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Are Islamic stock markets immune from contagion during the financial crisis?

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ABSTRACT

We assess the contagion effect of the global financial crisis (GFC) and the European debt crisis (EDC) on Islamic and conventional stock market indices of the US, GCC and Malaysia. We run the asymmetric dynamic conditional correlation GARCH specification on daily closing prices of relevant indices from 1 January 2006 through 31 December 2016. Our results show that the Malaysia Islamic stock market is exempted from the contagion effect of GFC and EDC when the shock stems from the US Islamic stock market. Investors in the US Islamic equity markets can create a safety net by reallocating some of their portfolios into Malaysia Islamic stock market, which appears to be more resilient. However, we do find a significant contagion influence between the US Islamic and GCC Islamic stock market, suggesting that the GCC Islamic stock market cannot provide an effective hedge for the US investors seeking a Shariah-compliant investment. Contagion effect generally is inconsistent and not significant for conventional stock markets of these three countries.

ملخص

نقوم بتقييم تأثير العدوى للأزمة المالية العالمية (GFC) وأزمة الديون الأوروبية (EDC) على مؤشرات أسواق الأسهم الإسلامية والتقليدية في الولايات المتحدة ودول مجلس التعاون الخليجي وماليزيا. ونقوم

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بتطبيق مواصفات الارتباط الشرطي الديناميكي غير المتماثل، التباين الذاتي الشرطي المعمم على أسعار الإغلاق اليومية للمؤشرات ذات الصلة من 1 يناير 2006 حتى 31 ديسمبر 2016. وتظهر نتائجنا أن سوق الأوراق المالية الإسلامية في ماليزيا مستثنى من تأثير عدوى الأزمة المالية العالمية وأزمة الديون الأوروبية عندما تأتي الصدمة من سوق الأوراق المالية الإسلامية في الولايات المتحدة. فالمستثمرين في أسواق الأسهم الإسلامية الأمريكية بإمكانهم إنشاء شبكة أمان عن طريق إعادة تخصيص بعض محافظهم الاستثمارية في سوق الأوراق المالية الإسلامية الماليزية التي تبدو أكثر مرونة. ومع ذلك، فإننا عثرنا على وجود تأثير للعدوى بين سوق الأوراق المالية الإسلامية الأمريكية ودول مجلس التعاون الخليجي، مما يشير إلى أن سوق الأوراق المالية الإسلامية في دول مجلس التعاون الخليجي لا يمكن أن توفر تحوطا فعالا للمستثمرين الأمريكيين الذين يسعون إلى استثمار متوافق مع الشريعة الإسلامية. *تأثير* العدوى بشكل عام غير متسق وغير مهم بالنسبة لأسواق الأوراق المالية التقليدية لهذه البلدان الثلاثة.

ABSTRAITE

Nous évaluons l'effet de contagion de la crise financière mondiale (GFC) et de la crise de la dette européenne (EDC) sur les indices boursiers islamiques et conventionnels des États-Unis, du CCG et de la Malaisie. Nous exécutons la spécification GARCH de corrélation conditionnelle dynamique asymétrique sur les prix de clôture quotidiens des indices pertinents du 1er janvier 2006 au 31 décembre 2016. Nos résultats montrent que le marché boursier islamique de Malaisie est exempté de l'effet de contagion du GFC et de l'EDC lorsque le choc provient du marché boursier islamique américain. Les investisseurs sur les marchés d'actions islamiques américains peuvent se créer un filet de sécurité en réaffectant une partie de leurs portefeuilles sur le marché des actions islamiques de Malaisie, qui semble plus résilient. Cependant, nous trouvons une influence de contagion significative entre le marché boursier islamique américain et celui du CCG, ce qui suggère que le marché boursier islamique du CCG ne peut pas fournir une couverture efficace aux investisseurs américains qui cherchent un investissement conforme à la charia. L'effet de *contagion* est généralement inconsistant et non significatif pour les marchés boursiers conventionnels de ces trois pays.

Keywords: Contagion; Financial crisis; Asymmetric dynamic conditional correlation (A-DCC); Islamic indices.

JEL Classification: G15, F65

1. Introduction

Financial liberalisation and globalisation have been the focus of policymakers in both developed and developing economies over the last three decades. The subsequent increased capital flows between countries has amplified the financial liberalisation and globalisation further (Ceballos et al., 2012). Given the historically assumed advantages of financial globalisation, for example, economic development of the nation and improved returns on financial investments, consolidated markets would often raise domestic market exposure to negative shocks from outside the countries (Caramazza et al., 2004). In a nutshell, amid economic instability, the domestic capital markets tend to co-move in tandem with their regional peers.

According to Forbes & Rigobon (2002), adverse shocks are transmissible via key economic links between countries, primarily via foreign trade and financial networks. This occurrence is known as market interdependence. A string of market meltdowns has uncovered a peculiar framework for cross-market transmitting adverse financial shocks since the 1990s. Unlike the conventional mechanism of transmitting economic shocks through plunged international trade, financial market's volatility has spread quickly from the crisis-originating country to other countries that share restricted economic relations (Billio and Caporin, 2010). Such crashes or crises are prevalent in the 1990s, for example, the 1994 Mexican currency crisis, the 1997 Southeast Asian currency crisis, the 1999 Russian Ruble crisis, and the latest one was the 2008 US subprime crisis. For starters, in 1997, when currency speculators attacked Hong Kong dollar, its equity market plummeted sharply. Countries like Brazil and South Africa too are not immune to financial crises. Forbes and Rigobon (2002) postulate that despite having different financial market sizes and structures, these countries' financial markets appeared to have co-moved and dropped significantly when Hong Kong's stock market plummets.

