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Stock Market Co-movement and Shock Transmission: Islamic versus Conventional Equity Indices

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ABSTRACT

Our study measures co-movements in Islamic and conventional equity markets, to discover contagion and to measure integration level. We apply wavelet decomposition to unveil the multi-horizon nature of co-movement. We find that the subprime crisis generates fundamental-based contagion for both markets. The less exposure for some Islamic indices can be due to low leverage effect and the exclusion of conventional financial stocks. We also find higher fundamental integration for Islamic markets, attributable to their allocation related to the real sector. Finally, we show a leading role of the LIBOR negatively over Islamic indices in the long run.

Key Words: Islamic finance, Shariah, Shock transmission, financial crisis, contagion, interdependence, market integration, wavelet analysis, wavelet coherency

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1. Introduction

Many studies have demonstrated the increasing importance of stock market co-movement as the major outcome of the globalized economies. The reasons for co-movement of equity markets across geographical borders may reflect either the level of integration or the evidence of contagion.

On the one hand, the evidence of financial contagion can be observed from the changing co-movement temporarily across different markets during crisis periods (Candelon, Piplack, & Straetmans, 2008; Chakrabarti & Roll, 2002; and so on). Theoretically, there are two distinctive characteristics of contagion with respect to its transmission channel, which include the pure and fundamental-based contagion (Dornbusch et al., 2002); Kaminsky & Reinhart, 2000). While the former is defined as an excessive transmission of shocks beyond any idiosyncratic disturbances and fundamental linkages (Forbes & Rigobon, 2002; Bae et al., 2003; Eichengreen et al., 1996), the latter is transmitted by way of financial market integration and trade linkages or interdependence (Calvo & Reinhart, 1996; N'Diaye, Zhang, & Zhang, 2010; Zhang, 2008). On the other hand, literature demonstrated that the phases of stock market integration can also be reflected through the increased cross-country market co-movements (Goetzmann et al., 2002; Bekaert et al., 2005; Bekaert & Harvey, 1995; Baele, 2005; and so on). Evaluating the integration level of a market with its trade counterparts and world markets is essential since it is recognized as key indicators of stock market development.

Apart from the mainstream financial industry, our study attempts to identify the nature of co-movement in the context of Islamic equity markets. This has been a major concern since the growing interest in Islamic finance globally has shifted in focus from a banking-based industry into capital market-based instruments. Theoretically, the issue of how Islamic equity markets noticeably differ from their conventional counterparts is mainly due to the role of *Shari'ah* (Islamic law) screening. The modern *Shari'ah* scholars have provided general rules to evaluate as to whether a particular firm is *halal* (lawful) or *haram* (unlawful) for investment (Derigs & Marzban, 2008). The *Shari'ah* rules do not allow businesses related to immoral activities (e.g. liquor, gambling, etc.), and the most distinct feature of Islamic firms would be the limit of leverage using interest-based debt[5]. The filtering criteria consequently will take out the large non-compliant firms from the pool of investable equities, leaving the remaining *Shari'ah* compliant firms available to become smaller and portray more volatile returns (Hussein & Omran, 2005). In other words, the lower leverage, smaller size of firms, and under-diversification of the market, will be the main distinctive features of Islamic equity market.

Our study investigates the nature of co-movement amongst the Islamic equity markets as compared to those amongst their mainstream counterparts. The comparative study attempts to identify whether Islamic equity markets are less integrated, among themselves, as well as less susceptible to the recent US-born subprime crisis impact. We also investigate the relationship between Islamic equity indices and LIBOR. This is relevant since the use of interest rate as a benchmark for Islamic asset pricing has been extensively debated among Islamic scholars. The stability of Islamic capital markets will be highly influenced by the interest rate being adjusted within conventional system.

As to the sample of our study, we study the regional equity markets, which include the United States, Eurozone and Asia-Pacific. The length of our daily observations is between 2006 and 2011. For the methodology, we emphasize on the multi-horizon nature of co-movement. We perform multi-timescale analysis using wavelet decompositions to decompose any observed variable on scale-by-scale basis. The decomposition may capture both time series and frequency domain simultaneously. This may provide an ability to distinguish between higher frequencies and lower frequencies. The concept is similar to prior studies by Bodart & Candelon (2009) and Orlov (2009) that examined contagion by associating high and low frequencies with contagion and interdependence. In addition, to observe the phases of stock

[5] (i) a company's debt financing is not more than 33 percent of its capital, (ii) interest-related income of a company is not more than 10 percent of its total income, (iii) the composition of account receivables and liquid assets (cash at banks and marketable securities) compared to total assets is minimum at 51 percent while a few cite 33 percent as an acceptable ratio.

market integration, our study uses wavelet coherence with a rolling-window in the multi-horizon nature to evaluate the changing co-movement across the different equity markets in the short term and long term.

The remaining part of the study is organized as follows: section two reports the summary of the literature review of the study. Sources of data and methodology of the study are presented in section three. Results and their interpretations are described in section four. Finally, the study wraps up with concluding remarks in section five.

2. Literature review

Our literature review is structured as follows. The first is to present the theoretical underpinnings on financial contagion and interdependence, along with some empirical findings of contagion effects. The second is to present some empirical findings of stock market integration in both developed and emerging countries. The third is to present some comparative studies between Islamic and conventional equity markets.

2.1. Theoretical foundation of financial contagion and empirical studies

Dornbusch et al. (2002) and Kaminsky & Reinhart (2000) have mentioned the two distinctive characteristics between "fundamentals-based" and "pure" contagion.

The pure contagion is defined as an excessive transmission of shocks from the crash in origin country into others beyond any idiosyncratic disturbances and fundamental linkages (Forbes & Rigobon, 2002; Bae et al., 2003; Eichengreen et al., 1996). The sentiment shift of investors, unrelated to economic fundamentals (Kumar & Persaud, 2002; Dailami et al., 2008), may lead to a general reversal of funds and eventually trigger financial crises (Forbes & Rigobon, 2002; Kleimeier & Sander, 2003). The role of herd behaviour may burst asset bubbles created by self-fulfilling expectations, moral hazard, or government guarantees, either implied or explicit (Krugman, 1998).

There are some empirical studies that supported the evidence of pure contagion. Candelon, Piplack, & Straetmans (2008) found a significant increase of cross-country correlations in five Asian stock markets, which are Singapore, Thailand, South Korea, Taiwan and Malaysia, in the Asian crisis period. The stability test suggested that the rising co-movement is more of a sudden nature (i.e. contagion or ''Asian Flu'') rather than gradual (i.e. financial integration). Other studies further accentuated the major role of herding behaviour. For example, Kaminsky & Schmukler (1999) studied Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand, during the 1997 Asian crisis. They found that some of the large unlikely changes could be explained by apparent substantial news such as international organizations, credit rating agencies, and so on.

