Risk transmission between Islamic and conventional stock markets: A return and volatility spillover analysis

Abstract. This paper contributes to the current debate on the empirical validity of the decoupling hypothesis of the Islamic stock market from its mainstream counterparts by examining return and volatility spillovers across the global Islamic stock market, three main conventional national stock markets (the US, the UK and Japan) and a number of influential macroeconomic and financial variables over the period from July 1996 to June 2016. To that end, the VAR-based spillover index approach based on the generalized VAR framework developed by Diebold and Yilmaz (2012) is applied. The empirical analysis shows strong interactions in return and volatility among the global Islamic stock market, the conventional stock markets and the set of major risk factors considered. This finding means that the Islamic equity universe does not constitute a viable alternative for investors who wish to hedge their investments against the vagaries of stock markets, but it is exposed to the same global factors and risks hitting the conventional financial system. Therefore, this evidence leads to the rejection of the decoupling hypothesis of the Islamic stock market from conventional stock markets, which has significant implications for faith-based investors and policy makers in terms of portfolio diversification, hedging strategies and contagion risk.

Keywords: Islamic stock market, conventional stock markets, global risk factors, return and volatility spillovers, spillover index approach

JEL Classification: C58, G01, G15

1. Introduction

Born in its modern form in some Arab countries during the 1970s, the Islamic financial industry has experienced a spectacular expansion over the last decade, particularly in the aftermath of the global financial crisis of 2007-2009. According to the Islamic Financial Services Industry Stability Report 2015, Islamic finance assets have exhibited an impressive compounded average annual growth rate of 17% between 2009 and 2013. In fact, the total value of Islamic financial assets under management reached around US$ 2.2 trillion at the end of 2015. The fundamental difference between the Islamic and conventional financial systems is that the former is based on the principles of *Sharia* (Islamic law), which prohibits the payment and receipt of interest (*riba*), transactions involving excessive uncertainty (*gharar*) and gambling (*maysir*), which includes speculation, short selling and financial derivatives without underlying real transactions. Islamic finance is also based on the principle of profit-and-loss sharing in an asset-based system that is unlike the conventional interest-rate based system. The Islamic stock market constitutes one of the areas of Islamic finance that has received more attention over the last few years. In practice, Islamic equity investments must pass two screens in order to ensure *Sharia* compliance. The first screen is qualitative and excludes shares of all those companies engaged in activities incompatible with Islamic principles. These include firms whose major line of business is dealing with financial transactions involving interest, gambling activity, alcohol, tobacco, entertainment, weapons, pork-related products and/or excessive risk taking. The second screen is quantitative and utilizes a number of financial ratios to remove companies with permissible core activities, but that generate a significant portion of revenue from non-permissible activities such as borrowing or lending money on interest and/or have a large proportion of assets in liquid form. As pointed out by Girard and Hassan (2008) and Hussein and Omran (2005), Islamic stock indices are growth and small-cap oriented, while conventional stock indices are relatively more value and mid-cap focused.

The main motivation for this study derives from the widespread perception that the peculiar and conservative nature of *Sharia*-compliant investments may provide Islamic financial assets a certain protection against the increasing risk and instability in international financial markets. From this perspective, Islamic equity investments should be less vulnerable to exogenous economic and financial shocks compared with their mainstream counterparts due to the lower leverage ratios and interest involvement of Islamic stocks as well as the restrictions on investable

industries and on conducting speculative activities imposed by the *Sharia* screening process. This strand of opinion has led to the emergence of the decoupling hypothesis, which states that the performance of the Islamic equity universe should be segmented or only weakly linked to that of the conventional equity markets. The empirical validity of this hypothesis would demonstrate that Islamic stocks can act as a cushion to mitigate potential losses caused by unexpected financial crises and, therefore, may have important consequences for investors and portfolio managers. As noted by Ibrahim (2015), the decoupling hypothesis has become the subject of intense scrutiny in recent years, triggering a rapidly growing body of literature primarily focused on the performance of Islamic stock indices vis-à-vis conventional stock market indices and the interactions between them, especially after the recent global financial crisis. In contrast, the research on the transmission of shocks between Islamic and conventional equity markets remains quite limited and it has only gained some momentum in the wake of the global financial turmoil of 2007-2009. In any case, the evidence in the existing literature on the decoupling hypothesis is not entirely conclusive.

The central research question of this paper is to ascertain whether *Sharia*-compliant equities represent an alternative class of investment with distinctive characteristics that allow investors to obtain effective diversification benefits and downside risk reductions, particularly in turmoil periods. To answer this question, we examine the dynamics of return and volatility spillovers across the global Islamic stock market, the conventional stock markets of three major developed countries (the US, the UK and Japan) and a number of influential macroeconomic and financial indicators using the spillover index approach developed by Diebold and Yilmaz (2012). This methodology builds on the concept of forecast error variance decomposition and is insensitive to the ordering of the variables owing to the use of a generalized vector autoregression (VAR) framework.[1] The VAR-based spillover index approach enables one to assess the magnitude and direction of return and volatility spillovers across financial variables over time, and hence it provides an alternative way to check the validity of the decoupling hypothesis of the Islamic stock market from the conventional stock markets. For example, the finding of significant spillover effects among the global Islamic stock market, the conventional stock markets and the selected macro-finance variables would imply that Islamic equities are not isolated from their

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[1] The generalized VAR framework represents a significant improvement over the traditional Cholesky-factor identification used in standard VAR models, the results of which may be dependent on the ordering of variables.

mainstream counterparts and are not immune to external economic and financial shocks, which would lead to the rejection of the decoupling hypothesis. The set of macroeconomic and financial variables considered in this study includes the VIX volatility index, the U.S. equity market-related uncertainty index, changes in U.S. 10-year Treasury bond yields and the international crude oil price. These variables constitute commonly accepted indicators of the level of uncertainty and risk in the stock, bond and oil markets and they become fundamental driving forces of the world financial system during periods of financial stress.

This paper contributes to the ongoing debate about the validity of the decoupling hypothesis of Islamic equities from their conventional counterparts in two ways. First, to the best of our knowledge, this study is the first that analyzes return and volatility spillovers among Islamic stocks, their mainstream counterparts and several major global risk factors employing the spillover index approach proposed by Diebold and Yilmaz (2012). Understanding the magnitude and direction of spillover effects across Islamic and conventional equities and their variation over time may be very helpful for investors and portfolio managers to develop more effective asset allocation, portfolio rebalancing and hedging strategies. This information may also be valuable for policy makers interested in implementing stability-oriented policies aimed at reducing contagion risk and for regulators in order to design an appropriate regulatory framework. Second, by covering a relatively long time period that includes the global financial turmoil of 2007-2009 and the eurozone sovereign debt crisis of 2010-2012, this study enables us to figure out whether the most recent crisis episodes have significantly altered the risk transmission mechanism across Islamic and conventional equity markets.

Our empirical results reveal strong spillover effects in returns and volatility among the global Islamic and conventional stock markets and the selected macroeconomic and financial variables over the entire sample period. A general trend towards increased spillovers is apparent since the onset of the global financial crisis, which is consistent with the emergence of a new post-crisis scenario in which market participants are much more interested in knowing the true level of risk of financial instruments and pay greater attention to the development of major macroeconomic and financial indicators. It is also shown that the global Islamic stock market and the U.S. conventional stock market appear as the principal transmitters of return and volatility spillovers to the other markets and variables. This evidence implies that the global Islamic equity market is not decoupled from its mainstream counterparts, but it is exposed to the same economic and

financial shocks hitting the conventional financial system through massive capital movements and changes in investor sentiment, particularly during episodes of financial turmoil. A critical implication of these findings is that Islamic equity investments provide neither an effective cushion against the increasing risk and instability in conventional financial markets nor large diversification benefits for investors and portfolio managers. Furthermore, the Islamic regulatory authorities should seriously consider the possibility of including additional financial instruments such as some type of financial derivative in *Sharia*-compliant investment portfolios in order to protect faith-based investors from the vicissitudes of the conventional financial system.

The remainder of the paper is structured as follows. In Section 2, a brief review of the literature on the link between Islamic and conventional equity markets is given. Section 3 presents the econometric methodology employed in this study, while Section 4 describes the data used. Section 5 reports the main empirical results and provides some robustness tests. Finally, Section 6 offers some concluding remarks.