Since the negative shocks are transmissible to countries with little or no economic and trade relations, the increased cross-market co-movements are challenging to be justified by shared economic fundamentals argument (Billio and Caporin, 2010). In this scenario, fundamental economic linkages between countries will be insufficient in explaining the intensified market correlations. Instead the shift of the transmission

mechanism is believed to play pivotal role in the dramatic increase of cross-market co-movements in wake of the financial demise. In particular, such an occurrence has been referred to as the financial contagion effects of external shocks (Bekaert, Harvey, and Ng, 2005).

The topic of contagion vs financial interdependence has been a subject of academic debate in international finance. In general, past researches on this subject have focused on its two aspects of implications, namely the resilience of a country's financial system, and the risk-return benefits of diversified international portfolio investments. In order to improve the vulnerability of financial system against external shocks, it is crucial for the domestic policymakers to disentangle the mechanism through which adverse turbulences are transmitted to the domestic economy. With adequate knowledge on the transmission mechanism of shocks, effective preventive policies can be structured to improve the resilience of the domestic economy against external economic turbulences. In the scenario that adverse external shocks are spread to the domestic market through the fundamental economic linkages, the preventive policies should emphasise on the uplifting of the macroeconomic fundamentals (Moser, 2003).

With regards to the international portfolio investments, the primary concern of investors is to optimise the risk-return benefits of their diversified international portfolio investments. In finance, portfolio diversification can yield maximum benefit when assets can be diversified into financial markets with little or no cross-market correlations (Masih and Masih, 2001). Since the financial contagion effect will significantly increase the cross-market co-movements in the wake of the adverse economic shocks, the potential diversification benefits of the portfolio investments will be severely undermined, when they are needed the most (Pericoli and Sbracia, 2003). Thus, it is crucial for the international portfolio investors to consider financial contagion risk in structuring their optimal portfolio investments.

Given the enormous implications of the contagious financial crises, voluminous research has been conducted to explore the presence of the financial contagion among emerging as well as mature equity markets. Such trends have been dramatically picking-up after the incidence of the 1997 Asian financial crisis (Khalid and Kawai, 2003), and then pushed to new heights after the demise of the recent 2008 US Subprime Crisis

(Forbes, 2012). However, past researches have revealed mixed evidence on the presence of financial contagion, even if the crisis period and countries under investigation are the same. Some believed that the cross-market transmission of crisis is because of the fundamental links between countries; others upheld that it is the contagion effects of the crisis that induced those transmissions.

Another observation from the past financial contagion studies is the concentration of research on conventional stock markets. Over the last two decades, the Islamic finance industry has experienced dramatic growth across the global, partially contributed by the resilience of Islamic financial system (Pok, 2012) and the rapid accumulation of wealth in the major oil producing Muslim nations (Ho, Masood, Rehmand, and Bellalah, 2012). The size of the global Islamic finance industry has expanded more than 40 percent since 2012 to approximately $2.4 trillion in 2017 (Hanieh, 2019). Among all the inventions of Islamic financial instruments, Shariah-compliant stock market indices is believed to be a significant design which enables both Islamic institutional and individual investors to profit from diversifying their investments into Shariah-compliant stocks (El Khamlichi, Sarkar, Arouri, and Teulon, 2014). It is believed that due to the Shariah-compliance characteristics, namely the advocation of real economic activities rather than debt stimulated growth, and the prohibition of *maisir* (gambling), *riba* (usury), *gharar* (ambiguity), and financial derivatives (Smolo and Mirakhor, 2010), Islamic stocks have outperformed their conventional counterparts during the economic turmoil (Arif et al., 2021; Welling, 2020). And increasingly, Islamic stock markets have been populated as safe-havens for portfolio investors to diversify their investments.

Finally, though Islamic stock markets have often been perceived to be an effective avenue for diversifying portfolio investment risk, these benefits would be severely undermined when the markets are affected by financial contagion effects. Thus, a comparison of the contagiousness of financial market meltdowns like between Islamic and conventional stock markets in both developed and developing countries, such as the US, Malaysia and GCC is essentially needed, so that researchers can suggest and formulate better portfolio investment strategies for more effective domestic fiscal policies in these financial markets.

GFC is deemed as one of the most severe economic turmoil in the last two decades by many analysts. A case in point is about Fannie Mae and Freddie Mac, two US government special investment vehicle that was involved in the US secondary market for housing loan securities – they wrote about 40 percent of housing loans in the US. To rescue the US banking system, Fannie and Freddie, in 2008, the US government introduced the Troubled Asset Relief Program. The financial community believes the cross-countries propagation of the systematic risk during the GFC has resulted in the demise of the European debt market in the middle of 2009, and eventually the rising anxieties of contagion effects into international financial markets (Kenourgios, Naifar, and Dimitriou, 2016). The EDC problem started with the failure of the banking structure in Iceland, after which, it infected banks in Portugal, Italy, Ireland, Greece and Spain, Greece, Ireland, Italy as well as Portugal. The crisis has resulted in a massive loss of public confidence in European economies. Some European countries that were anxious about the possibility of financial contagion following the fall of the Euro had stepped in to write a financial guarantee to the International Monetary Fund (IMF). To stave off EDC, the European Central Bank announced that it would not hesitate to buy government as well as private bonds. Debts of a few Eurozone countries then were downgraded by rating agencies. EDC reached its peak between 2010 and 2012.

Our current study aims at assessing the financial contagion effect of both GFC and EDC on equity market indexes in the selected Muslim countries, as well as their Islamic indexes counterpart. We claim this is our main contribution – whilst many past kinds of research have explored the effect of contagion of the financial markets' meltdowns on regional markets, but almost no research has studied both conventional and Islamic stock market indices simultaneously. We believe our study is essential as many scholars have argued for the resiliency of the Islamic markets – that Islamic markets are immune to the crisis – if this conjecture is true, then Islamic stock markets should provide a compelling investment or hedge strategy to investors.

2. Review of Literature

In spite of the surge of research interests recently on the subject of financial contagion effects, researchers cannot agree on the definition of the issue. In general, there are three main types of financial contagion: a)

fundamental contagion, b) pure contagion, c) shift contagion. For the first category, financial contagion refers to the co-movements of asset market returns that result from fundamental economic linkages, namely common global factors, trade linkages, or financial linkages (Karolyi, 2003). Since these fundamental linkages are mostly stable across both the tranquil and crisis periods, past financial contagion studies have commonly perceived such scenarios as the market interdependency (Forbes & Rigobon, 2001; Karolyi, 2003), or the loose form of financial contagion based on the classification given by World Bank (World Bank, 2009).

Specifically, the latter two categories of the financial contagion are commonly known as the restrictive versions, in accordance with the classification of the World Bank. The shift contagion indicates that the strength in the propagation of shocks become stronger during the turmoil periods in comparisons with the tranquil periods (Forbes & Rigobon, 2001). According to their definition, the evidence of financial contagion can be examined through the magnitude of deviations in the cross-market correlations. In particular, when the correlation between the crisis-originating and another country increases significantly during the period of crisis relative to the period of tranquil, it signifies the presence of the financial contagion effects from the first to the second market.

Several empirical studies have applied the correlation coefficient-based approach to examine the evidence of the shift contagion. For instance, King & Wadhwani (1990) investigated the changes in the bivariate correlations of stock market returns in London, New York, and Tokyo before and after the US stock market meltdown in 1987. The analysis revealed the significant increase of correlations between the market, hence indicating the existence of contagion effect. In a latter study, Calvo and Reinhart (1996) explored the contagion effects of the 1994 Mexico currency crisis between Latin American and Asian stock markets. The authors concluded that since the correlations between the Asian and Latin American stock markets increased dramatically after the Mexican currency crisis, they confirmed the existence of the shift contagion. Forbes and Rigobon (2002) too documented shift contagion effect in the 1997 Asian financial crisis, 1994 Mexican currency crisis and 1987 the US stock market meltdown.

Though shift contagion is relatively easier to be tested empirically, researchers need to be cautious. Since the correlation between stock

markets are conditioned on the stock market volatilities, it will increase too when the stock market variance increases in the crisis period; such analysis provides biased results towards the acceptance of contagion hypothesis (Forbes and Rigobon, 2002). As an effective remedy, the authors propose adjusting this bias by correcting the increased volatility in the correlation analysis. However, the modified correlation coefficient approach will be appropriate when the assumptions of no exogenous global shocks or feedback of shocks from non-crisis to crisis-hit countries are upheld (Forbes & Rigobon, 2002). After applying this adjusted correlation approach, the authors have rejected the hypothesis of contagion effects for the three selected crisis periods.

Using the same approach, Collins and Biekpe (2003) rejected the contagion effects hypothesis originating from the 1997 Asian financial crisis to the African equity markets. In the same vein, Serwa and Bohl (2005) did not find contagion effects emanating from the 1997 Asian financial crisis to either Central or Eastern or Western European equity markets. Corsetti et al. (2005) argued since the common global factor was found to be one of the main drivers in spreading idiosyncratic shocks from the crisis to the non-crisis countries, the proposal to adjust the correlation in the absence of feedback shocks seems unrealistic. As a result, the adjusted correlation measure is believed to be biased towards rejecting the presence of significant financial contagion effects (Serwa & Bohl, 2005).

As for the last category, pure contagion can be considered as a crisis in one market to another. The market equilibrium was affected so much so that investors' expectations changed dramatically (Shen, Li, Wang, & Su, 2015). To this point, Masson (1999) argued that how the shocks being transmitted between countries can not be explained by fundamental factors. Thus, the initial condition to test for such contagion is to identify the fundamental linkages between countries. In general, past researches have controlled the effects of fundamental linkages through the regression of the model residuals. Since the market return models cannot explain the residuals, it represents the extent of cross-market correlations that failed to be captured by the fundamental linkages between the markets.

For instance, having controlled for the effects of fundamental linkages between countries, both the currency and equity market returns of the Southeast Asian countries had declined substantially, after the Asian crisis in 1997. Baig and Goldfajn (1998) argued since there was a

substantial rise in the co-movement between markets following the crisis, this surge in co-movements indicates the presence of the financial contagion effects in these asset markets. In another study, Kaminsky and Reinhart (2000) examined the evidence of the contagion effects in Asia, Europe, and Latin America, during the period between 1970 and 1998. After controlling for the fundamental impacts of trade and finance, the study concluded that a crisis elsewhere is most likely to be propagated into the stock markets of the sampled countries. In other words, the study confirmed the presence of the contagion effects in these markets, in the aftermath of the 1994 Mexican, 1997 Asian, and 1998 Russian crises.

Despite its popularity in the past empirical contagion studies, the pure contagion studies have encountered some difficulties in identifying the set of macroeconomic variables that are causing contagion – in other words, it is almost impossible to control for the confounding effect (Baele & Inghelbrecht, 2010). To overcome such constraints, past empirical research studies have proposed two approaches. First is to use the latent factor models to represent the asset market returns, which avoids the explicit specification of the fundamental variables (Karolyi, 2003). More specifically, a latent world factor can be installed in the asset market return model to represent the fundamental variables that determine asset returns (Dungey et al., 2005). Besides such constraints, pure contagion is still believed to account for a broader view of the contagion, and the application of this definition in the financial contagion analysis model is expected to provide information on the source of contagion (Rigobon, 2002).

In this study, we use Masson's (1999) description of financial contagion. Financial contagion occurs when shocks are transmitted beyond fundamental economic linkages between the markets. This definition assumes that the extreme cross-market co-movements have resulted in the structural break. These dynamics are beyond risk-return relationship explanation. Shen et al. (2015) indicated that such contagion is often caused by financial panic, irrationality behaviour, and incomplete information or risk aversion, and the financial mechanism to explain these phenomena could be the informational-friction mechanism of Calvo and Mendoza (2000) and the herding mechanism of Khan and Park (2009).

3. Data & Methodology

3.1. Data description

Having said the primary objective of this study is to provide the comparative evidence on the resilience of conventional and Islamic stock markets to the contagion effect of the GFC and EDC , we performed data search from Bloomberg database on both conventional and Islamic stock market indices in 57 member countries in the Organization of Islamic Cooperation (OIC) for the period spanning from 1st January 2006 to 31st December 2016. Due to the constrain of the available data on conventional and Islamic stock market indices for the sampled period in the targeted countries, we have only managed to retrieve ten years of daily closing price data in US Dollars for Dow Jones GCC Index (for GCC countries) and FBM Exchange Main Board All-Share Index (for Malaysia). In addition, since the U.S. financial market is commonly perceived as the origin of the GFC and EDC, we have also collected data from Dow Jones Industry Average Index and Dow Jones Islamic Market U.S. Index for the U.S. conventional and Islamic stock market, respectively. For ease and clarity, the conventional as well as Islamic indices for the US, GCC and Malaysia, are written in the tables as DJ, DJ-i, GCC, GCC-i and Msia, Msia-i, respectively (-i denotes Islamic index).

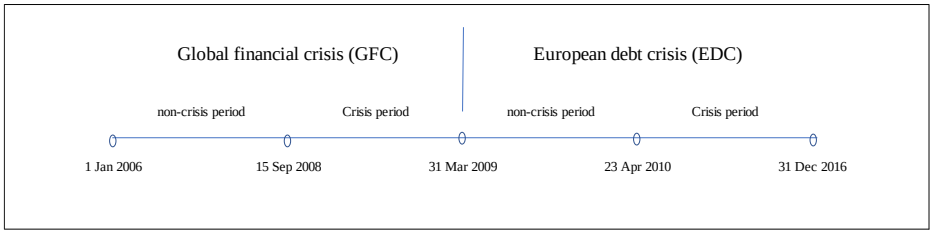
The application of the daily data in our study is to enable us to have a sufficient number of observations to avoid the potential data inefficiency issue in our Asymmetric DCC analysis (Kenourgios et al., 2016). For each index, the price series p_t has been transformed into a continuous return by taking natural log returns or $r_t = \log p_t - \log p_{t-1}$.

The selection of the data range has also taken into consideration the stable and turmoil period for both GFC and EDC. The examination of the financial contagion requires identification of the changes in the pair-wise dynamic correlations between crisis and non-crisis periods. Past empirical researches on financial contagion effects have primarily relied on two approaches to determine the crisis period and its duration, namely, the economic approach and the statistical approach. The former is also commonly referred to as the ad-hoc approach, which determines the crisis windows based on the fundamental news or critical economic events, for instance in studies by Forbes & Rigobon (2002), Bau (2012), Dimitriou et al. (2013), On the contrary, the statistical approach relies on the

econometric models to estimate the crisis windows. This approach has been adopted by Dungey and Gajurel (2014), Dungey, Milunovich, Thorp, and Yang (2015).

Since both approaches are believed to possess some degree of arbitrariness (Baur, 2012), in this study, we define the crisis and non-crisis period of GFC and EDC by using the economic approach. We define the crisis periods for GFC and EDC as from 16 Sep 2008 through to 31 Mar 2009 and 23 Apr to 31 Dec 2016. Whereas, we describe non-crisis periods for GFC and EDC as from 1 Jan 2006 to 15 Sep 2008 and 1 Apr 2009 to 22 Apr 2010, respectively. Please refer to Figure 1 below.

Figure 1. Classification of crisis and non-crisis period for GFC and EDC



Note: This figure shows the classification of crisis and non-crisis period for the global financial crisis (GFC) and the European debt crisis (EDC) defined in this study.

3.2 Methodology

We employ multivariate GARCH models to explore the transmission mechanism as well as correlation and volatility dynamics among financial markets. We first apply the vector GARCH (VECH) model of Bollerslev, Engle, Wooldridge, Engle, and Wooldridge (1988). This model has two significant drawbacks: first, the guarantee on the positive-definite of the conditional covariances; and second, the problem of dimensionality resulting from a considerable number of variables in the specification (Jerez, Casals, and Sotoca, 2009).

To address the drawback of the multivariate GARCH model, the BEKK[4] model has been suggested. Bollerslev (1990), in contrast, proposed the Constant Conditional Correlation (CCC) specification to simplify the

[4] BEKK is the acronym for the multivariate ARCH models developed by Yoshi Baba, Rob Engle, Dennis Kraft, and Ken Kroner (Engle and Kroner, 1995).

estimation and inference procedures. However, the constant correlations assumption is a bit too idealistic for time-series data, especially in times of stress when correlations can rapidly change (Frank and Hesse, 2009).

Extending from the CCC model, Engle (2002) proposed the Dynamic Conditional Correlation (DCC) model to incorporate the time-varying correlations. Then Cappiello, Engle, and Sheppard (2006) went further to modify the DCC model to include the asymmetric specification to capture the heterogeneity of the disturbances on the dynamics of the conditional correlation. Engle (2002) then advanced the CCC model by incorporating time-varying characteristic specification – he termed as Dynamic CCC model. Cappiello, Engle and Sheppard (2006) afterwards went a step further to improvise the model to capture the heterogeneity of the disturbances by incorporating the asymmetric specification. This model is as ADCC (Asymmetric DCC) model.

3.2.1. Model specification

We examine financial contagion effects by assessing the dynamic structural break in the correlation between stock markets' (cross-markets) returns, and it is essential to construct a proper model to represent the asset market returns for the sampled countries. Following Kenourgios et al. (2016), our model specification is as follows:

$$r_t = \beta_0 + \beta_1 r_{t-1} + \varepsilon_t \quad (1)$$

$$\varepsilon_t | I_{t-1} \sim N(0, H_t), \quad (2)$$

where $r_t = [r_{1t}, r_{2t}]$ is a 2 multiply 1 vector of daily returns of the stock markets, and $\varepsilon_t = [\varepsilon_{1t}, \varepsilon_{2t}]$ is a 2 multiply 1 vector of innovations. We assume the error term to be normally-distributed at time t-1 (I_{t-1}). The ε_{t-1} in the equation is an AR (1) term, and the inclusion of which follows the conventional approach of the DCC model.

Next, we decompose the variance-covariance (conditional) of matrix H_t as listed below:

$$H_t = D_t P_t D_t \quad (3)$$

where and P_t is a correlation matrix, conditional and time-varying. From the univariate GARCH models, D_t is a k multiply k matrix (diagonal) of

variance conditioned with $\sqrt{h_{it}}$ on the ith diagonal. We then specify D_t as follows:

$$h_{it} = \omega + a_1 h_{i,t-1} + \beta_1 \varepsilon_{i,t-1}^2 \quad (4)$$

where $z_{it} = r_{it}/\sqrt{h_{i,t}}$ is the standardized residential [0,1], and h_{it} is the conditional variance. The coefficients then need to fulfil two constrains: $a_1 > 1$ and $a_1 + \beta_1 < 1$, to ensure that h_{it} is stable.

Having obtained the conditional variances, the DCC model can be evolved into the following:

$$\mathrm{Q}_t = (1 - a - b)\bar{P} + a\varepsilon_{t-1}\varepsilon'_{t-1} + bQ_{t-1} \quad (5)$$

$$\mathrm{P}_t = Q_t^{*-1} Q_t Q_t^{*-1} \quad (6)$$

where $\bar{P} = E[\varepsilon_t, \varepsilon'_t]$, and a and b are scalars that must fulfil the condition of $a + b < 1$. Besides, Q_t^* is a matrix (diagonal) that contains the square root of the i[th] diagonal component of Q_t, which can be represented as $\sqrt{q_{ii,t}}$. If Q_t is positive, Q_t^* will be a matrix that satisfies $\mathrm{P}_t = Q_t^{*-1} Q_t Q_t^{*-1}$.

To address the issue of an asymmetric factor in the model, Cappiello et al. (2006) modified the specification in the DCC model as below:

$$\begin{aligned}\mathrm{Q}_t = (\bar{P} - A'\bar{P}A - B'\bar{P}B - G'\bar{N}G) + A'\varepsilon_{t-1}\varepsilon'_{t-1}A \\ + G'n_{t-1}n'_{t-1}G + B'Q_{t-1}B\end{aligned} \quad (7)$$

where G, B and A are k multiply k parameter matrices, $n_t = I[\varepsilon_t < 0] \mathrm{o} \varepsilon_t$ ($I[\cdot]$ is a k multiply 1 function (indicator) that takes on the value of 1 if the arguments are correct and 0 if false, and "o" is the Hadamard matrix) and $\bar{N} = E[n_t n'_{t-1}]$. Equation (7) above shows the specification for Asymmetric Generalised DCC Model (AG-DCC).

To test for changes in the dynamic correlation in the DCC model across crisis and turbulent periods, following Kenourgios et al. (2016), we incorporate dummy variables (DM_{GFC} and DM_{EDC}) to enable us to determine which of the two crises (GFC and EDC) induces significant financial contagion effects. In particular, we create two dummies and specify the mean equation as follows:

$$\rho_{ij,t} = c_0 + k_1 DM_{GFC} + k_2 DM_{EDC} + \eta_{ij,t} \quad (8)$$

where $\rho_{ij,t}$ describes the pair-wise dynamic conditional correlation (DCC), whereas DM is a dummy (predictor) variable for the crisis under study. In particular, DM_{GFC} denotes GFC (16 Sep 2008 to 31 Mar 2009), while DM_{EDC} denotes the EDC (23 Apr 2010 to 31 Dec 2016), respectively.

The crisis dummy will tell if structural changes do exist in the correlation coefficient. We describe the null and alternative hypotheses as follows:

$H_0: k_\mu \leq 0$ (No Financial Contagion Effects exist)

$H_1: k_\mu > 0$ (Financial Contagion Effects exist)

In the hypothesis, $\mu = 1, 2$ denote the GFC and EDC, correspondingly. We employ t-test statistic to test whether the dummy coefficients in Equation 8 are significant. A significantly positive dummy coefficient suggests that the correlation coefficient derived from the turmoil period is different significantly as compared to that of the stable period, hence providing evidence of the existence of the financial contagion effects.

4. Results and Discussion

4.1. Descriptive statistics

We provide descriptive statistics in Table 1. The average stock market index returns are positive and quite similar for all the markets under study, with the exception of the GCC indices. Both GCC Islamic and conventional stock market indices depict negative average returns. The standard deviations of market return which measure market volatility, show that the US Islamic stock market index return is the most explosive, succeeded by the US conventional stock market index.

Table 1. Descriptive statistics of conventional and Islamic indices of US, GCC and Malaysia

	US		GCC		Malaysia	
	DJ	DJ-i	GCC	GCC-i	Msia	Msia-i
No of days	2768	2768	3620	3620	2716	2716
Std dev	0.0117	0.0122	0.0098	0.0114	0.0105	0.0104
Variance	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Skewness	-1.3519	-1.2714	-1.2024	-1.1657	-1.339	-1.2586
Kurtosis	11.2806	11.8017	11.0089	11.6277	11.0841	11.5878
Minimum	-0.082	-0.097	-0.0786	-0.0913	-0.1233	-0.1095
Maximum	0.1051	0.1174	0.0657	0.0816	0.053	0.0565
Mean	0.0002	0.0002	-0.0002	-0.0002	0.0002	0.0002
ADF Stat.	-30.638***	-36.679***	-34.893***	-38.143***	-33.930***	-30.140***
JB Stat.	25.403***	24.760***	32.210***	21.214***	12.538***	42.218***
BG LM Stat (5)	10.8622***	10.2671***	27.6369***	23.0308***	7.3432***	1.2430***
ARCH (4)	98.3923***	114.4596**	303.2303***	138.6006***	188.4808***	47.496***

Note: This table shows descriptive statistics of conventional and Islamic indices of the US, GCC and Malaysia data used in this study. "-i" denotes Islamic index. "***","**", and "*" denote statistical significance at the 1% level, 5% level, and 10% level, respectively. "JB" stands for Jarque-Bera Normality Test. "BG LM" denotes the Breusch–Godfrey's LM test. Four lags have been applied in the ARCH-LM test. The automated lag selection has been employed in the ADF test, and the optimal lag length is determined through AIC.

Notably, the returns series for all the sampled countries unveil negative skewness as well as excessive kurtosis. The excess kurtosis is measured as the value in excess of the normal distribution's reference value of 3. The presence of high excess kurtosis implies the data resembles the pattern of high peaks and fat tails, as well as asymmetry towards the negative values in the distributions of the series of market returns. Further, we apply the Jarque-Bera test to examine the normality of the sampled returns series and find the sampled market returns generally are not normally distributed.

We then apply the Augmented Dickey-Fuller (ADF) test to assess the stationarity of the return series of our data sample. After that, we select the Akaike Information Criterion (AIC) to determine the optimal lag length. The ADF test results rejected the unit root hypothesis at the 1% significance in all of our data sample. Subsequently, we run the Breusch-

Godfrey's Lagrange Multiplier (BG LM) test on the autocorrelation of the sampled data. The results from the autocorrelation tests up to five (5) lags which indicate the presence of significant autocorrelation for all levels of significance. Finally, the ARCH Lagrange Multiplier (LM) statistic tests show the existence of significant ARCH effects up to four (4) lags for the return series of all the sampled countries. Based on the characteristics of the dataset, we believe the Asymmetric GARCH is the most suitable model to capture the asymmetry.

4.2 Asymmetric DCC GARCH

In order to test for the financial contagion effects of GFC and EDC among the sampled stock markets through the Asymmetric DCC GARCH model, we apply a three-step approach in our analysis. First, we estimate a univariate GARCH (1,1) for each market time series. In particular, the GARCH (1,1) transformed mean and variance equations for each time series are listed as follows:

Malaysia conventional stock market index (Msia):

$$r_{Msia,t} = 0.0002 - 0.4342r_{Msia,t-1} + 0.0462r_{Msia,t-2} + 0.2305u_{Msia,t-1} + u_{Msia,t} \quad (9)$$

$$\sigma^2_{Msia,t} = 0.0528 + 0.2146u^2_{Msia,t-1} + 0.7839\sigma^2_{Msia,t-1} \quad (10)$$

Malaysia Islamic stock market index (Msia-i):

$$r_{Msia-i,t} = -0.6152 - 0.7r_{Msia-i,t-1} + 0.6796r_{Msia-i,t-2} + 0.6482u_{Msia-i,t-1} + u_{Msia-i,t} \quad (11)$$

$$\sigma^2_{Msia-i,t} = 5.29 \times 10^{-6} + 0.1162u^2_{Msia-i,t-1} + 0.8724\sigma^2_{Msia-i,t-1} \quad (12)$$

GCC conventional stock market index (GCC):

$$r_{GCC,t} = 0.0005 - 0.1376r_{GCC,t-1} + 0.0795r_{GCC,t-2} + 0.2462u_{GCC,t-1} + u_{GCC,t} \quad (13)$$

$$\sigma^2_{GCC,t} = 0.0136 + 0.4295u^2_{GCC,t-1} + 0.2394\sigma^2_{GCC,t-1} \quad (14)$$

GCC Islamic stock market index (GCC-i):

$$r_{GCC-i,t} = 0.0005 + 0.7239r_{GCC-i,t-1} - 0.7633u_{GCC-i,t-1} + u_{GCC-i,t} \quad (15)$$

$$\sigma^2_{GCC-i,t} = 1.7 \times 10^{-6} + 0.1050u^2_{GCC-i,t-1} + 0.8882\sigma^2_{GCC-i,t-1} \quad (16)$$

The US Conventional Stock Market index (DJ):

$$r_{DJ,t} = 0.0003 - 0.9385r_{DJ,t-1} + 0.0213r_{DJ,t-2} + 0.3467u_{DJ,t-1} + u_{DJ,t} \quad (17)$$

$$\sigma^2_{DJ,t} = 0.0436 + 0.8356u^2_{DJ,t-1} + 0.2946\sigma^2_{DJ,t-1} \quad (18)$$

The US Islamic stock market index (DJ-i):

$$r_{DJ-i,t} = 0.0007 - 0.7734r_{DJ-i,t-1} + 0.0213r_{DJ-i,t-2} + 0.3240u_{DJ-i,t-1} + u_{DJ-i,t} \quad (19)$$

$$\sigma^2_{DJ-i,t} = 3.5 \times 10^{-6} + 0.096u^2_{DJ-i,t-1} + 0.0.896\sigma^2_{DJ-i,t-1} \quad (20)$$

Further, we estimate the A-DCC based on the bivariate A-DCC GARCH model (Equation 7). In Table 2 below, we show the estimated coefficients from the A-DCC model.

Table 2. Estimates of bivariate asymmetric DCC GARCH model

Parameter	Conventional Stock Markets indices			Islamic stock market indices		
	DJ -Msia	DJ - GCC	Msia - GCC	DJ-i - GCC-i	DJ-i - Msia-i	Msia-i - GCC-i
a_i	0.0137*	0.0052**	0.0052**	0.0048**	0.0052**	0.0001
b_i	0.2231**	0.8202	0.8682**	0.2222**	0.8682**	0.0001
g_i	0.0262***	0.0067*	0.0076**	0.0002**	0.0076**	0.0001

Note: This table shows bivariate estimates derived from the asymmetric DCC GARCH model (Equation 7), when the matrices A, B and G are replaced by the scalars a, b, g. "***", "**", and "*" denotes statistical significance at the 1%, 5%, and 10%, respectively.

The estimated coefficients a_i and b_i are significantly positive and dissimilar from zero, except for the $b_{DJI-DJGCC}$. Furthermore, the estimated asymmetric coefficient g_i is a positive sign, suggesting that the asymmetric movements are significantly present. The A-DCC estimates generally imply that the bivariate correlations between the stock markets under study are markedly higher during the crisis than that of during the good times. Overall, these estimates indicate that, in general, the data set fits the A-DCC GARCH model. Therefore, the derived A-DCC series in our study can be used to reflect the evolution of correlations over time.

Finally, we model the bivariate A-DCC correlations with intercept breaks to test the proposition that the GFC and EDC produce a substantial effect on the bivariate A-DCC correlations, so as to provide evidence for financial contagion effect. We tabulate the estimates on the significance of the crisis dummy variables for GFC and EDC based on Equation 8 in the following Table 3.

Table 3. Results (estimates) of the contagion effect.

Parameter	Conventional Stock Markets indices			Islamic stock market indices		
	DJ -Msia	DJ - GCC	Msia - GCC	DJ-i - GCC-i	DJ-i - Msia-i	Msia-i - GCC-i
K_1	-0.0002	-0.0083*	0.0022**	0.0029**	-0.0063***	-0.0031***
	-0.0023	-0.0028	-0.0028	-0.0014	-0.0013	-0.0011
K_2	-0.0002	-0.0002	0.0018	-0.0006	-0.0051***	0.0032***
	-0.0017	-0.0017	-0.0018	-0.001	-0.0009	-0.0008
C_0	-0.0842***	0.0218***	-0.0088***	-0.0211***	0.0196***	0.0328***
	-0.0002	-0.0002	-0.0002	-0.0003	-0.0003	-0.0003

Note: This table shows the results (estimates) of the contagion effect. The estimates are derived from Equation 8; $K_1$and K_2 represent the impact of GFC and EDC on the dynamics of the bivariate A-DCC correlations, and C_0 denotes the significance of the constant term in the equation. The statistical significance tests used in this study are based on t-statistics. Figures in parentheses are standard errors. "***", "**", and "*" denotes statistical significance at the 1%, 5%, and 10%, respectively.

At first sight, the GFC dummy coefficient k_1 show significantly negative values (dissimilar to those of the pre-crisis period) for all Islamic stock indices pairs under study. Meanwhile, for the conventional stock markets GFC dummy coefficient k_1 is negative and significantly different only for

US stock market (DJ) with the GCC stock market (GCC) (-0.0083), but positive and significant for Malaysia stock market (Msia) with GCC stock markets (GCC) (0.0022). This result indicates that the Islamic markets generally offer a relatively more effective shield for investors during the GFC. In other words, the GFC, resulting from the US Subprime Crisis and the global economic downturn, could have induced investors to diversify their investments into Islamic stock markets.

These investments seem to have provided Islamic market investors higher returns as compared to that of conventional markets during the financial crisis. This phenomenon can be explained by the *Shariah*-compliance filtering, where the firms with high toxic assets and high debt-leverage ratios are excluded from the Islamic indices (A. Hassan, Antoniou, & Paudyal, 2005; Saiti, Bacha, & Masih, 2014).

The only significant contagious effect during the GFC (when k_1 is significantly positive) could be seen from the US Islamic stock market (DJ-i) to the GCC Islamic stock market (GCC-i), which yields a positive and significant coefficient (0.0029), and for the conventional stock markets; is from Malaysia (Msia) to GCC (0.0022). These findings indicate that investors have options to allocate their portfolios during the GFC; for those investors who are exposed to the GCC Islamic stocks, they could allocate their portfolio into Malaysia Islamic stocks to obtain better returns. As for those investors who were exposed to the US conventional stocks, they could diversify their portfolio to include investment in GCC conventional stocks.

Looking at the estimates for dummy coefficients during the EDC, k_2 is the only significantly negative coefficient for one equity pair, that is, the US Islamic stock market (DJ-i) and the Malaysia Islamic stock market (Msia-i) (-0.0051). This finding indicates that Malaysia Islamic stock market (Msia-i) is somewhat immune to the adverse impact of crisis during EDC. Interestingly, there is a significant and positive contagion effect between the Malaysia Islamic (Msia-i) and the GCC Islamic stock markets (GCC-i) (0.0032). However, for the conventional stock markets, the contagion effect is not significant for all pairs of stock markets. These findings indicate that Islamic stock markets do exhibit some advantages over their conventional counterparts in mitigating the financial contagion risk during a crisis. For the US Islamic investors, it appears that allocating their portfolio into Malaysia Islamic stock market (Msia-i) could provide

them with the much-needed hedge and safety nets as well as returns enhancement.

5 Conclusion

In this study, we assess the effect of financial contagion of the GFC and EDC on selected stock markets (Islamic and conventional) in the US, GCC and Malaysia. We run A-DCC GARCH on daily closing prices data of relevant stock (equity) market indexes, that covers the period from 1 Jan 2006 through to 31 Dec 2016. We define financial contagion as the transmission of shocks beyond the fundamental economic linkages between the markets (Masson, 1998). According to this definition, the phenomenon of contagion can be detected from the structural break inherent in the time-varying correlation dynamics resulting from the explosive cross-market co-movements beyond the inter-temporal risk-return relation. To examine the evidence of this phenomenon, in this study, we utilise Cappiello, Engle, and Sheppard's (2006) Asymmetric Dynamic Conditional Coefficient (A-DCC) GARCH specification.

Generally, we find a significant asymmetry for all the stock markets returns under study. Our results suggest that the bivariate correlations among the sampled return series are significantly higher during the downturns than during the upturns. Thus, the bivariate asymmetric DCC series are fit to be used for examining the pair-wise correlation changes among the sampled stock market indices. We then investigate the evidence of significant financial contagion effects by modelling the bivariate A-DCC correlations with intercept break and crisis dummies. Our estimates on the significance of the crisis dummies have three crucial findings. First, the Malaysia Islamic stock market generally is exempted from the financial contagion risk that stems from the US Islamic stock market in both GFC and EDC. During the GFC, however, it seems there exists a significant contagion effect between US Islamic and GCC Islamic stock market, suggesting the GCC Islamic stock market does not provide an effective hedge for investors. Secondly, considerable contagion effects are found between Malaysia conventional and GCC conventional stock market during GFC as well as between Malaysia Islamic and GCC Islamic stock market during EDC – a signal that intra-regional portfolio investments and rebalancing between Malaysia and GCC may not be an effective strategy, and in fact, it should be avoided. This result perhaps can be explained by the fact that Malaysia is one of the prominent leaders

in the world's Islamic capital market. Third, the results of contagion effect of GFC and EDC for conventional stock markets of the US, GCC and Malaysia are mixed at best – during GFC, there is a weak hint of no contagion between the US conventional and GCC conventional stock market and evidence of contagion between Malaysia conventional and GCC conventional, but there are no significant results of contagion or no contagion during EDC.

By and large, our results indicate that Malaysia Islamic stock markets can provide an effective hedge strategy for US investors seeking *Shariah*-compliant investments. In the event of the economic meltdown or financial crisis, it seems that the Malaysia Islamic stock market is more resilient to shocks (compared to GCC Islamic stock markets) that are coming from US Islamic stock markets. But somehow the results for contagion effects between Malaysia Islamic and GCC Islamic stock markets yield opposite results for GFC and EDC. These inconsistent results suggest that intra-regional portfolio investments between Malaysia and GCC may not be an effective diversification strategy for risk mitigation during financial turmoil and that the temporary calming approach, like the pre-emptive monetary policy to increase the interest rates, or unrelenting intervention in the foreign exchange market to protect against speculative currency attacks, must be undertaken by governments in both financial markets to mitigate the intra-regional transmission of shocks during the global economic turbulence (Saiti, Bacha, & Masih, 2015).

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