On the other hand, the fundamental-based contagion is defined as a transmission of shocks by way of financial market integration and real linkages in non-crisis and crisis periods, thereby reflecting normal interdependence across borders (Calvo & Reinhart, 1996). As to the empirical findings in interdependence, Bodart & Candelon (2009) studied the impact of the Mexican and Asian financial crises among eleven emerging countries in Asia and Latin America, and evidenced a contagion during both crises. Higher interdependence caused the spread of the crisis in Asia but the spillover effects were restricted to the region. N'Diaye, Zhang, & Zhang (2010) and Zhang (2008) also discussed how the US economic downturn had an impact on the Asia–Pacific economy via the traditional trade linkage.

So far, these empirical findings still involve an intensive debate as to whether shock transmission channels were pure excessive or fundamentals-based linkages amongst the equity markets. Our comparative study attempts to identify whether Islamic market is less susceptible to the impact of the recent subprime crisis, along with its nature of transmission channel.

2.2. Exploring stock market integration

There are numerous empirical studies which attempt to measure the level of stock market integration across countries. The financial landscape of integration in emerging countries is different as compared to that in developed countries.

In emerging countries, many empirical studies found the nature of low integration across equity markets. For example Click and Plummer (2005) suggested the nature of incomplete integration. Through applying the cointegration technique to five equity markets in the ASEAN countries, they found only one cointegrating vector, implying incomplete integration.

On the other hand, some studies have evidenced a higher integration level in the developed equity markets. For example, Askari & Chatterjee (2005) found high correlation between stock-market index returns and interest rates for three different groups of countries (Eurozone countries, non-Eurozone European countries, and three countries outside the EU). Their finding shows that the euro has benefited the non-Eurozone countries through a lower cost of capital.

Our comparative study attempts to measure the level of integration recently amongst the Islamic equity markets, and compare to those amongst their mainstream counterparts.

2.3. Islamic equity indices

There have been a number of empirical studies in Islamic equity indices as compared to their conventional counterparts. Al-Zoubi & Maghyereh (2007), applying the Risk Metrics, Student-t APARCH and skewed Student-t APARCH, showed that the DJIM is less risky than its respective benchmark. Hakim & Rashidian (2002) use a CAPM and find that the DJIMI performs well as compared to the Dow Jones World Index (DJW), but underperforms the Dow Jones Sustainability World Index (DJS). By capturing the effects of industry, size, economic conditions, and performance measures, some studies show that Islamic indices outperform during bull period while underperform during bear period, with the reasons of investing in growth and small-cap firms (Hussein 2004, 2005; Girard & Hassan, 2005). Hoepner, Rammal, & Rezec (2011) find that Islamic funds from Malaysia or GCC neither significantly underperform their respective benchmarks nor are significantly affected by small-size stocks.

What is lacking in the existing literature is a study focusing on investigating the impact of the recent crisis on Islamic equity markets as well as their nature of integration.

3. Data and methodology

We use daily Islamic equity indices and conventional equity indices in three regions, which include Asia Pacific, Eurozone and United States. The individual indices are obtained from Dow Jones Islamic Market indices and Dow Jones Total Market indices. The length of observation is daily from 30 November 2006 till 10 March 2011. All data are sourced from *Datastream International*.

3.1. Discrete wavelet transform

We follow the study of Gallegati (2010) in using discrete wavelet transform to identify financial contagion. Firstly, daily returns of individual indices are calculated from stock price (P) as follows,

$$r_{it} = ln\left(\frac{P_{it}}{P_{it-1}}\right) \text{ for stock } i \text{ at day t} \quad (1)$$

After calculating the return series for every individual index, we use wavelet analysis to observe co-movement between the two indices. As to wavelet decomposition, we use non-decimated orthogonal Maximum Overlap Discrete Wavelet Transform (MODWT) with *symmlet 8* as a wavelet function to obtain a multi-scale decomposition of the return series. There are two major reasons. Firstly, the Maximum Overlap Discrete Wavelet Transform (MODWT) is used with the advantage on the flexibility of the length of data (not requiring the integral power of two), as well as the time invariant property. Secondly, the wavelet family *symmlet 8* is chosen to get the least asymmetry property which is more appropriate for financial series.

Any function $f(t)$ in $L^2(R)$ is represented by wavelet series expansion as follows:

$$f(t) = \sum_k \upsilon_{J,k}\, \phi_{J,k}(t) + \sum_k \omega_{J,k}\, \psi_{J,k}(t) + \sum_k \omega_{j,k}\, \psi_{j,k}(t) + \cdots + \sum_k \omega_{1,k}\, \psi_{1,k}(t) \quad (2)$$

, where the coefficients $\upsilon_{J,k} = \sum_k \phi_{J,k} f(t)$ represent the underlying smooth behaviour of the series at the coarsest scale (the scaling coefficients) while $\omega_{j,k} = \sum_k \psi_{j,k} f(t)$ represent the scale deviations from the smooth process. Father wavelets represent the low-frequency (smooth) parts of the series, whereas mother wavelets represent the high-frequency (detailed) parts of the series. $\phi_{J,k}$, $\psi_{j,k}$ represents scaling and wavelet functions which satisfy the conditions as follows:

$$\int \phi_{J,k}(t)\phi_{J,k^*}(t)dt = \delta_{k,k^*}, \quad (3)$$

$$\int \psi_{j,k}(t)\psi_{j^*,k^*}(t)dt = \delta_{j,j^*}\delta_{k,k^*}, \quad (4)$$

$$\int \psi_{j,k}(t)\phi_{j,k^*}(t)dt = 0, \ \forall j,k, \quad (5)$$

, where $\delta_{j,k}$ is the Kronecker delta. The scaling function, which is the "father wavelet", is defined by:

$$\phi_{J,k}(t) = 2^{-\frac{J}{2}}\phi\left(\frac{t-2^J k}{2^J}\right) \quad (6)$$

, and the wavelet function, which is the "mother wavelet", is defined by:

$$\psi_{j,k}(t) = 2^{-\frac{j}{2}}\psi\left(\frac{t-2^j k}{2^j}\right) \quad (7)$$

As a fundamentals-based contagion reflects normal interdependence via real and financial linkages while a pure contagion represents excessive co-movement beyond what fundamental suggests, then wavelet analysis decomposes the stock market return into two parts: (i) a low-frequency part; and (ii) a high-frequency part, which can be linked to interdependence and contagion, respectively (Bodart & Candelon, 2009; Orlov, 2009).

The wavelet correlation between two time series $\rho_{XY}(\lambda_j)$ is defined as the ratio of the wavelet covariance, $\gamma_{XY}(\lambda_j)$, and the square root of their wavelet variances $\sigma_X(\lambda_j)$ and $\sigma_Y(\lambda_j)$ (see Whitcher et al., 1999, 2000). To obtain volatility in different timescales, wavelet variance analysis is applied that requires decomposing the variance of a time series into pieces associated to different time scales. This will show which timescales are important contributors to the overall volatility of a series (Percival & Walden, 2000). Let $x1, x2, \ldots\ldots\ldots, xn$ be a time series with variance σ_x^2. If $v_x^2(\tau j)$ is defined as the wavelet variance for scale $\tau_j = 2^{j-1}$, then the following relationship holds:

$$\sigma_x^2 = \sum_{j=1}^{\infty} v_x^2(\tau_j) \tag{8}$$

The above relationship is similar to that between the variance of a stationary process and its spectral density function (SDF):

$$\sigma_x^2 = \int_{-1/2}^{1/2} S_x(f)df \tag{9}$$

, where $S_X(f)$ denotes the SDF at the frequency f [−1/2,1/2]. An unbiased estimator of the wavelet variance will be as follows:

$$\hat{v}_x^2(\tau_j) = \frac{1}{(n'_j - L'_j)2^j} \sum_{t=L'_j-1}^{n'_j-1} d_{j,t}^2 \tag{10}$$

, where $n'_j = (n/2^j)$ is the number of MODWT coefficients at level j; n is the sample size; $L'_j = (L - 2)(1 - 1/2^j)$ is the number of MODWT boundary coefficients at level j (provided that $n'_j > L'_j$); L is the width of the wavelet filter.

The wavelet correlation coefficient $\rho_{XY}(\lambda_j)$ provides a standardized measure of the relationship between the two time series in multi-timescales with $|\tilde{\rho}_{XY}(\lambda_j)| \leq 1$. Therefore, the unbiased estimator of the wavelet correlation for scale *j*, $\tilde{\rho}_{xy}^I(\lambda_j)$, can be defined by

$$\tilde{\rho}_{XY}(\lambda_j) = \frac{\tilde{\gamma}_{XY}(\lambda_j)}{\tilde{\sigma}_X(\lambda_j)\tilde{\sigma}_Y(\lambda_j)} \tag{11}$$

, where $\tilde{\sigma}_X(\lambda_j)$ and $\tilde{\sigma}_Y(\lambda_j)$ are the unbiased estimators of the wavelet variances, and $\tilde{\gamma}_{XY}(\lambda_j)$ is the unbiased estimators of the wavelet covariance. We follow Gencay et al (2002) for a wavelet-based approach to test for significant difference. Our study tests whether wavelet correlation coefficients on a scale-by-scale basis between pre-crisis and crisis periods are significantly different. The significant change is identified by observing approximate confidence intervals between pre-crisis and crisis periods[6]. The null hypothesis of no statistically significant difference can be rejected if 95% approximate confidence intervals are non-overlapping (see Gençay et al., 2002, for more details).

$$H_0: \tilde{\rho}_{xy}^I(\lambda_j) = \tilde{\rho}_{xy}^{II}(\lambda_j) \tag{12}$$

, where $\tilde{\rho}_{xy}^I(\lambda_j)$ and $\tilde{\rho}_{xy}^{II}(\lambda_j)$ denote wavelet correlation coefficients estimated for the non-crisis and crisis periods, respectively. The null can be rejected when 95% approximate confidence intervals are non-overlapping (see Gencay et al., 2002, for more details).

[6] See Whitcher et al. (2000) for detailed explanation on statistically testing the hypothesis of equality of wavelet correlations based on derived formula for an approximate 100(1 − 2p)% confidence intervals estimator robust to non-Gaussianity. Their study mentions that non-overlapping approximate confidence intervals of estimated wavelet correlation coefficient could be translated into a visual method.

3.2. Continuous wavelet transform

We follow the study of Grinsted et al. (2004) and Aguiar-Conraria & Soares (2011) which apply wavelet coherency in the form of continuous wavelet transform. The continuous wavelet transform of a time series x_t with respect to ψ is a function of two variables given by the following convolution

$$W_x(\tau,s) = \int_{-\infty}^{+\infty} x(t)\bar{\psi}_{\tau,s}(t)dt = \frac{1}{\sqrt{s}}\int_{-\infty}^{+\infty}\left[x(t)\,\bar{\psi}\left(\frac{t-\tau}{s}\right)\right]dt, \quad (13)$$

, where the bar denotes the complex conjugate, τ is the time position or translation parameter controlling its location, s is the scale or dilation parameter that controls the width of the wavelet, and $\frac{1}{\sqrt{s}}$ is a normalization factor to make sure that wavelet transforms are comparable across scales (frequency bands) and time series.

As to the mother wavelet, the most frequent choice is the Morlet wavelet which is given by

$$\psi_{\omega_0}(t) = \pi^{-\frac{1}{4}}e^{j\omega_0 t}e^{-\frac{t^2}{2}} \quad (14)$$

The Morlet wavelet is a complex sine wave within a Gaussian envelope while ω_0 is the wave number (see, for example, Adisson (2002) for further details). Commonly, the results are obtained with a particular choice ω_0 equal to 6 as it provides a good balance between time and frequency localization (see, for example, Grinsted et al. (2004)). Aguiar-Conraria & Soares (2011) mention that the Morlet wavelet is frequently used mainly due to four properties: (1) the three sensible ways in converting wavelet scales into frequencies are equal; (2) it has optimal joint time-frequency concentration; (3) the time radius and the frequency radius are equal; (4) it is an analytic wavelet.

Similar with Fourier analysis, several interesting features can be obtained in the wavelet domain. We can define the wavelet power spectrum as

$$(WPS)_x(\tau,s) = |W_x(\tau,s)|^2 \quad (15)$$

It measures the relative contribution at each time and at each scale (frequency band) to the time series' variance. Similarly, we can define the cross-wavelet spectrum as

$$W_{xy}(\tau,s) = W_x(\tau,s)\overline{W_y}(\tau,s), \quad (16)$$

, where $Wx(\tau,s)$ and $Wy(\tau,s)$ are wavelet transforms of two time series $x(t)$ and $y(t)$. The cross-wavelet spectrum can be decomposed into real and imaginary parts since the mother wavelet is in general complex. We define the cross wavelet power, as $|W_{xy}(\tau, s)|$, which depicts the local covariance between two time-series at each time and frequency. On the other hand, the wavelet coherency has a major advantage of being normalized by the power spectrum of the two time-series. Similar in Fourier analysis, we can define wavelet coherency of given two time-series $x(t)$ and $y(t)$ as:

$$R_{xy}(\tau,s) = \frac{|S(W_{xy}(\tau,s)|}{\sqrt{S(|W_{xx}(\tau,s)|)S(|W_{yy}(\tau,s)|}} \quad (17)$$

, where S denotes a smoothing operator in both time and scale (frequency band). We can use wavelet squared coherency to measure co-movement of two time series over time and across frequencies. Such a wavelet-based measure allows for a richer description on the co-movement between two variables of interest. Similar to the squared coefficient of correlation, $R^2(\tau,s)$ is in the range between 0 and 1 with a high (low) value indicating a strong (weak) co-movement. Hence, by observing the contour plot of the above measure, we can identify the regions in the time–frequency space where the two time series move together and, specifically, assess both time and frequency varying features of the co-movement. We will rely on Monte Carlo simulations for statistical inference.

The use of a complex-valued wavelet is a major advantage that we can compute the phase of the wavelet transform of each series. By computing the phase-difference, we can obtain information about the possible delays of the oscillations of the two series as a function of time and scale (frequency band). The phase difference can be defined as

$$\phi_{x,y}(s,\tau) = \tan^{-1}\left(\frac{\Im(W_{xy}(s,\tau))}{\Re(W_{xy}(s,\tau))}\right) \tag{18}$$

The information on the signs of each part is to determine the value of $\phi_{xy} \in [-\pi, \pi]$. A phase-difference of zero indicates that the time-series co-move at the specified frequency; if $\phi_{xy} \in [0, \pi/2]$, then the series move in phase with time-series x leads y; $\phi_{xy} \in [-\pi/2, 0]$ indicates the leading role of y; a phase-difference is π (or $-\pi$) will be an anti-phase relation; if $\phi_{xy} \in [\pi/2, \pi]$, then y is leading; time-series x is leading if $\phi_{xy} \in [-\pi, -\pi/2]$.

4. Data and Empirical Results

4.1. Documenting the abrupt changes in response to common shocks

Our study explores empirically the markets' co-movements in response to common shocks originating from the crisis. In this section, our major concern is on documenting the 'abrupt' changes of co-movement in relation to a 'sudden stop' contagion effect amongst the Islamic equity markets during the crisis period.

We follow Gallegati (2010) who has applied discrete wavelet transform in order to identify contagion effect. We estimate the wavelet-unbiased pairwise correlation coefficients, $\tilde{\rho}XY(\lambda j)$, between the stock returns of the two countries that are exposed to common shock. The correlation coefficients are obtained for both pre-crisis and crisis periods, and then we identify whether the change of correlation, identifying the evidence of contagion, is statistically significant.

Technically, we decompose the series and focus on wavelet coefficients w1, w2, and w3, related to changes of 1-2 days, 2-4 days, and 4-8 days, respectively, similar to the study by Gallegati (2010). The relevance of these detailed timescales, as well as our term 'abrupt', can be supported by some previous studies which suggested that the pure contagion in relation to a sudden stop is very fast and tends to dissipate in a week or even less (Baig & Goldfajn, 1998; Ait-Sahalia et al., 2010). The correlation coefficients were calculated using 6 months periods before and after the date of each crisis.

Figure 1 and Table 1 show the results of wavelet correlation in pre-crisis and crisis periods. The blue line deals with wavelet correlation coefficients for the non-crisis period while the red line corresponds to wavelet correlation coefficients during the crisis period. The dashed lines are defined as the upper and lower bound for the approximate 90% confidence interval with the assumption of a non-Gaussian process. The change of wavelet correlation coefficient is not statistically significant if the confidence intervals are overlapping.

Table 1. Wavelet correlation

Estimated wavelet correlation between two Islamic region-indices. * denotes 10% significance level.

Islamic US – Islamic Eurozone

Scales	pre-crisis	crisis	
1-2 days	0.216	0.422	*
2-4 days	0.530	0.759	*
4-8 days	0.721	0.858	*

Islamic US – Islamic Asia Pacific

Scales	pre-crisis	crisis	
1-2 days	-0.197	-0.036	*
2-4 days	0.209	0.416	*
4-8 days	0.584	0.781	*

Islamic Eurozone – Islamic Asia Pacific

Scales	pre-crisis	crisis	
1-2 days	0.168	0.354	*
2-4 days	0.562	0.671	
4-8 days	0.679	0.855	*

Figure 1. Wavelet correlation breakdown

Estimated wavelet correlation between two Islamic region-indices for the pre-crisis (blue line) and crisis periods (red line). The upper and lower lines denote the upper and lower bounds for the approximate 90% confidence interval, respectively. The null hypothesis of no difference can be rejected when the confidence intervals are non-overlapping.

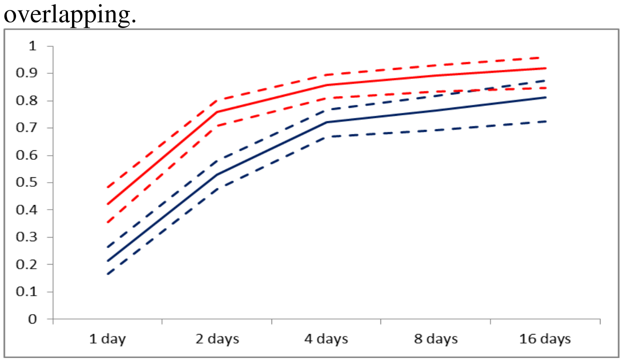


Figure 1-a: Islamic US – Islamic Eurozone

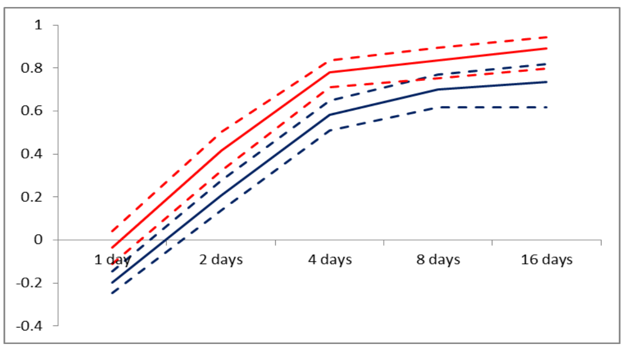


Figure 1-b: Islamic US – Islamic Asia Pacific

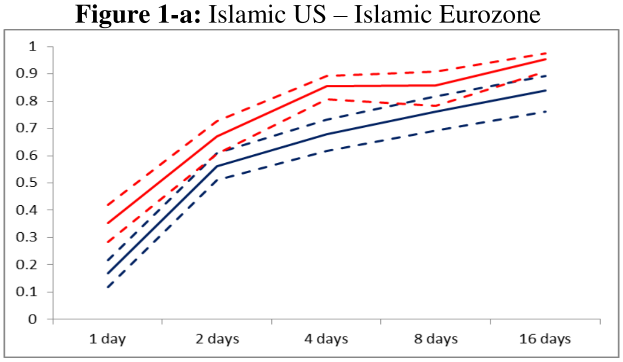


Figure 1-c: Islamic Eurozone – Islamic Asia Pacific

Looking at the results above, we find statistically significant correlation-breakdowns for all Islamic index-pairs. The index-pairs of Islamic US-Islamic Eurozone and Islamic US-Islamic Asia Pacific absorb the impacts at all three timescales while the index-pair of Islamic Eurozone-Islamic Asia Pacific at the first and third timescales. This evidence of a 'sudden stop' contagion effect means that the Islamic equity markets are exposed to a rapid reversal of funds. Specifically, the shock from crash in origin country can be abruptly channeled across borders through the spread of investors' sentiment in relation to the effect of negative news (Kaminsky & Schmukler, 1999), the raising of risk premium (Vayanos, 2004; Acharya & Pedersen, 2005; Longstaff, 2008), and flight-to-quality attributable to liquidity shocks in the global investors' portfolio (Allen & Gale, 2000; Brunnermeier & Pedersen, 2009). Since Islamic stock is a part of the investment universe, it remains sensitive to simultaneous drop of assets prices. In addition, the exclusion of some large corporations through Shariah filtering process may result in a less diversification of Islamic portfolio, thereby further increasing its exposure to any volatility shock.

As we evidence the sudden contagion effect amongst the Islamic equity markets, the next section investigates the shock transmission channels and performs a comparative study between Islamic and conventional equity indices. The concern also includes the degree of market integration.

4.2. Contagion and market integration

To discover shock transmission channels, we use continuous wavelet transform and wavelet coherence. We extend our decomposition into multiple frequency bands (timescales) in longer horizon.

The continuous wavelet transform focuses on the evolution of volatility of an individual index while the wavelet squared coherency measures the market co-movement between equity indices. The wavelet decomposition in continuous form also applies a rolling-window in a multi-horizon nature, in order to capture temporary change of co-movement and volatility during crisis period, as well as to measure the progress of market integration. Figure 2 presents continuous wavelet transform for each individual index while Figure 3 shows wavelet squared coherency and wavelet phase-difference between the equity indices[7].

Technically, continuous wavelet transform in Figure 2 reveals power spectrum which measures the level of variance for each index. The power spectrum ranges from blue (low coherency) to red (high coherency) as a measure of variance level. The thick black contour designates the 5% significance level against red noise and the cone of influence (COI) where edge effects might distort the picture which is shown as a lighter shade.

On the other hand, wavelet coherency in Figure 3 is displayed through a contour plot. The horizontal axis denotes time component while the vertical axis represents frequency component, which is converted to time units (years). The coherency ranges from blue (low coherency) to red (high coherency) as a measure of co-movement level. A region of high coherency between two equity indices indicates strong local correlation. The thick black line in the coherency plots designates the statistically significant area at 5% significance level estimated from a Monte Carlo simulation. Therefore, the cross-wavelet coherency has a power to investigate varying characteristics of the relationship between index returns in the time–frequency domain.

[7]The results of wavelet coherency are derived using Wavelet coherence package toolbox developed by Grinsted et al. (2004)

Figure 2. Continuous wavelet transform for Islamic and conventional indices

Continuous wavelet transform of individual Islamic and conventional equity indices. The thick black contour designates the 5% significance level against red noise and the cone of influence (COI) where edge effects might distort the picture which is shown as a lighter shade.

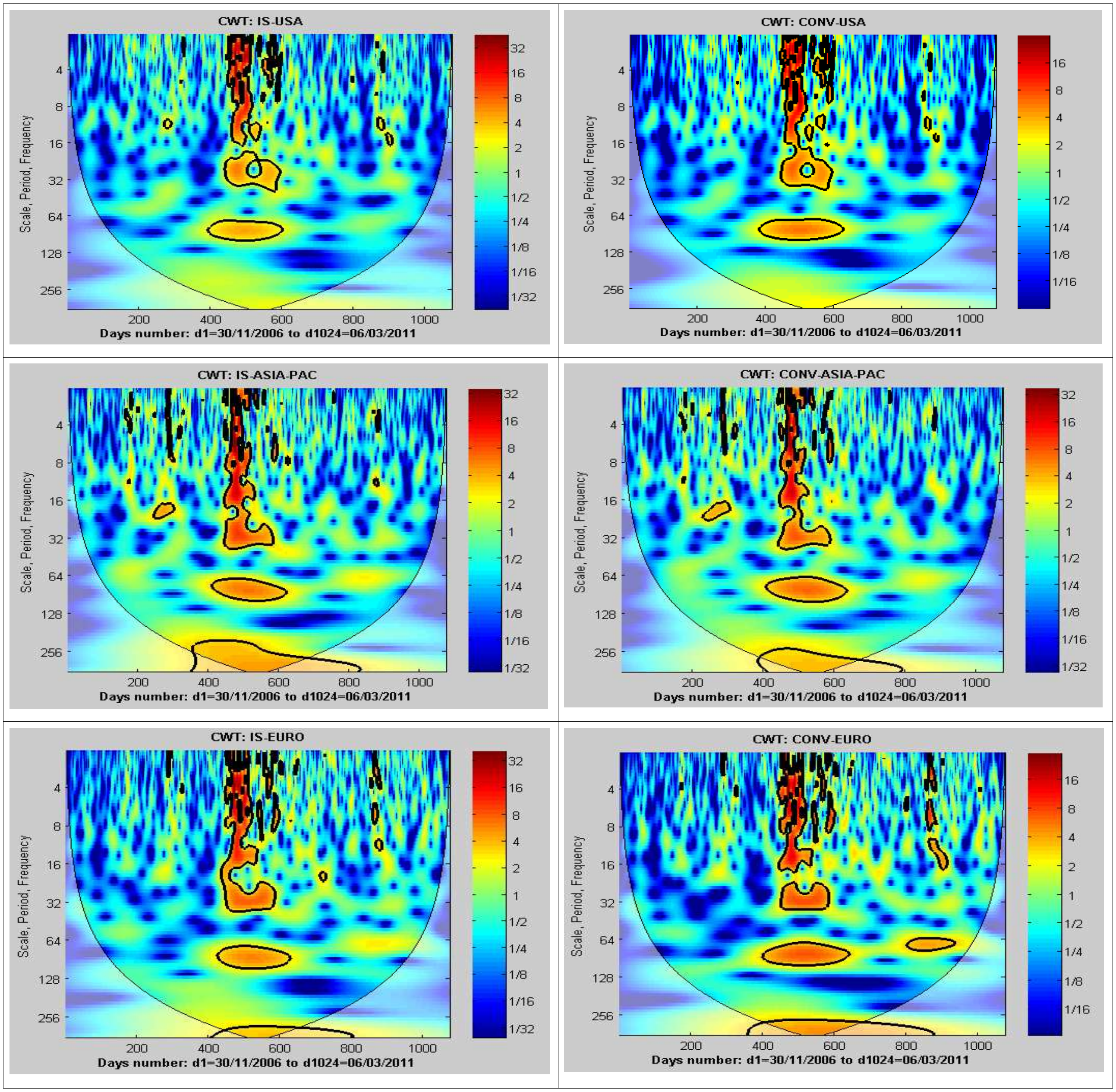
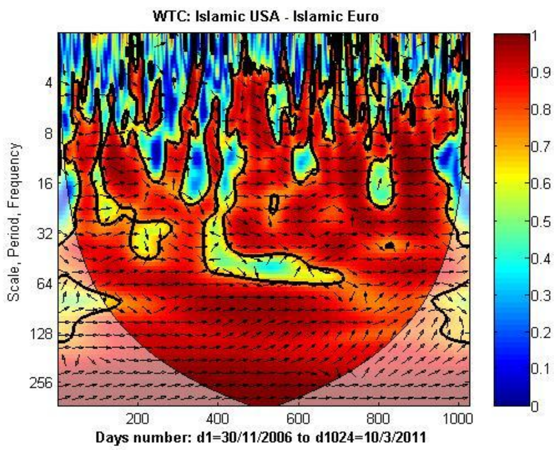


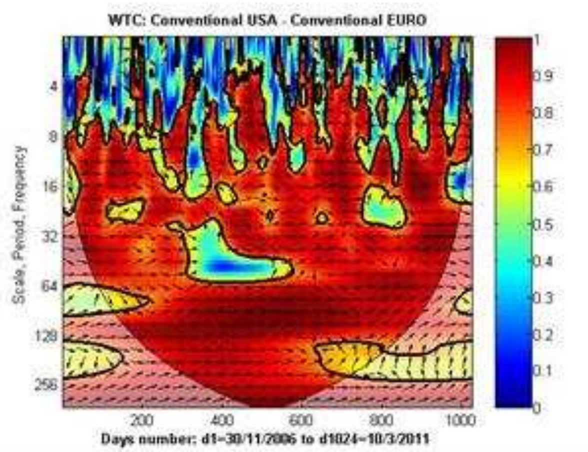
Figure 3. Cross-wavelet coherency for Islamic and conventional index-pairs

Cross-wavelet coherency and phase plots between Islamic equity indices and between conventional equity indices. The 5% significance level against red noise is shown as a thick contour. The relative phase relationship is shown as pointing arrows: Right: in-phase; Left: anti-phase; Down: X leading Y by 90°; Up: Y leading X by 90°.

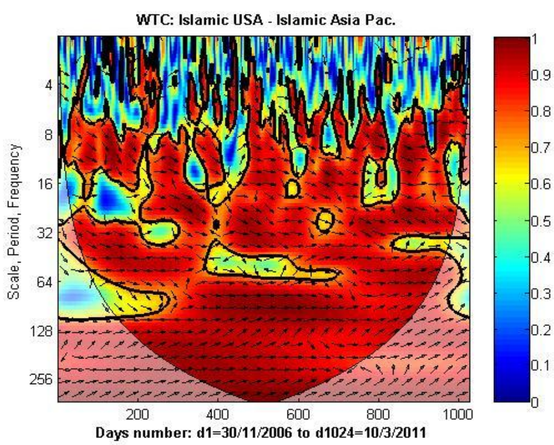
WTC: Islamic US – Islamic Eurozone



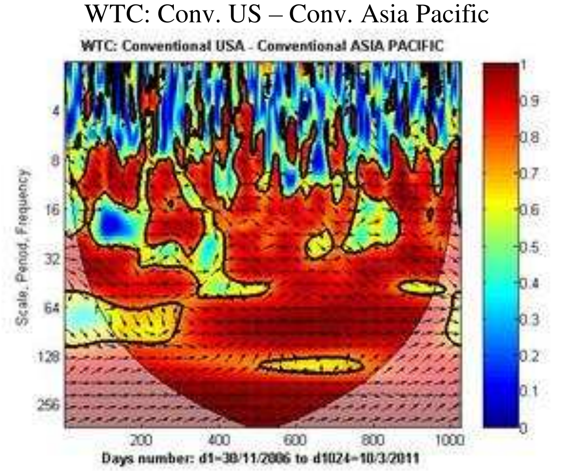
WTC: Conv. US – Conv. Eurozone



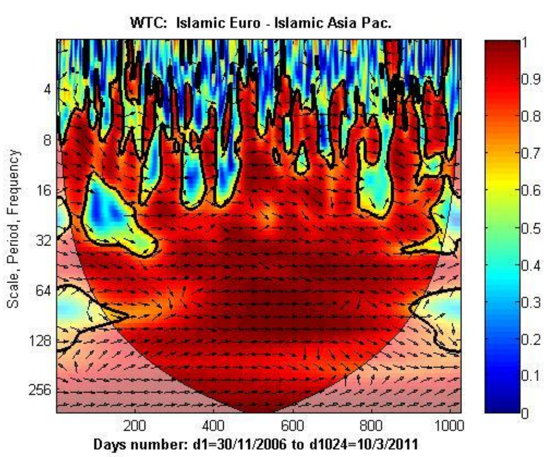
WTC: Islamic US – Islamic Asia Pacific



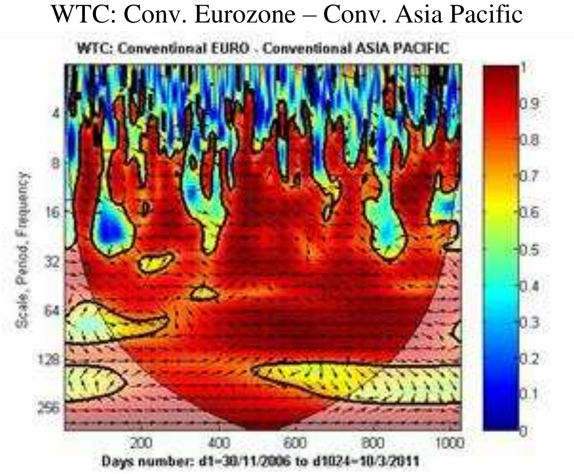
WTC: Conv. US – Conv. Asia Pacific



WTC: Islamic Eurozone – Islamic Asia Pacific



WTC: Conv. Eurozone – Conv. Asia Pacific



In addition, wavelet phase-difference attempts to discover the dynamics of financial linkages by observing the lead-lag relationship in multi-horizon nature between the stock markets. To interpret the graph, for example for Islamic US-Islamic Eurozone, the relative phase relationship is shown as pointing arrows: Right: in-phase; Left: anti-phase; Down: Islamic US leading Islamic Eurozone by 90°; Up: Islamic Eurozone leading Islamic US by 90°. The wavelet phase-difference also can be presented as graph showing frequency band 1~4 years. A phase-difference of zero indicates that the time-series co-move at the specified frequency[8]; if $\phi_{xy} \epsilon\ [0,\frac{\Pi}{2}]$, then the series move in phase with time-series y leads x; $\phi_{xy} \epsilon\ [-\frac{\Pi}{2},0]$ indicates the leading role of x; a phase-difference is π (or $-\pi$) will be an anti-phase relation; if $\phi_{xy} \epsilon\ [\frac{\Pi}{2}, \pi]$, then x is leading; time-series y is leading if $\phi_{xy} \epsilon\ [-\pi, -\frac{\Pi}{2}]$.

4.2.1. Exploring short-term and long-term shocks related to contagion

To detect the evidence of short-term and long-term shocks from Figure 2 and 3, we consider that the high frequency bands (below 32 days) may reveal information related to short-run market linkages, i.e. liquidity preferences, cross-border asset listing and trading, market panic/sentiment, and so on. On the other hand, the low frequency bands (above 32 days) may represent fundamental linkages closely related to the real economy. This frequency range also may reflect long-run equilibrium relationship (convergence) amongst the different stock markets. The concept is similar to Bodart & Candelon (2009) and Orlov (2009) who have associated high and low frequencies with contagion and interdependence.

Looking at Figure 3, some important information reveal and can be drawn intuitively. Our coherency plots generally display three large areas of high-coherency in the year 2007, 2008, and 2010. The year 2007 can be linked to the first stage of the US subprime crisis remarked by the ‘August factor’, which is followed by the major global instability in September 2008, attributable to the Lehman’s collapse. The last period reveals the significant impact of the Eurozone crisis in 2010.

To discover the shock transmission channel, our coherency plots in Figure 3 show that co-movement, at higher frequency-bands (below 32 days) and lower frequency-bands (above 32 days), have increased simultaneously in 2007 and 2008 for both Islamic and conventional index-pairs. This goes along with a raising volatility of individual indices at both frequency bands displayed in Figure 2. Our results therefore indicate the evidence of fundamental-based contagion, with the structural shock being transmitted mainly by way of fundamental linkages (real sector, trade-ties, etc.). While the structural shock in the US is understandable as the origin of the crisis, the major consequence for EMU countries has been the injection of the first large emergency loan in August 2007 by the European Central Bank in response to noticeable pressures in the interbank market. The global crisis eventually was transformed into sovereign debt crisis in this region. As to the fundamental channel for Asia Pacific, N’Diaye, Zhang, & Zhang (2010) and Zhang (2008) discussed how the US economic downturn had an impact on the Asia–Pacific economy via the traditional trade linkage.

In 2010, we also can see the rise in the short-term and long-term co-movement for all index-pairs, attributable to the Eurozone crisis. However, it is only the conventional Eurozone equity market which is exposed to a long-term volatility shock at frequency band 64 days. This signifies the severity of its sovereign debt crisis that started initially from Greece in autumn 2009, followed by the first Greek rescue package in March 2010, and spread further to Portugal, Spain, Italy and Ireland. There has been a major role of contagion among EMU members, where the market pricing behavior had shifted from a convergence trade model into macro-fundamentals and international risk (Arghyroua & Kontonikas, 2012).

As to the lead-lag relationships, the co-movements between the US equity index and other indices show arrows pointing downwards in 2007/08 at higher frequency bands below 32 days, which confirms

[8]The results are derived using ASToolbox by Aguiar-Conraria&Soares (2011)

the leading role of the US generating short-term shocks during the subprime crisis period. Nevertheless, we can find arrows pointing upwards at lower frequency bands from the two regions towards the US market. This may imply the presence of long-term shocks generated as adverse feedback loops, which are manifested through the trade channel as well as the deepening of sovereign debt crisis in the EMU.

In addition, we observe high coherency areas at frequency bands below 16 days, confirming our previous results pertaining to the rapid reversal of funds. However, the size of these high coherency areas is considerably smaller as compared to those in the longer horizon. This is understandable since the transmission of news across different regions would entail a gradual process of absorbing complete information in domestic market, which results in a slower decision process in adjusting portfolio risk-return trade off. The substantial role of transactions cost also would be taken into consideration when investors are willing to flee from risky to safe assets.

To compare between Islamic and conventional equity markets, the degree of high co-movement amongst the Islamic index-pairs is almost the same as compared to those amongst the conventional ones. However, the difference between the two can be evidenced from the severity of the impacts presented by rising volatilities. We can see that the conventional US and Eurozone equity indices are exposed to higher structural volatility shocks during the subprime crisis period. Moreover, it is only the conventional Eurozone index that portrays the long-term shock on volatility attributable to Eurozone crisis. This is understandable when we look at the characteristics of stocks included in the Islamic index. Firstly, Islamic stock has lower leverage effect, due to the limit of interest-based debt imposed by Shariah screening, during market turbulence. The leverage effect suggests that firms with lower debt/equity ratios should have a lower negative relation between current returns and stock volatility compared to firms with higher debt/equity ratios. Secondly, Islamic finance with the principle of *bay ad-dayn* and *gharar* has prohibited the firms to have and trade structured financial products (CDO), derivatives (CDS), as well as other toxic assets which played an important role in triggering crisis. Therefore, the Islamic financial institutions (IFIs) included in the Islamic portfolio were not directly affected by the global crisis. This can be supported further by looking at its constituent list, where many financial institutions other than banks have been included in the Islamic financial sector portfolio since the number of Islamic banks is relatively much lower than conventional banks.

Despite this, Islamic indices are still vulnerable, at a lesser degree, to shocks during market turbulence. The rationale can be the exclusion of some large corporations through Shariah filtering process, which may result in a less diversification of Islamic portfolio. This further increases its exposure to any volatility shock.

As to the Asia Pacific market, we can see that the Islamic index absorbs higher long-term shocks to volatility. This can be attributed to the impact of the recent crisis on Asia Pacific economies. The evidence of long term shocks may confirm some previous studies which found that the US turmoil has affected the Asia–Pacific economy via the traditional trade linkage (N'Diaye, Zhang, & Zhang, 2010; Zhang, 2008, for example). Since the Islamic portfolio put a relatively higher allocation into stocks closely related to the real sector, this may considerably increase its vulnerability to fundamental-based contagion.

4.2.2. Market integration

This section attempts to measure markets' co-movements as a proxy of their integration level. Previous studies by Bekaert et al. (2005) and Goetzmann et al. (2005) have documented a positive causality of market integration into market dependence. Given the well-integrated equity markets, the assets prices will be explained mostly by common factors so that a local market return would be determined by their covariances with other markets (Bekaert & Harvey, 1995; Baele, 2005; Bekaert et al., 2005).

Wavelet coherency with a rolling-window may provide evaluation of market integration level. From our coherency plots at Figure 3, beyond the crisis periods mentioned before, we can find large low coherency areas especially at frequency bands below 128 days for all index-pairs. This may indicate the nature of incomplete stock market integration across markets, since these frequency bands represent market activities in the short run such as cross-border assets listing and trading, as well as the opportunity for liquidity to cross borders amongst the concerned equity markets. On the other hand, we observe completely high co-movement at longer frequency bands for entire observations. This implies the presence of strong fundamental linkages amongst the concerned equity markets, i.e. globalized equity market, economic integration, trade ties, and so on.

To compare between Islamic and conventional index-pairs, the two have almost the same degree of co-movement across different frequency bands. Nonetheless, the Islamic index-pairs have slightly higher co-movement at lower frequency bands, signifying higher fundamental integration level. The rationale can be linked to the composition of Islamic equity portfolio since it has substantial allocation to stocks closely related to the real sector.

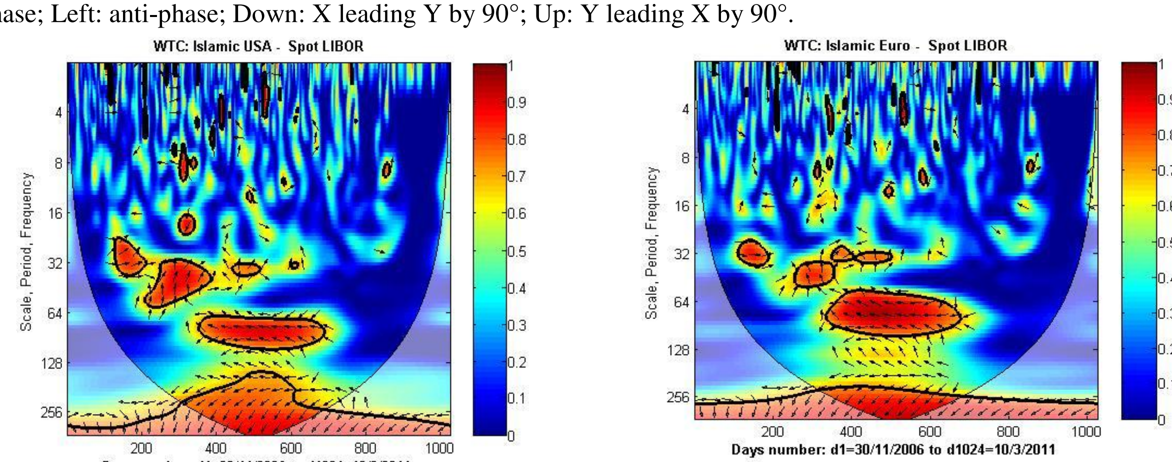
4.3. The impact of conventional rate

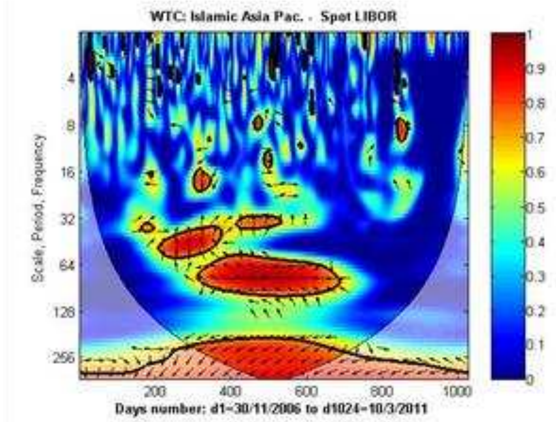
The low-interest rate regime in United States and the rise of interest rate that triggered the bubble burst in housing market cannot be ignored as one of the main sources of the global crisis. Specifically, Islamic financial industry still confronts a major controversial debate with respects to asset pricing benchmark using the conventional rate such as LIBOR. Therefore, our study attempts to observe the relationship between the Islamic equities and LIBOR in time-frequency space.

Looking at Figure 4, we may observe a significant high coherency areas at frequency-bands 32-64 days and 64-128 days in 2007 and 2008. It seems that the lead-lag relationships are not homogeneous across frequency-bands since arrows point left, down and up constantly. This implies that the short term interest rate has been adjusted in response to the global economic shock. On the other hand, we find that the Islamic equity indices are highly correlated with LIBOR at lower frequency bands above 128 days. This may confirm that LIBOR (conventional rate) has been used as a benchmark for Islamic asset pricing. High co-movement at low frequency bands simply means that LIBOR has been treated as a discount rate of future cash flows of the Islamic equity, given the fact that the classical asset pricing always deals with a long-run equilibrium framework. To support this evidence, wavelet phase difference demonstrates a leading role of LIBOR negatively against the Islamic equity indices. Therefore, the negative relationship between discount rate and asset price is in line with what have been suggested in asset pricing theory.

Figure 4. Cross-wavelet coherency between Islamic indices and LIBOR

Cross-wavelet coherency and phase plots between Islamic equity indices and LIBOR. The 5% significance level against red noise is shown as a thick contour. The relative phase relationship is shown as pointing arrows: Right: in-phase; Left: anti-phase; Down: X leading Y by 90°; Up: Y leading X by 90°.





5. Concluding remarks

Our study attempts to examine the nature of stock market co-movements amongst the Islamic equity markets vis-à-vis those amongst their conventional counterparts across different regions (Asia Pacific, U.S. and Eurozone.) between 2006 until 2011. The first is to discover the evidence of contagion attributable to common shocks originating from the subprime and Eurozone crises. We aim to identify the transmission channel either pure contagion or fundamentals-based contagion/interdependence. The second is to measure the market integration level as it may increase the vulnerability of the market to external shocks. The main objective of this comparative study is to identify whether Islamic equity markets are less integrated, among themselves, as well as less susceptible to the most recent crisis impact. The third is to asses the relationship between the Islamic equity indices and LIBOR since the Islamic financial industry still confronts a major controversial debate with respects to asset pricing benchmark using the conventional rate. Our study applies wavelet analysis to capture both time series and frequency domain simultaneously. This provides an ability to observe the multi-horizon nature of co-movement and lead-lag relationship.

Our findings show that Islamic and conventional indices are exposed to contagion effects during the first and second stages of the US-born crisis, as well as the Eurozone crisis. We discover the presence of fundamental-based contagion in the subprime crisis period, with the structural shock being transmitted mainly by way of fundamental linkages (real sector, trade-ties, etc.). To compare, the difference between Islamic and conventional indices can be evidenced from the severity of the crisis impacts. We find that the conventional US and Eurozone equity indices have absorbed higher structural volatility shocks during the subprime crisis period. Moreover, it is only the conventional Eurozone index that portrays the long-term shock on volatility attributable to Eurozone crisis. This can be explained by lower leverage effect of Islamic stocks, as well as the exclusion of financial firms which have and trade structured financial products (CDO), derivatives (CDS), as well as other toxic assets. Despite this, Islamic indices are still exposed to a 'sudden stop' contagion effect along with volatility shocks. The rationale can be the exclusion of some large corporations through Shariah filtering process, which may result in a less diversification of Islamic portfolio. Therefore, this further increases its exposure to any volatility shock. On the other hand, our finding shows that the Islamic Asia Pacific index absorbs higher long-term shocks to volatility. As the US turmoil has affected the Asia–Pacific economy via the traditional trade linkage, the Islamic portfolio that put a relatively higher allocation into stocks closely related to the real sector will be more vulnerable to fundamental-based contagion.

Our results also show low integration level in the short-term, which implies the nature of incomplete stock market integration across markets for both Islamic and conventional markets. This may indicate a lower incidence of cross-border assets listing and trading, lack of opportunity for liquidity to cross borders, and dampened flows of foreign investments into equities. However, we find the presence of strong fundamental integration level representing the globalized equity markets, economic integration, trade ties, and so on. The fundamental integration level amongst the Islamic markets is slightly higher. This can be linked to the composition of Islamic equity portfolio since it has substantial allocation to stocks closely related to the real sector. Finally, our results show that the LIBOR has a leading role negatively against all Islamic equity indices in the long run. This simply means that LIBOR has been treated as a discount rate of future cash flows of Islamic equity.

To this end, it is imperative to improve the development and resiliency in the Islamic equity market. Firstly, as shocks are transmitted via fundamental linkages (real sector, trade ties, etc.), it emphasizes the need to diversify the underlying economy. As emerging countries have experienced a substantial trade surplus in pre-crisis period, too much dependency on western countries should be mitigated through more integrating emerging economies, including amongst Muslim countries. The significant improvement of trade linkages could be an effective solution. Secondly, it needs to enhance the degree of integration by improving equity market infrastructure and its depth. It can be attained by increasing the cross listing and trading of compliant assets around the globe. Alternatively, creating Shariah compliant depositary receipt can be the first step to achieve a similar objective at a relatively lower cost. Therefore, it is expected that compliant assets have a contribution to boost stock market development, where a well-functioning stock market can promote economic growth by fuelling the engine of growth through faster capital accumulation, as well as by improving economic efficiency and productivity through better resource allocation. Finally, Islamic financial industry should create a new benchmark with a rate equal to the natural rate of return of the economy. The solution proposed by Sheikh Taqi Usmani can be adopted for achieving this objective, by creating a common pool that invests in asset-backed instruments like musharaka, ijara, etc, rather than tawarruq which still involves controversy. If majority assets are in tangible form, its units can be traded on the basis of their net asset value on periodical basis. The agreed profit from those assets therefore can be a reference for the rate of return.

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