2. Literature review

The Islamic finance industry has undergone an unprecedented expansion over the last decade, driven by the rising demand for *Sharia*-compliant investment products as a result of the accumulation of tremendous oil wealth in Islamic countries, the strong willingness of regulators to support the development of Islamic financial markets and the apparent resilience of Islamic investments during the global financial crisis of 2007-2009. The extraordinary growth of the Islamic financial industry has led to a corresponding upsurge in academic research. Although this literature is still in its infancy compared to that conducted on conventional financial markets, it can be classified into five categories. The early research on Islamic finance deals with the unique characteristics of the Islamic financial system, particularly the prohibition of paying and receiving interest (*riba*) and the quantitative screening process based on financial ratios (e.g. Bashir, 1983; Karsten, 1982). The second strand focuses on the comparative performance of Islamic stock indices and their mainstream counterparts in terms of risk and return. However, the evidence regarding the performance of Islamic equity investments vis-à-vis conventional equities is not conclusive. For example, Al-Zoubi and Maghyered (2007), Ashraf and Mohammad (2014) and Shamsuddin (2014) find that Islamic stock indices outperform their mainstream benchmarks on the basis of risk-adjusted returns. In contrast, Abbes (2012), Girard and Hassan (2008) and

Hussein (2004) demonstrate that there are no significant differences in performance between Islamic and conventional equity markets. In line with the popular view that Islamic investments offer good hedging opportunities during adverse economic conditions, the third strand of literature investigates the relative performance of Islamic stock markets during the recent global financial crisis period. In this respect, several studies, such as those of Al-Khazali et al. (2014), Ho et al. (2014) and Jawadi et al. (2014), reveal that Islamic equity indices have outperformed their mainstream counterparts during the financial turmoil of 2007-2009 due to the lower volatility and beta of Islamic stocks and the conservative nature of *Sharia*-compliant investments.

The fourth strand concentrates on the degree of co-movement and dependence between Islamic and conventional stock indices and their link with a number of major macroeconomic and financial variables, such as the international crude oil price, the VIX volatility index, some investor sentiment indicators and short-term and long-term interest rates, using a wide range of empirical methodologies. This body of research pays special attention to the validity of the decoupling hypothesis of the Islamic equity market from the conventional financial system. The decoupling hypothesis is rooted in the assumption that Islamic stocks, as a result of their more conservative nature and the sector and financial ratio screening, can be seen as an alternative investment class that has its own distinctive characteristics and does not move in tandem with mainstream stocks (Masih et al., 2016). Accordingly, the basic idea of the decoupling hypothesis is that there should be a weak correlation between *Sharia*-compliant stocks and their conventional counterparts. Thus, Islamic equity investments may provide investors significant diversification benefits and play a safe haven role during episodes of financial stress. In this context, Ajmi et al. (2014) identify significant linear and nonlinear Granger causality relationships among the global Islamic stock market, the conventional stock markets for the U.S., Europe and Asia, and several global economic and financial shocks. Using a copula approach, Hammoudeh et al. (2014) find significant time-varying dependence among the global Islamic stock market index, three major global conventional stock indices from the U.S., Asia and Europe and a various global economic and financial risk factors. Similarly, applying quantile regression analysis, Naifar (2016) detects significant co-movement across quantiles between the global Islamic stock market, the conventional U.S. stock market and a set of influential macro-finance variables. The empirical findings of these three studies indicate that the Islamic stock

market is not decoupled from its mainstream counterparts, but it is exposed to global shocks common to the global financial system as well as contagion risks during periods of financial crisis. Hence, this evidence leads to the rejection of the decoupling hypothesis.

In a related research, Yilmaz et al. (2015) analyze the interactions among ten major Islamic equity sector indices using the consistent dynamic conditional correlation (cDCC) and the dynamic equicorrelation (DECO) models. Their results show highly integrated Islamic stock sectors as a result of heightened global financialization over the last decade, thus supporting the weakening of the decoupling hypothesis of Islamic equity finance from its conventional counterpart. Ben Nasr et al. (2016) model and forecast the volatility of returns of the Dow Jones global Islamic market index applying a number of up-to-date statistical models allowing for long memory and regime-switching dynamics. They find that the Islamic stock market shares all basic stylized facts of traditional asset classes, which suggests that Islamic equities can hardly provide any safeguard against extreme market gyrations. In a similar vein, Aloui et al. (2016) investigate the co-movement between investors' sentiment and U.S. Islamic and conventional stock returns using wavelet squared coherence and asymmetric causality methodologies. Their results reveal that Islamic equity returns do not behave differently from their mainstream counterparts, casting doubt over the validity of the decoupling hypothesis. Also employing wavelet coherence analysis, Dewandaru et al. (2014) and Rizvi et al. (2015) note a gradual increase of co-movement of Islamic stock markets vis-à-vis their conventional counterparts across different regions, which represents again evidence contrary to the decoupling hypothesis. Nevertheless, there are also a few contributions that support the decoupling hypothesis. In this regard, based on the application of the DCC-GARCH model, Rizvi and Arshad (2014) observe that a large set of Islamic and conventional equity market indices exhibit a weak correlation, especially during the recent global financial crisis. This implies that Islamic equities offer a partial insulation to investors in times of financial turmoil. In addition, applying the asymmetric DCC (A-DCC) model into a multivariate asymmetric power ARCH (APARCH) framework, Kenourgios et al. (2016) provide strong evidence in favor of the decoupling hypothesis of the Islamic securities from the conventional financial system for various developed and emerging countries. They conclude that Islamic equities and bonds offer effective diversification benefits, particularly during turbulent periods.

The transmission of shocks between Islamic and conventional stock markets has been much less explored until now in the literature. However, it is possible to find some studies addressing this

issue, which form the fifth strand of research. For example, Dania and Malhotra (2013) document significant positive return and volatility spillovers from conventional market index funds in four major global markets (North America, European Union, Far East and Pacific region) to their Islamic counterparts. In contrast, Majdoub and Mansour (2014) do not detect significant volatility spillovers from the U.S. Islamic stock market into five Islamic emerging stock markets (Turkey, Indonesia, Pakistan, Qatar and Malaysia) using a number of multivariate GARCH models. According to these authors, the peculiar specificities of the Islamic finance industry play a key role in explaining this result. In a related study, using the causality-in-variance test proposed by Hafner and Herwartz (2006) and generalized impulse response functions, Nazlioglu et al. (2015) find significant volatility transfers between the Dow Jones Islamic equity market and the conventional equity markets for the US, Europe and Asia over the pre-financial crisis and the in- and post-financial crisis periods. This evidence implies the presence of contagion effects among these global stock markets, which have remained unaffected by the recent international financial crisis. More recently, Mensi et al. (2016) analyze dynamic volatility spillovers between global Islamic and conventional stock indices at the sector level employing various multivariate GARCH specifications. Their results indicate an increase in the degree of integration between Islamic stock indices and their benchmark counterparts at the sector level since the onset of the 2007-2009 global financial crisis. Overall, the empirical evidence available, although not entirely conclusive, suggests the existence of significant spillover effects between Islamic and conventional stock markets, implying that Islamic equities are not decoupled from the conventional financial system.

Building on this body of work, our research aims to shed additional light on the risk transmission between the Islamic stock market and its mainstream counterparts using the VAR-based spillover index approach developed by Diebold and Yilmaz (2012). This framework has been widely employed in recent years to examine the international information transmission mechanisms across stock markets (Balli et al., 2015; Tsai, 2014; Yarovaya et al., 2016). However, to the best of our knowledge, there is no study that explores the dynamic interactions between Islamic and conventional equity markets, while including a number of major global economic and financial factors as well, within the framework of the spillover index methodology of Diebold and Yilmaz (2012). In fact, the only study that has applied the spillover index approach in the context of Islamic finance so far is that of Maghyereh and Awartani (2016), who investigate return and

volatility spillovers across global Islamic bonds (*Sukuk*), global conventional bonds, global Islamic equities and global conventional equities. Despite sharing the same methodological framework, our paper focuses on the spillover effects in returns and volatility among the global Islamic stock market, the conventional stock markets for the U.S., the U.K. and Japan and a number of influential macroeconomic and financial variables.

3. Data description and preliminary analysis

3.1. Data

The dataset used in this study consists of daily closing prices for several Islamic and conventional equity markets as well as for a number of major macroeconomic and financial risk factors over the period ranging from July 15, 1996 to June 30, 2016 (totaling 5,027 daily observations). The Dow Jones Islamic market (DJIM) index is employed as a proxy for the global Islamic stock market. As noted by Naifar et al. (2016), the DJIM was launched in February 1999 and constitutes the first Islamic index created for investors seeking *Sharia*-compliant equities. The DJIM index measures the global universe of investable equities that have been screened for *Sharia* compliance, representing the most comprehensive and widely used index of Islamic stocks in the world. This index includes data for over 12,000 companies from 77 countries, although most of the stocks in the DJIM universe are located in non-Muslim developed countries. According to the Dow Jones website, the U.S. has the highest country allocation (60.53%) in the DJIM index at the end of October 2016, followed by Japan (7.63%), Switzerland (4.67%) and the UK (3.69%). Further, the Dow Jones stock market indices for the U.S., the UK and Japan, which represent the overall stock market for each of these countries, are utilized as a proxy for the conventional equity market. The U.S., the UK and Japan stock indices are selected because they are currently the three largest stock markets in the world and cover different geographical areas. All the stock market indices are expressed in U.S. dollar terms to have a homogenous dataset and to avoid issues of exchange rate risk.[2]

A number of influential macroeconomic and financial variables that reflect the degree of uncertainty and risk in the stock, bond and oil markets are also considered in this study, namely the VIX index, the U.S. equity market-related uncertainty index developed by Baker et al.

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[2] In order to avoid asynchronicity issues caused by different time zones, we have matched equity prices from day *t* for the global Islamic stock market and the U.S. and UK conventional stock markets with equity prices from day *t+1* for the Japanese stock market.

(2012), the U.S. 10-year Treasury bond yield and the WTI (West Texas Intermediate) crude oil price. These risk factors may affect significantly the risk-taking behavior of market participants during periods of financial turmoil, thus exerting a remarkable influence on the global financial environment.

The VIX is the Chicago Board Options Exchange (CBOE) Volatility index, which measures the implied volatility of the S&P 500 index options over the next 30 days. The VIX, often referred to as the fear index, is typically interpreted as a measure of investors' risk aversion. A surge in the VIX indicates greater fear in the stock market and is usually associated with declines in stock prices. The U.S. equity market-related uncertainty index introduced by Baker et al. (2012) is designed to capture the economic uncertainty in the U.S. equity market. It is based on the number of news articles published in national newspapers that contain terms related to stock market uncertainty. The higher the values of this index, the greater the uncertainty in the U.S. equity market. Hence, it is also expected that an increase in this index brings about a fall in the stock market. The U.S. 10-year Treasury yield is used as a proxy for the long-term world interest rates. Long-term interest rates are broadly accepted as one of the most influential macroeconomic variables affecting the stock market. In general, interest rates impact stock prices through two basic channels. First, movements in interest rates have a direct effect on the discount rate used in standard equity valuation models. Second, interest rate changes affect firms' expectations about future cash flows by altering the cost of borrowing for firms. These two channels suggest an inverse connection between interest rate fluctuations and stock returns. However, a positive relationship between both variables is also possible if interest rates and stock prices move in the same direction following changes in economic prospects (Ferrer et al., 2016). For example, interest rates and equity prices may increase simultaneously in response to an improvement in the economic outlook.

Lastly, the WTI oil spot price is employed as a proxy for the international crude oil price. Oil prices have become a main source of instability and uncertainty in the world economy over the last decades since oil is a vital input in the production of a wide range of goods and services. Numerous empirical studies have investigated the relationship between oil prices and stock market performance (e.g., Jones and Kaul, 1996; Miller and Ratti, 2009; Sadorsky, 1999), although with mixed conclusions depending on the specific time period considered, the source of oil price shocks and the type of countries analysed (net oil-importing or net oil-exporting

countries). In particular, oil prices can influence stock returns via at least two channels. Firstly, oil price fluctuations can cause changes in expected cash flows due to their effect on the production costs and the overall economy. Secondly, oil price shocks can affect the discount rate utilized in stock valuation models by altering inflation expectations. Daily stock returns and oil price fluctuations are calculated as the first logarithmic difference between two consecutive observations. Following the usual practice, changes in U.S. 10-year Treasury bond yields are computed as the first difference in the level of bond yields between two successive observations. In turn, the VIX and the U.S. equity market-related uncertainty index are presented in log-level form. All data series are collected from Thomson Reuters DataStream. Figure 1 plots the time evolution of all daily series. Visual inspection of this figure shows the strong variability of all variables over the period of study. As can be seen, the global Islamic stock market index and the three national conventional stock indices have a very similar behaviour throughout the sample. Furthermore, the effect of an exceptional economic event such as the recent global financial crisis is clearly pronounced for almost all series.

INSERT FIGURE 1 ABOUT HERE

3.2. Summary statistics

Table 1 provides the descriptive statistics of Islamic and conventional stock returns as well as of the major global risk factors used in the analysis. In order to better appreciate the impact of the global financial crisis that began in the summer of 2007 on the variables under consideration, some descriptive statistics in Table 1 are computed for the whole sample and the three following sub-periods: the pre-crisis period (from July 15, 1996 to July 31, 2007), the global financial crisis period (from August 1, 2007 to June 30, 2009) and the post-crisis period (from July 1, 2009 to June 30, 2016). In line with, among others, Barth et al. (2009) and Choudhry et al. (2015), the start of the collapse of the sub-prime mortgage market in the U.S. during August 2007 is used as the beginning of the crisis period. Likewise, the U.S. National Bureau of Economic Research (NBER) identifies June 2009 as the official end date of the economic recession associated with the financial crisis. The mean daily returns of Islamic and conventional stock indices are very close to zero in all cases and rather small compared to their respective standard deviations, which indicates a relatively high volatility in the stock markets under study. It is also worth noting that the results in terms of mean returns and volatility, as measured by the standard deviation, vary

notably across sub-periods. There are no large differences in mean returns between Islamic and conventional stock indices, although the average return of the DJIM index during the global financial crisis period is slightly higher than that of conventional national stock market indices. However, the volatility of the DJIM index is lower than that of conventional stock indices regardless of the sub-period. This evidence concerning the mean return and standard deviation suggests that Islamic equities seem to have performed slightly better compared to their mainstream counterparts (excepting the Japanese case) during the recent financial crisis sub-period. As expected, the lowest average stock return and the highest volatility are observed for all the stock indices during the crisis period, demonstrating the dramatic impact of the global financial crisis on the worldwide stock markets.

The series of Islamic and conventional stock returns and oil price changes exhibit negative asymmetry, which suggests an increased likelihood of suffering losses. Instead, the VIX, the U.S. equity market-related uncertainty index and the changes in U.S. 10-year Treasury yields show positive skewness. The kurtosis statistic is more than 3 for all the series excepting the stock market-related uncertainty index, proving that almost all the series are leptokurtic (more peaked around the mean and with fatter tails than the normal distribution). The high skewness and kurtosis values support the use of a skewed-t distribution in subsequent estimations. The departure from normality is formally confirmed by the Jarque-Bera test statistics, which reject the null hypothesis of a normal distribution for all the series at the 1% significance level. The Ljung-Box Q-test statistics for autocorrelation up to the 12th order in the raw series and squared series show evidence of serial correlation in all the series. Moreover, the Lagrange multiplier test for the presence of conditional heteroscedasticity detects significant ARCH effects in all the series, which supports the use of GARCH-type processes for modelling some stylized facts of financial data such as asymmetry, fat tails and volatility clustering.

INSERT TABLE 1 ABOUT HERE

In addition, the standard Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests are performed to determine the order of integration of each variable. The results of both tests, presented in Table 2, show that all the Islamic and conventional stock return series are stationary, i.e. I(0), at the 1% level. Regarding the macro-finance variables, the ADF and PP tests reveal that the changes in the U.S. 10-year Treasury bond yield and the crude oil price

fluctuations, as well as the log-levels of the VIX and the U.S. equity market-related uncertainty index, are also stationary at the usual significance levels.

Given that the macroeconomic and financial variables considered in this study may have a significant nonlinear component in their respective data generating processes, the nonlinear Fourier ADF (FADF hereafter) unit root test developed by Enders and Lee (2012) is utilized as a robustness check. The FADF test is a modified version of the linear ADF unit root test that takes into account the possible nonlinearity using the Fourier approximation. The starting point of the FADF test is that nonlinearities of an unknown form, including structural changes, can be captured by using a small number of low frequency components from a Fourier approximation. The nonlinear FADF statistic (τ_{DF}) is based on the following equation:

$$\Delta y_t = \rho y_{t-1} + c_0 + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + \sum_{i=1}^{l} c_i \Delta y_{t-i} + e_t \tag{1}$$

where k represents the frequency selected for the Fourier approximation, γ_1 and γ_2 measure the amplitude and displacement of the sinusoidal component of the deterministic term, T is the number of observations, l represents the number of lags of the variable under study and e_t is a mean zero stationary process. Note that τ_{DF} is the t-statistic for the null hypothesis of a unit root, $\rho = 0$, in Eq. (1). Enders and Lee (2012) demonstrated that the asymptotic distribution of the τ_{DF} statistic depends only on the frequency k and the sample size T, while it is invariant to all other parameters in the data generating process. The conventional ADF unit root test emerges as a special case of the FADF test when the trigonometric terms are set to zero ($\gamma_1 = \gamma_2 = 0$). Moreover, Enders and Lee (2012) suggest to employ a usual F-statistic to examine whether a nonlinear trend exists in the data generating process. The nonlinear FADF test would be appropriate if the null hypothesis of linearity is rejected. In contrast, if the F-statistic is less than the critical value, the null hypothesis of linearity is not rejected. In such a case, Enders and Lee (2012) recommend to use the standard linear ADF test to gain power. According to these authors, a Fourier function with $k=1$ or $k=2$ is suitable to capture unknown structural breaks and nonlinearity in most series avoiding possible over-fitting problems. Monte Carlo experiments indicate that the FADF test has very good size and power properties with no more than one or two frequencies. Hence, the maximum frequency ($k_{\max}$) is set to 2 and the optimal frequency ($\tilde{k}$), i.e. the frequency that minimizes the sum of squared residuals (SSR) from the regression in

Equation (1), is selected through the data-driven grid-search method suggested by Enders and Lee (2012). Furthermore, the optimal lag length ($\tilde{l}$) is chosen by minimizing the Akaike Information Criterion (AIC).

The results of the nonlinear FADF unit root test are also displayed in Table 2. We can conclude from the fourth column that two frequencies work best for the vast majority of series. As can be seen, the *F*-statistics fail to reject the null hypothesis of linearity for all series, implying that the traditional linear ADF test is more suitable to assess the unit root properties of the variables. Therefore, on the basis of the findings of the standard ADF unit root test reported above, it can be stated that all series under consideration are stationary at usual levels. In any case, it is worth noting that the τ_{DF} statistics confirm the stationarity of all series at the 1% level.

<div align="center">INSERT TABLE 2 ABOUT HERE</div>

3.3. Modeling conditional volatility

The conditional volatility of the series to be used in the analysis of volatility spillovers is estimated from the threshold generalized autoregressive conditional heteroscedasticity (TGARCH) model with a skewed-*t* distribution. The TGARCH specification proposed by Zakoian (1994) is well-known for its ability to reproduce the asymmetric behavior of the conditional variance as it recognizes that negative shocks may have greater impact on volatility than positive shocks of equal magnitude. In this framework, it is assumed that the conditional mean equation of a series x_t is adequately described by an ARMA (*m,n*) process as:

$$x_t = \emptyset_0 + \sum_{j=1}^{m} \emptyset_j \, x_{t-j} + \varepsilon_t - \sum_{i=1}^{n} \theta_i \, \varepsilon_{t-i} \tag{2}$$

where x_t denotes the time series under study, *m* and *n* are non-negative integers, $\emptyset_0$ is a constant term and $\emptyset_j$ and θ_i stand for the autoregressive (AR) and moving average (MA) parameters. In addition, ε_t is a disturbance term defined as $\varepsilon_t = \sigma_t z_t$, where σ_t is the conditional standard deviation and z_t are the standardized residuals with zero mean and unit variance.

The variance of x_t is given by the variance of ε_t, whose dynamics is described by a TGARCH (*p,q*) model specified as follows:

$$\sigma_t^2 = \omega + \sum_{k=1}^{p} \beta_k \, \sigma_{t-k}^2 + \sum_{h=1}^{q} \alpha_h \, \varepsilon_{t-h}^2 + \sum_{h=1}^{q} \lambda_h \, 1_{t-h} \varepsilon_{t-h}^2 \tag{3}$$

where ω is a constant term, σ^2_{t-k} is the previous periods' conditional variance (GARCH term), ε^2_{t-h} denotes news about volatility from previous periods (ARCH term), $1_{t-h} = 1$ is a dummy that takes the value of 1 if $\varepsilon_{t-h} < 0$ and zero otherwise and λ_h is the asymmetry or leverage parameter that captures asymmetric effects. If $\lambda_h > 0$ and is statistically significant, then there is evidence of the leverage effect, implying that negative shocks cause more volatility than positive shocks of the same magnitude. When $\lambda_h = 0$, the volatility model in Eq. (3) collapses to the standard GARCH model. Lastly, z_t is an $i.i.d.$ random variable with zero mean and unit variance that follows a skewed-t density distribution which captures the fat tail and asymmetries in the time series. This distribution is specified as follows:

$$f(z_t, \nu, \eta) = \begin{cases} bc\left(1 + \frac{1}{\nu-2}\left(\frac{bz_t+a}{1-\eta}\right)^2\right)^{-(\nu+1)/2} & z_t < -a/b \\ bc\left(1 + \frac{1}{\nu-2}\left(\frac{bz_t+a}{1+\eta}\right)^2\right)^{-(\nu+1)/2} & z_t \geq -a/b \end{cases} \tag{4}$$

where ν and η are the degrees of freedom parameters ($2 < \nu < \infty$) and the symmetric parameter ($-1 < \eta < 1$), respectively. The constants a, b and c are given by $a = 4\eta c(\frac{\nu-2}{\nu-1})$, $b^2 = 1 + 3\eta^2 - a^2$, and $c = \Gamma(\frac{\nu+1}{2})/\sqrt{\pi(\nu-2)}\Gamma\left(\frac{\nu}{2}\right)$, respectively. If $\eta = 0$ and $\nu \to \infty$, then the skewed-t converges to the standard Gaussian distribution, whereas if $\eta = 0$ and ν is finite, the skewed-t converges to the symmetric Student-t distribution.

The estimation results for the conditional mean equation and the conditional variance equation of the univariate ARMA-TGARCH model for all series are presented in Table 3. The coefficients for the ARCH and GARCH terms are significant at the usual levels for the vast majority of series. Furthermore, there is strong evidence of volatility asymmetry as the asymmetry parameter λ_h is significant for all the series, which validates the appropriateness of the TGARCH process to model the conditional volatility of the series under consideration. The estimates of the asymmetry and degree of freedom parameters for the skewed Student-t distribution are significant for most series, indicating that the error terms are non-normal and are well characterized by a distribution with asymmetries and fat tails.

INSERT TABLE 3 ABOUT HERE

In order to get a first overview of the dynamic interactions between Islamic and conventional stock markets, Figure 2 shows the time path of the pairwise correlation coefficients between the DJIM index and each of the conventional stock market indices for the US, the UK and Japan in a rolling window framework. Rolling return and volatility correlations in Panels A and B of Figure 2, respectively, have been calculated using 200-day rolling windows.[3]

As expected, the rolling pairwise correlations, both in terms of returns and volatility, between the DJIM index and each of the conventional national stock market indices are high and positive over the whole sample, indicating a pronounced positive association between Islamic and conventional stock markets. It is also worth noting that the correlations in volatility are generally higher and exhibit a much more stable behaviour over time than the correlations in returns, which suggests the existence of a particularly strong connection in terms of volatility between Islamic and conventional equity markets. Interestingly, the DJIM index has the highest positive correlation, both in returns and volatility, with the conventional U.S. stock market index, followed by the conventional British and Japanese stock indices. This finding may be attributed to the fact that the U.S. is the country with the largest amount of stocks traded on the DJIM index. In particular, in October 2016 more than 60% of total stocks in the DJIM index were U.S. stocks. The fundamental implication of this preliminary analysis is the huge amount of commonality across the global Islamic stock market and the three conventional national stock markets. This can be seen as a clear indication of significant linkages across Islamic and conventional equity markets and justifies the use of the spillover index approach of Diebold and Yilmaz (2012) in this context.

<center>INSERT FIGURE 2 ABOUT HERE</center>

4. Econometric approach

The return and volatility spillovers are measured in this study using the spillover index approach introduced by Diebold and Yilmaz (2012), which is a generalization of their own work in

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[3] Since our main focus is to study the interrelationships between Islamic and conventional stock markets, only the rolling pairwise correlations between stock markets are displayed in Figure 2. However, the rolling correlation coefficients between the different stock markets and each of the major macro-finance variables are available upon request from the authors.

Diebold and Yilmaz (2009).[4] The spillover index methodology is based on the notion of forecast error variance decomposition in the generalized VAR framework of Koop et al. (1996) and Pesaran and Shin (1998). The main advantage of the generalized VAR approach is that it eliminates any possible dependence of the variance decomposition results on the ordering of the variables, which is not accounted for in the Cholesky factorization used in Diebold and Yilmaz (2009). This approach allows one to identify the portion of the forecast error variance of a variable i which can be attributed to shocks in another variable j $(i \neq j)$ and aggregate these measures in order to construct spillover indices. Hence, the Diebold-Yilmaz methodology provides a simple and intuitive way of measuring spillover effects across a set of variables. In addition, by using rolling window estimation the Diebold-Yilmaz approach captures the evolution of the magnitude and direction of spillover effects over time, thus clarifying if a particular variable is a net transmitter or receiver of spillovers at each point in time.

The starting point of the analysis is the following covariance stationary N-variable VAR(p) specification:

$$y_t = \sum_{i=1}^{p} \Phi_i y_{t-i} + \varepsilon_t \tag{5}$$

where y_t is a vector of endogenous variables composed of the DJIM index, the Dow Jones U.S., UK and Japan stock market indices and the set of major global risk factors considered. Specifically, y_t will be either a vector of returns or a vector of volatilities depending on whether return spillovers or volatility spillovers are examined, respectively. Φ_i denotes a $N \times N$ matrix of parameters to be estimated, $t = 1, \dots, T$ is the time index and $n = 1, \dots, N$ is the variable index. In addition, $\varepsilon_t \sim i.i.d\ (0, \Sigma)$ is a vector of identically and independently distributed errors, with Σ being its covariance matrix.

The stationary VAR(p) system in Eq. (5) can be written in its infinite moving average form as follows:

$$y_t = \sum_{j=0}^{\infty} \Theta_j \varepsilon_{t-i} \tag{6}$$

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[4] The spillover measures proposed by Diebold and Yilmaz (2009) are based on the Cholesky-factor identification of VAR models, and thus the resulting variance decompositions can depend heavily on the particular ordering of the variables in the VAR.

where the $N \times N$ moving average coefficient matrices Θ_j are derived using the following recursion: $\Theta_j = \sum_{t=1}^{p} \Theta_{j-t} \Phi_t$, with Θ_0 being a $N \times N$ identity matrix and $\Theta_j = 0$ for $\forall j < 0$. As indicated by Diebold and Yilmaz (2012), the moving average representation (and transformations such as impulse response functions or variance decompositions) are the key to understanding the dynamics of the system as it allows the computation of variance decompositions. Given this VAR framework, the H-step-ahead forecast error variance decomposition attributable to the different variables under consideration is given by:

$$\theta_{ij}^g(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' \Theta_h \Sigma e_j)^2}{\sum_{h=0}^{H-1}(e_i' \Theta_h \Sigma \Theta_h' e_i)} \tag{7}$$

where Σ denotes the covariance matrix of the vector of errors ε_t, σ_{jj} is the standard deviation of the error term for the jth equation and e_i is a selection vector, with one as the ith element and zero otherwise. This yields a $N \times N$ matrix $\theta(H) = \left[\theta_{ij}(H)\right]_{i,j=1,\dots,N}$, where each entry gives the contribution of variable j to the forecast error variance of variable i. The own-variable and cross-variable contributions are contained in the main diagonal and the off-diagonal elements of the $\theta(H)$ matrix, respectively. In the generalized VAR framework the shocks to each variable are not orthogonalized and, thus, the sum of own- and cross-variable variance contribution shares in each row of the variance decomposition matrix is not equal to one, i.e. $\sum_{j=1}^{N} \theta_{ij}^g(H) \neq 1$. Therefore, each entry of the variance decomposition matrix is normalized by dividing by the row sum as:

$$\tilde{\theta}_{ij}^g(H) = \frac{\theta_{ij}^g(H)}{\sum_{j=1}^{N} \theta_{ij}^g(H)} \tag{8}$$

Note that by construction $\sum_{j=1}^{N} \tilde{\theta}_{ij}^g(H) = 1$ and $\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^g(H) = N$.

As pointed out by Fengler and Gisler (2015), this expression represents approximately the fraction of the H-step-ahead forecast error variance of variable i generated by a shock to variable j.

Using the above normalized variance contributions, we can now construct several spillover measures which capture the degree of interdependence among the variables of the system. The total spillover index measures the average contribution of spillovers from shocks across all variables to the total forecast error variance and is given by:

$$S^g(H) = \frac{\sum_{\substack{i,j=1 \\ i\neq j}}^{N} \tilde{\theta}_{ij}^g(H)}{N} \times 100 \qquad (9)$$

The total spillover index is the sum of all the off-diagonal elements of the generalized variance decomposition relative to the number of variables in the specific VAR system at hand. It summarizes how much of the forecast error variances can be explained by spillovers.

The approach of Diebold and Yilmaz (2012) is quite flexible and also enables the determination of the direction of spillovers, which is crucial in spillover analysis. In this context, the directional spillovers transmitted from market i to all other markets j can be defined as:

$$S_{i\rightarrow j}^g(H) = \frac{\sum_{\substack{i,j=1 \\ i\neq j}}^{N} \tilde{\theta}_{ji}^g(H)}{N} \times 100 \qquad (10)$$

In a similar fashion, the directional spillovers received by market i from all other markets j are given by:

$$S_{j\rightarrow i}^g(H) = \frac{\sum_{\substack{i,j=1 \\ j\neq i}}^{N} \tilde{\theta}_{ij}^g(H)}{N} \times 100 \qquad (11)$$

The directional spillovers allow one to identify the most important drivers of the total spillover index.

From Eqs. (10) and (11) it is straightforward to calculate the net directional spillover index for market i as:

$$S_i^g(H) = S_{i\rightarrow j}^g(H) - S_{j\rightarrow i}^g(H) \qquad (12)$$

This spillover index is the difference between the spillover effects transmitted by market i to all other markets and those received by i from all other markets. Positive values of the net directional spillover index imply that market i is a net transmitter of spillover effects to all other markets, whereas negative values indicate that market i is a net receiver of spillover effects from all other markets.

Finally, it is also interesting to further decompose the directional spillovers into pairwise directional spillovers in order to assess the spillover linkages between two variables. Thus, the net pairwise directional spillovers between markets i and j are simply the difference between the gross spillover effects transmitted from market i to market j and those transmitted from j to i:

$$S_{ij}^g(H) = \left(\frac{\tilde{\theta}_{ji}^g(H) - \tilde{\theta}_{ij}^g(H)}{N}\right) \times 100 \qquad (13)$$

The net pairwise spillovers indicate whether a market i is a net receiver or a net transmitter of information from/to another market j. Positive values of the net pairwise spillover index imply that market i is a net transmitter of spillover effects to market j, whereas negative values imply that market i is a net receiver of spillover effects from market j. In short, the spillover index approach measures the intensity of interdependence among a set of variables and allows a decomposition of spillover effects by source and recipient.

5. Empirical results

This section presents the results of return and volatility spillover analyses based on the spillover index approach of Diebold and Yilmaz (2012) as well as a number of robustness checks. Following Diebold and Yilmaz (2009, 2012), a rolling window approach is applied because it is a simple and effective means to approximate the possibly time-varying spillover mechanisms of financial data. In particular, the spillover indices are estimated using 200-day rolling sample windows and a forecast horizon of $H = 30$ days. At each window, the lag specification p of the VAR model is selected by minimizing the Schwarz information criterion.

5.1. Return spillovers

Figure 3 illustrates the time evolution of the total return spillover index across the global Islamic stock market, the conventional national stock markets for the U.S., the UK and Japan and the four major global risk factors considered. Spillover effects in return have significant values during the full sample, reflecting the presence of strong linkages among Islamic and conventional equities and the selected risk factors. However, two different phases of return spillovers can be identified. The first phase, which spans from the start of the sample period until approximately June 2007, is characterized by fairly stable values, at around 40%, of the total return spillover index. The second phase begins at the end of July 2007, coinciding with the outbreak of the sub-prime crisis in the U.S. mortgage market, and its main distinctive feature is the gradual and steady increase in the level of the total return spillover index. As expected, the bankruptcy of Lehman Brothers in September 2008 had a critical impact on the total return spillover index, which reached a record high of 64.49% on September 29, 2008. From that date until the end of the study period, the spillover return index remained at higher levels than during

the initial part of the sample, suggesting the appearance of a new scenario of increasing interdependence among financial markets in which market participants have become more responsive to economic and financial shocks. Two additional facts are noteworthy in the final part of the period of analysis. First, the total return spillover index reached its all-time high of 71.70% on January 19, 2012. This date corresponds to one of the toughest stages of the European sovereign debt crisis, marked by the rise in sovereign bond yields of several peripheral eurozone countries to historic highs and the downgrading of credit ratings for a number of European countries. Second, the total return spillover index experienced a drop to stand at levels of about 50% between April 2013 and August 2015 as a result of the reduced financial stress driven by the recovery of the global economy and the lower degree of economic uncertainty.

INSERT FIGURE 3 ABOUT HERE

The next step in the empirical analysis is to incorporate directional information in order to identify the main net transmitters and receivers of return spillovers. Figure 4 displays the net directional return spillovers for all variables under consideration. Interestingly, the highest positive values of the net directional return spillovers during the full sample period are found for the DJIM index and the Dow Jones U.S. stock index, implying that the global Islamic equity market and the U.S. conventional equity market are the most relevant transmitters of return spillovers to the other markets and variables over the whole sample. It is worth noting that the return spillovers from Islamic equities tend to be slightly higher than those of conventional U.S. equities over virtually the entire sample. As expected, the magnitude of return spillovers from the global Islamic and the U.S. stock markets reaches its historic high at the end of 2008, during the most acute phase of the global financial crisis. These findings indicate that the Islamic stock universe is not isolated from conventional stock markets, thus strongly rejecting the perception that Islamic equities can provide a cushion against the increasing risk and rising instability in conventional financial markets just because they comply with the *Sharia* principles.

The dominant influence of the U.S. stock index is as one would expect given the leading role of the U.S. stock market in the global financial system.[5] In contrast, the prominent role of the DJIM index as a key net transmitter of return spillovers is a more striking result a priori. A possible

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[5] Similar results emphasizing the dominant role of the U.S. stock market on the rest of international stock markets have been obtained by, among others, Awartani et al. (2013), Masih and Masih (2001) and Sosvilla-Rivero and Rodríguez (2010).

explanation for the similar capacity of the Islamic stock market and the U.S. conventional stock market in terms of transmission of return spillovers relies on the fact that the DJIM index is a sub-portfolio of U.S. stocks. As mentioned earlier, currently more than 60.50% of the universe of Islamic equities are listed on the U.S. stock market. Hence, it is not surprising that the global Islamic market and the U.S. equity market play a similar role in the transmission of spillover effects as they share a large common ground. The VIX index is also identified as a significant transmitter of return spillovers to the other markets and variables for most of the sample period, although to a lesser extent than the global Islamic and U.S. conventional stock indices. This result demonstrates the high influence of the level of uncertainty and investors' risk aversion as measured by the VIX on international financial markets. In turn, the role of the UK conventional stock market as a net transmitter or receiver of return spillovers has changed notably over time. Specifically, the Dow Jones UK stock index appears as a net receiver of return spillovers to the other variables from January 1997 to September 2007 and from April 2013 to May 2015. Instead, it acts as a net transmitter of spillover effects during the global financial crisis period, showing the greater relevance of the UK stock market in times of financial turmoil. Additionally, the net directional return spillovers from the Dow Jones Japan stock index, the U.S. equity market-related uncertainty index, changes in the U.S. 10-year Treasury yield and oil price fluctuations all have negative values over most of the sample period, suggesting that these four variables are net spillover receivers. In particular, the Japanese conventional stock market appears as the most important receiver of return spillovers, reaching its historical highs in November 2008 during the most acute phase of the global financial crisis. In this respect, as argued by Greenwood-Nimmo et al. (2015), the overwhelming dominance of foreign factors on the Japanese equity market may be due to the high degree of economic openness and the heavy export-orientation of the Japanese economy.

INSERT FIGURE 4 ABOUT HERE

Next, we turn our attention to the pairwise directional return spillovers. Figure 5 plots the network diagram of the average pairwise directional return spillovers among all possible pairs formed by the eight variables examined for three sub-periods: pre-crisis (from July 15, 1996 to July 31, 2007), financial crisis (from August 1, 2007 to June 30, 2009) and post-crisis (from July 1, 2009 to June 30, 2016). The most significant result of this pairwise analysis is that the DJIM index, the Dow Jones U.S. stock index and, to a lesser extent, the VIX emerge as the main

transmitters of return spillovers during the different sub-periods, confirming the evidence presented in Figure 4 for the analysis of directional spillovers performed on all variables taken together. In particular, the DJIM index and the Dow Jones U.S. index transmit return spillovers to all other variables during the whole sample period. The pairwise spillover effects are especially high between the DJIM index and the Dow Jones U.S. stock index in the two possible directions, supporting again the rejection of the decoupling hypothesis of Islamic equities from their conventional counterparts. As expected, the number and intensity of pairwise return spillover effects increase from the onset of the global financial crisis in July 2007, reflecting the new scenario of increased interdependence among financial markets. On the contrary, oil price fluctuations, changes in U.S. 10-year Treasury bond yields, the U.S. equity market-related uncertainty index and, particularly, the Dow Jones Japan stock index are the key receivers of return spillovers throughout the sample period.

<div align="center">INSERT FIGURE 5 ABOUT HERE</div>

5.2. Volatility spillovers

This section reports the estimated volatility spillovers across the global Islamic stock market, the conventional stock markets for the U.S., the UK and Japan and the selected major global risk factors. Figure 6 depicts the dynamics of the total volatility spillover index employing 200-day rolling windows and a forecast horizon of 30 days over the examined time period. The total volatility spillover index exhibits a rather similar pattern to that of the total return spillover index, although the magnitude of volatility spillovers is slightly higher than that of return spillovers throughout the sample. As can be seen, the total volatility spillover index moves relatively smoothly in values around 50% during the period prior to the international financial crisis. However, as with the total return spillover index, a general rise in the total volatility spillover index takes place from the onset of the U.S. sub-prime crisis in the summer of 2007, reflecting the higher degree of market linkage caused by the recent global financial crisis. Thus, a record high of nearly 80% is reached in October 2008 during the days following the Lehman Brothers collapse. Another important peak in the total volatility spillover index occurs in May 2010 within the framework of the intensification of the European sovereign debt crisis caused by the announcement of the Greek bailout package financed by the European Union, the European Central Bank and the International Monetary Fund. Two additional peaks in the total volatility

spillover index are located in May 2012 and September 2015, coinciding with two sizeable corrections in the U.S. stock market in a context of strong economic uncertainty.

INSERT FIGURE 6 ABOUT HERE

To examine the direction of volatility spillovers, Figure 7 displays the time evolution of the net directional volatility spillovers for all variables in our model. The directional volatility spillovers follow a similar pattern to that seen in the directional return spillovers, demonstrating the significant interactions among Islamic and conventional equity markets and the key global risk factors. Specifically, the DJIM index, the Dow Jones U.S. stock index and, to a lesser degree, the VIX emerge as the largest sources of volatility spillovers throughout the sample period. Conversely, the Dow Jones UK stock index, the Dow Jones Japan stock index, the U.S. equity market-related uncertainty index, changes in U.S. 10-year Treasury bond yields and crude oil price fluctuations are clearly identified as net receivers of volatility spillovers from all other variables over the whole sample.

INSERT FIGURE 7 ABOUT HERE

Lastly, Figure 8 displays the network diagram of the average pairwise directional volatility spillovers among all possible pairs of variables for the three following sub-periods: pre-crisis (from July 1996 to July 2007), financial crisis (from August 2007 to June 2009) and post-crisis (from July 2009 to June 2016). The DJIM index, the Dow Jones U.S. stock index and the VIX are also identified in this pairwise analysis as the dominant transmitters of volatility spillovers to the other markets and variables during the three sub-periods considered. Again, the pairwise directional volatility spillovers are particularly strong between the DJIM index and the Dow Jones U.S. index in the two possible directions. Moreover, the DJIM index transmits significant volatility spillovers to the Dow Jones UK and Japan stock indices over the whole sample period. These findings corroborate that the global Islamic stock market is not at all segmented from conventional stock markets. It is also shown that the number and intensity of pairwise volatility spillover effects also experience a rise from the beginning of the financial crisis in July 2007. In contrast, the pairwise analysis reveals that oil price fluctuations, changes in U.S. 10-year Treasury bond yields, the U.S. equity market-related uncertainty index and, mainly, the Dow Jones Japan stock index constitute the key receivers of volatility spillovers.

INSERT FIGURE 8 ABOUT HERE

5.3. Robustness tests.

In this section, a number of robustness tests are conducted to ensure the reliability of the empirical results. In a first step, we explore the sensitivity of the spillover index estimates to the choice of the size of the rolling window and the forecast horizon. The findings of these initial robustness checks are reported in Figure 9. Panels A.1 and B.1 of Figure 9 present the total return spillover index and total volatility spillover index estimates for different rolling window sizes, respectively. The 200-day option is the one chosen for the main empirical analysis in this study and which has been already displayed in Figures 3 and 6. As can be seen, the total return and volatility spillover indices estimated using a 100-day or a 300-day window follow a very similar pattern to that of the 200-day window over the entire sample period.

Furthermore, Panels A.2 and B.2 of Figure 9 plot the total return spillover index and total volatility spillover index estimates for four alternative forecast horizons: 10, 20, 30 and 40 days (being H=30 days the forecast horizon considered in our primary empirical analysis). Visual inspection of these graphs reveals that there is virtually no sensitivity of the total return and volatility spillover indices to the forecast horizon. This is a desirable property as it indicates convergence in forecast error variance decompositions as the time horizon increases. To sum up, these robustness checks lead to qualitatively similar results to those obtained in our baseline model described earlier, suggesting that the dynamic behavior of the total return and volatility spillover measures over the full sample period is robust to the choice of alternative window lengths and forecast horizons in the VAR system.

INSERT FIGURE 9 ABOUT HERE

In a second step, we check whether our results are robust to the use of an alternative empirical methodology. In particular, the asymmetric generalized dynamic conditional correlation GARCH (AGDCC-GARCH hereafter) model developed by Cappiello et al. (2006) is employed to that end. The AGDCC-GARCH specification generalizes and improves substantially the DCC-GARCH process of Engle (2002) by accounting for asymmetries in the conditional correlation structure that are not considered in the DCC-GARCH framework. Thus, the AGDCC-GARCH model takes into account not only the time-varying correlation between asset returns, but also the asymmetric response of correlation to positive and negative shocks. The estimation process of the AGDCC specification comprises two phases. In the first phase, univariate GARCH models

are fitted for each series. In the second phase, the conditional correlation dynamics incorporating asymmetric effects is estimated.

The bivariate AGDCC-GARCH model estimated in the framework of the present study can be formulated as follows:

$$r_t | I_{t-1} \sim N(0, H_t) \tag{14}$$

$$H_t = D_t R_t D_t \tag{15}$$

$$\varepsilon_t = H_t^{1/2} z_t \tag{16}$$

$$R_t = \left[diag(Q_t)^{-1/2} \right] Q_t \left[diag(Q_t)^{-1/2} \right] \tag{17}$$

where $r_t = [r_{1t}, r_{2t}]'$ is a 2x1 vector of returns including the global Islamic stock market returns (r_{1t}) and one of the conventional national stock market returns (r_{2t}), H_t denotes the conditional covariance matrix of r_t, D_t is the diagonal matrix containing the conditional standard deviations from univariate GARCH models and R_t represents the time-varying conditional correlation matrix. Moreover, $\varepsilon_t = [\varepsilon_{1t}, \varepsilon_{2t}]'$ is a 2x1 vector of residuals conditional on the information set at time *t-1*, z_t denotes a 2x1 *i.i.d.* vector of standardized residuals and Q_t is the conditional correlation matrix of standardized residuals. [6]

Following Cappiello et al. (2006), in the setting of the AGDCC-GARCH model the elements of H_t are derived from the asymmetric univariate GARCH (1,1) model (GJR-GARCH) of Glosten et al. (1993) as follows:

$$h_{i,t} = \omega_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1} + d_i \varepsilon_{i,t-1}^2 I(\varepsilon_{i,t-1}) \tag{18}$$

where $h_{i,t}$ is the conditional variance of the return series, ω_i is a constant term, α_i captures the ARCH effect, β_i measures the persistence of the volatility process and d_i is the asymmetric GARCH term. In order to ensure positive and stable conditional variances, the parameters must satisfy the constraints $\alpha_i > 0$ and $\alpha_i + \beta_i < 1$. As noted by Kenourgios (2014), once this univariate volatility specification is estimated, the standardized residuals z_t are utilized to estimate the conditional correlation parameters.

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[6] For more details on the application of the AGDCC-GARCH model to characterize stock return correlation dynamics see, for example, Kenourgios (2014).

In the above equation, the indicator function, i.e. $I(\varepsilon_{i,t-1})$, is equal to one if $\varepsilon_{i,t-1} < 0$, and 0 otherwise. A positive value for d_i implies that the negative shocks tend to increase the conditional variance more than the positive ones. Thus, the AGDCC-GARCH model allows capturing an often observed characteristic of financial assets, according to which unexpected drops in asset prices tend to rise volatility more than unexpected increases in asset prices of the same magnitude. In other words, this phenomenon means that bad news increase volatility more than good news.

In addition, the dynamics of Q in the AGDCC-GARCH model is given by:

$$Q_t = (1 - \theta_1 - \theta_2)\bar{Q} - \phi\bar{N} + \theta_1(z_{t-1}z'_{t-1}) + \theta_2 Q_{t-1} + \phi(\eta_{t-1}\eta'_{t-1}) \tag{19}$$

where θ_1, θ_2 and ϕ are parameter matrices, $\eta_t = I(z_t < 0) \circ z_t$ is an indicator function that takes the value of one if the argument is true and zero otherwise, and " $\circ$ " indicates the Hadamard product, $\bar{Q}_j = E[z_t, z'_t]$ and $\bar{N}_j = E[\eta_t, \eta'_t]$ are the unconditional correlation matrices of z_t and η_t, respectively. It is worth mentioning that ϕ represents the parameter of correlation asymmetry. Setting $\phi = 0$ reduces the AGDCC-GARCH to the standard DCC-GARCH model, which ignores correlation asymmetry.

Lastly, in the setting provided by the AGDCC-GARCH model, the time-varying correlation matrix is given by:

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1} \tag{20}$$

where Q_t^* is a diagonal matrix with a square root of the i*th* diagonal of Q_t on its i*th* diagonal position.

Figure 10 depicts the time-varying conditional correlation estimates from the bivariate AGDCC-GARCH model between the returns of the global Islamic stock index and the returns of each of the three conventional national stock indices. As can be seen, the dynamic conditional correlations between the returns of the DJIM index and the returns of the conventional stock indices take positive values throughout the sample period, except for some isolated cases when considering the Japanese stock index. Furthermore, it should be noted that the conditional correlations between the DJIM index and the conventional U.S. and UK stock indices remain at very high positive levels during the entire sample period, especially in the U.S. case. This high

and relatively stable positive conditional correlation confirms the existence of a strong connection between the global Islamic equity market and the conventional equity markets of the major developed countries. This finding is fully consistent with the results previously presented in this paper and reinforces the view that compliance with *Sharia* is not enough to isolate the Islamic equity universe from the vicissitudes of conventional stock markets. Therefore, the evidence of the dynamic correlation analysis using the AGDCC-GARCH specification also supports the rejection of the decoupling hypothesis of the global Islamic stock market from its mainstream counterparts.

INSERT FIGURE 10 ABOUT HERE

5.4. Discussion of results

Overall, the dynamics of both return and volatility spillovers reveal significant interactions both in return and volatility among the global Islamic stock market, the conventional national stock markets for the U.S., the UK and Japan, and a number of major macro-finance risk factors. It should also be highlighted that for the different spillover index measures used in this study the magnitude of volatility spillovers is generally higher than that of return spillovers. This implies that information transmission across Islamic and conventional stock markets and the selected risk factors through volatility is more intense than through returns. Furthermore, spillover effects have risen since the onset of the global financial crisis, suggesting an increasing degree of integration between the global Islamic stock market and its mainstream counterparts.

The high degree of association observed among the global Islamic stock market, the conventional national stock markets and the selected global risk factors, coupled with the fact that the global Islamic stock market and the U.S. conventional stock market are the principal transmitters of spillovers to other markets and variables, show unequivocally that the Islamic equity universe is not at all isolated from the mainstream equity markets. On the contrary, our analysis in a multivariate setting demonstrates that Islamic stocks are exposed to adverse shocks affecting the world financial system as well as to contagion risk during financial crises in the same manner as the conventional stock markets are. Thus, this evidence is opposed to the

popular perception that Islamic equity investments offer important diversification benefits and can act as a good cushion against risk and instability in conventional stock markets, particularly during episodes of financial stress. Hence, it seems clear that full compliance with *Sharia* rules is not restrictive enough to render global Islamic equity indices significantly different from the dynamics of conventional equity markets. Therefore, our findings can be interpreted as sound evidence against the empirical validity of the decoupling hypothesis of the Islamic global stock market from its mainstream counterparts. In addition, it is worth mentioning that the results of our study, in favour of the rejection of the decoupling hypothesis, are consistent with those from several recent contributions, such as Ajmi et al. (2014), Dewandaru et al. (2015), Hammoudeh et al. (2014) and Nazlioglu et al. (2015), based on the application of a variety of methodological approaches on different countries and sectors.

6. Concluding remarks.

The vertiginous growth of the Islamic finance industry over the last decade, together with its still enormous growth potential and its apparently greater resilience during the global financial crisis of 2007-2009, have generated a surge of interest to know whether the Islamic financial system reacts differently than conventional financial markets to major economic and financial shocks, especially in times of financial turbulence. This paper examines the return and volatility transmission among the global Islamic stock market, the conventional national stock markets for the U.S., the UK and Japan and a number of influential macroeconomic and financial variables, such as the VIX index, the U.S. equity market-related uncertainty index, changes in the U.S. 10-year Treasury bond yield and oil price fluctuations. To this end, the VAR-based spillover index approach developed by Diebold and Yilmaz (2012) is applied using daily data over the period from July 1996 to June 2016. The Diebold-Yilmaz methodology provides an ideal setting for measuring the magnitude and direction of return and volatility spillovers across Islamic and conventional stock markets and several key global risk factors in a time-varying environment, allowing us to shed additional light on the validity of the decoupling hypothesis of Islamic equities from their conventional counterparts.

Our empirical results show a significant transmission of risk in terms of return and volatility across Islamic and conventional stock markets and the selected major risk factors throughout the

sample period. Interestingly, increased spillover effects are observed from the beginning of the financial turmoil in the summer of 2007, possibly reflecting the general re-pricing of risk in financial markets arising from the recent global financial crisis. These findings suggest that the global Islamic equity market and its mainstream counterparts are closely linked and react in a similar way to economic and financial shocks hitting the world financial system. Therefore, based on this evidence, the decoupling hypothesis of the global Islamic equity market from the conventional financial system can be rejected, implying that the Islamic equity universe does not act as a hedge or a safe haven for investors, particularly during episodes of financial stress.

The outcome that the Islamic stock market is not immune to risks affecting conventional financial markets may have important implications for various market participants. For example, faith-based investors and portfolio managers cannot benefit from large portfolio diversification benefits associated with investing in Islamic equities, and hence they should include other classes of assets in their portfolios to minimize risk. For their part, policy makers should be aware of the high risk of contagion to the Islamic stock universe in times of turbulence or financial crisis and the need to implement policies aimed at fostering international financial stability. Finally, Islamic finance regulators should address the possibility of developing hedging instruments, such as Islamic financial derivatives, that hedge investors in Islamic equities against the risks and uncertainties affecting the conventional financial system. In addition, since the *Sharia* screening criteria have failed to reduce the risk exposure of Islamic stocks, it would be interesting to reflect on the desirability of reducing restrictions on investment, particularly on the required financial ratios, in order to make Islamic equity investments as competitive as their mainstream counterparts. However, it must be recognized that the implementation of these practices would be subject to much controversy because both of them violate the *Sharia* principles on which Islamic   finance   is   based.

References

Abbes, M.B. (2012). Risk and return of Islamic and conventional indices. *International Journal of Euro-Mediterranean Studies*, 5, 1-23.

Ajmi, A.N., Hammoudeh, S., Nguyen, D.K. and Sarafrazi, S. (2014). How strong are the causal relationships between Islamic stock markets and conventional financial systems? Evidence from linear and nonlinear tests. *Journal of International Financial Markets, Institutions & Money*, 28, 213-227.

Al-Khazali, O., Lean, H.H. and Samet, A. (2014). Do Islamic stock indexes outperform conventional stock indexes? A stochastic dominance approach. *Pacific-Basin Finance Journal*, 28, 29-46.

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

Aloui, C., Hkiri, B., Lau, C.K.M. and Yarovaya, L. (2016). Investors' sentiment and US Islamic and conventional indexes nexus: A time-frequency analysis. *Finance Research Letters*, 19, 54-59.

Ashraf, D. and Mohammad, N. (2014). Matching perception with the reality - Performance of Islamic equity investments. *Pacific-Basin Finance Journal*, 28, 175-189.

Awartani, B., Maghyereh, A.I. and Al Shiab, M. (2013). Directional spillovers from the U.S. and the Saudi market to equities in the Gulf Cooperation Council countries. *Journal of International Financial Markets, Institutions and Money*, 27, 224-242.

Baker, S. R., Bloom, N. and Davis, S.J. (2012). Measuring economic policy uncertainty. Available at www.policyuncertainty.com.

Balli, F., Balli, H.O., Louis, R.J. and Vo, T.K. (2015). The transmission of market shocks and bilateral linkages. *International Review of Financial Analysis*, 42, 349-357.

Bashir, B.A. (1983). Portfolio management of Islamic banks: certainty model. *Journal of Banking and Finance*, 7, 339-354.

Barth, J.R., Li, T., Lu, W., Phumiwasana, T. and Yago, G. (2009). *The Rise and Fall of the U.S. Mortgage and Credit Markets: A Comprehensive Analysis of the Meltdown*. New Jersey: John Wiley & Sons, Inc.

Ben Nasr, A., Lux, T., Ajmi, A.N. and Gupta, R. (2016). Forecasting the volatility of the Dow Jones Islamic stock market index: Long memory vs. regime switching. *International Review of Economics and Finance*, 45, 559-571.

Cappiello, L., Engle, R. and Sheppard, K. (2006). Asymmetric dynamics in the correlations of global equity bond and returns. *Journal of Financial Econometrics*, 4, 537-572.

Choudhry, T., Hassan, S.S. and Shabi, S. (2015). Relationship between gold and stock markets during the global financial crisis: Evidence from nonlinear causality tests. *International Review of Financial Analysis*, 41, 247-256.

Dania, A. and Malhotra, D.K. (2013). An empirical examination of the dynamic linkages of faith-based socially responsible investing. *Journal of Wealth Management*, 16, 65-79.

Dewandaru, G., Bach, O.I., Masih, A.M.M. and Masih, R. (2015). Risk-return characteristics of Islamic equity indices: Multi-timescales analysis. *Journal of Multinational Financial Management*, 29, 115-138.

Dewandaru, G., Rizvi, S.A.R., Masih, R., Masih, M. and Alhabshi, S.O. (2014). Stock market co-movements: Islamic versus conventional equity indices with multi-timescales analysis. *Economic Systems*, 38, 553-571.

Diebold, F.X. and Yilmaz, K. (2009). Measuring financial asset return and volatility spillovers, with application to global equity markets. *Economic Journal*, 119, 158-171.

Diebold, F.X. and Yilmaz, K. (2012). Better to give than to receive: Predictive directional measurement of volatility spillovers. *International Journal of Forecasting*, 28, 57-66.

Enders, W. and Lee, J. (2012). The flexible Fourier form and Dickey–Fuller type unit root tests. *Economics Letters*, 117(1), 196-199.

Engle, R.F. (2002). Dynamic conditional correlation-A simple class of multivariate GARCH models. *Journal of Business and Economic Statistics*, 20, 339-350.

Fengler, M.R. and Gisler, K.I.M. (2015). A variance spillover analysis without covariances: What do we miss? *Journal of International Money and Finance*, 51, 174-195.

Ferrer, R., Bolós, V. and Benítez, R. (2016). Interest rate changes and stock returns: A European multi-country study with wavelets. *International Review of Economics and Finance*, 44, 1-12.

Girard, E.C. and Hassan, M.K. (2008). Is there a cost to faith-based investing: Evidence from FTSE Islamic indices. *Journal of Investing*, 17, 112-121.

Glosten, L.R., Jagannathan, R. and Runkle, D.E. (1993). On the relation between the expected value and the volatility of the nominal excess return on stocks. *Journal of Finance*, 48, 1779-1801.

Greenwood-Nimmo, M., Nguyen, V.H. and Shin, Y. (2015). Measuring the connectedness of the global economy. *Melbourne Institute Working Paper*.

Hafner, C.M. and Herwartz, H. (2006). Testing for linear vector autoregressive dynamics under multivariate generalized autoregressive heteroscedasticity. *Statistica Neerlandica*, 63, 294-323.

Hammoudeh, S., Mensi, W., Reboredo, J.C. and Nguyen, D.K. (2014). Dynamic dependence of global Islamic stock index with global conventional indexes and risk factors. *Pacific-Basin Finance Journal*, 30, 189-206.

Ho, C.S.F., Rahman, N.A.A., Yusuf, N.H.M. and Zamzamin, Z. (2014). Performance of global Islamic versus conventional share indices: International evidence. *Pacific-Basin Finance Journal*, 28, 110-121.

Hussein, A.K. (2004). Ethical investment: Empirical evidence from FTSE Islamic index. *Islamic Economic Studies*, 12, 21-40.

Hussein, A.K. and Omran, M. (2005). Ethical investment revisited: Evidence from Dow Jones Islamic indexes. *Journal of Investing*, 14, 105-124.

Ibrahim, M.H. (2015). Issues in Islamic banking and finance: Islamic banks, Shari'ah-compliant investment and sukuk. *Pacific-Basin Finance Journal*, 34, 185-191.

Islamic Financial Services Industry Stability Report 2015 (2015). Islamic Financial Services Board (IFSB), May 2015.

Jawadi, F., Jawadi, N. and Louchichi, W. (2014). Conventional and Islamic stock price performance: An empirical investigation. *International Economics*, 137, 73-87.

Jones, C.M and Kaul, G. (1996). Oil and the stock markets. *Journal of Finance*, 51, 463-491.

Karanasos, M., Yfanti, S. and Karoglou, M. (2016). Multivariate FIAPARCH modelling of financial markets with dynamic correlations in times of crisis. *International Review of Financial Analysis*, 45, 332-349.

Karsten, I. (1982). Islam and financial intermediation. *IMF Staff Papers*, 29, 108-142.

Kenourgios, D. (2014). On financial contagion and implied market volatility. *International Review of Financial Analysis*, 34, 21-30.

Kenourgios, D., Naifar, N. and Dimitriou, D. (2016). Islamic financial markets and global crises Contagion or decoupling? *Economic Modelling*, 57, 36-46.

Koop, G., Pesaran, M.H. and Potter, S.M. (1996). Impulse response analysis in nonlinear multivariate models. *Journal of Econometrics*, 74, 119-147.

Majdoub, J. and Mansour, W. (2014). Islamic equity market integration and volatility spillover between emerging and US stock markets. *North American Journal of Economics and Finance*, 29, 452-470.

Maghyereh, A.I. and Awartani, B. (2016). Dynamic transmissions between Sukuk and bond markets. *Research in International Business and Finance*, 38, 246-261.

Masih, M., Kamil, N.K.M. and Bacha, O.I. (2016). Issues in Islamic equities: A literature survey. *Emerging Markets Finance and Trade*, DOI: 10.1080/1540496X.2016.1234370.

Masih, R. and Masih, A.M. (2001). Dynamic linkages and the propagation of stock market fluctuations driving major international stock markets: an analysis of the pre- and post-crash eras. *Quarterly Review of Economics and Finance*, 37, 859-885.

Mensi, W., Hammoudeh, S., