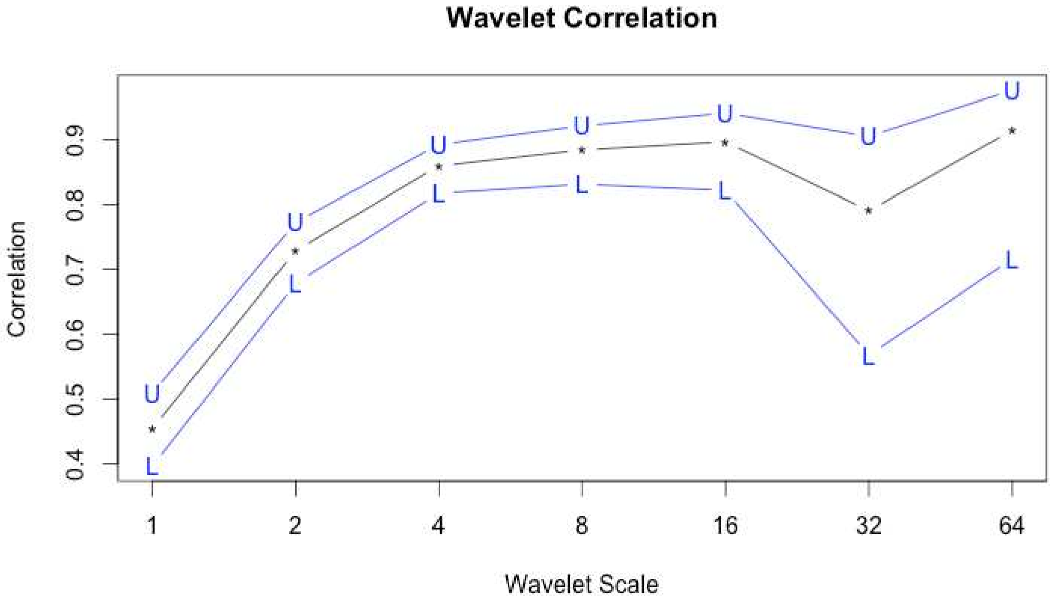
    Mean VaR Exceptions and the Associated Diagnostic Test Statistics
*******************************************************************************
 Mean Hit Rate (pihat statistic) =     .98113 with expected value of    .99000
 Standard Normal Test Statistic=  -1.4509[.147]
*******************************************************************************
```

A1-10: MGARCH – Testing for VaR Exceptions

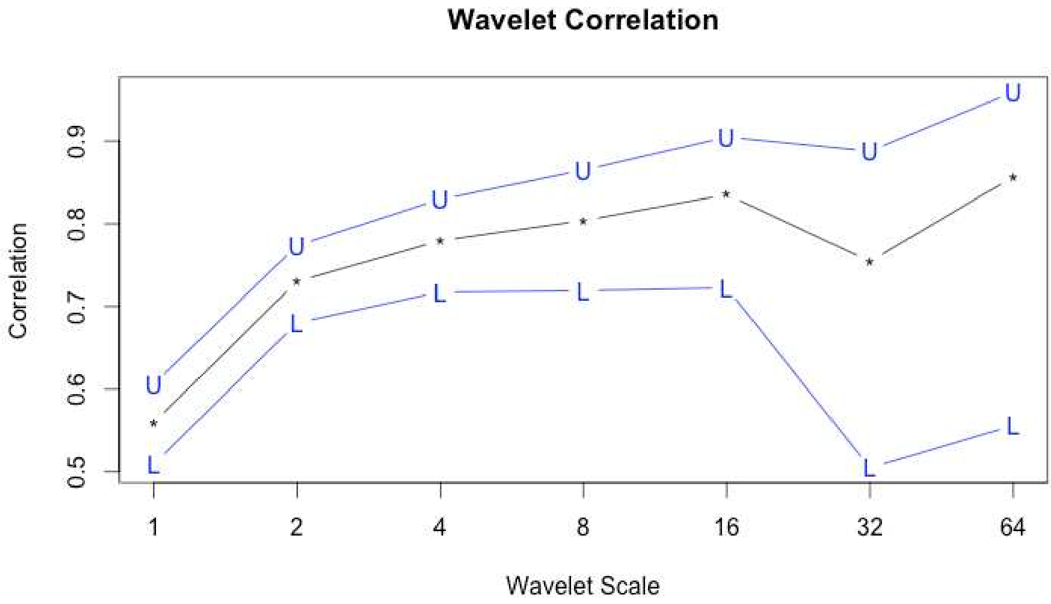
From the above table we can see that the mean hit rate (0.98113) is very close to the expected value (0.99000), and the test statistic is not significant, both supporting the validity of the t-DCC model.

APPENDIX 2. MODWT-WAVELET CORRELATION CHARTS AND UNDERLYING NUMBERS



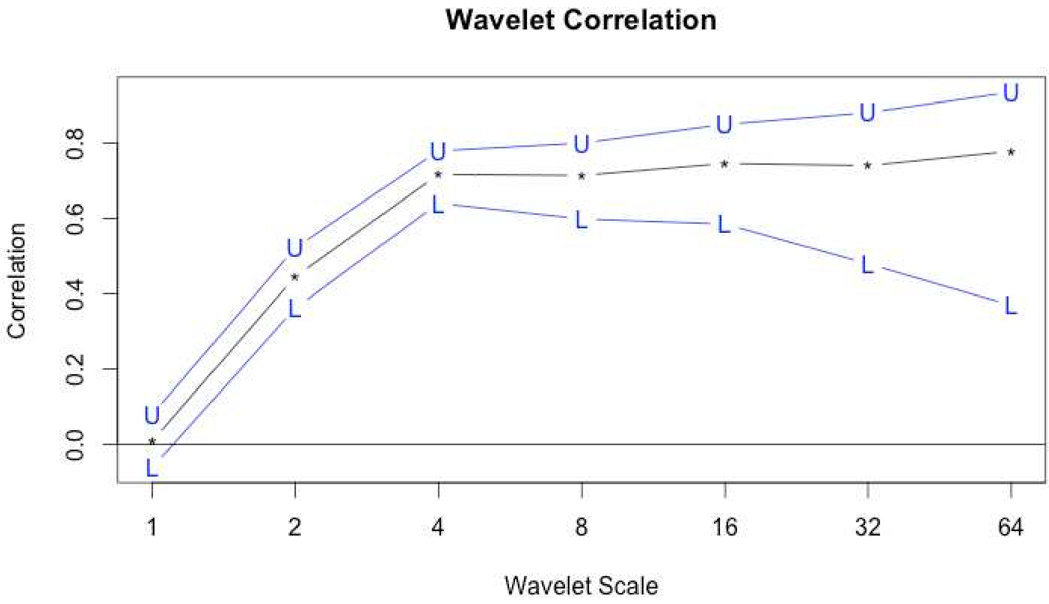
	wavecor	lower	upper
d1	0.45386	0.39605	0.50808
d2	0.72862	0.67819	0.77221
d3	0.85923	0.81716	0.89219
d4	0.88397	0.82071	0.92120
d5	0.89645	0.82159	0.94092
d6	0.79000	0.56744	0.90499
d7	0.91411	0.71565	0.97600
s7	0.95560	0.64171	0.99529

A2-1: MODWT - Wavelet Correlation ASIA-BRIC



	wavecor	lower	upper
d1	0.16903	0.09975	0.23668
d2	0.58414	0.51440	0.64620
d3	0.79809	0.74030	0.84417
d4	0.79727	0.71032	0.86025
d5	0.87519	0.78668	0.92845
d6	0.86742	0.71378	0.94140
d7	0.95528	0.84420	0.98769
s7	0.93025	0.48437	0.99251

A2-2: MODWT - Wavelet Correlation ASIA-EURO



	wavecor	lower	upper
d1	0.00808	-0.06141	0.07851
d2	0.44516	0.36151	0.52169
d3	0.71631	0.63979	0.77876
d4	0.71320	0.59825	0.79938
d5	0.74517	0.58487	0.84945
d6	0.73944	0.47889	0.88026
d7	0.77806	0.36886	0.93462
s7	0.72846	-0.203327	0.96784

A2-3: MODWT - Wavelet Correlation ASIA-USA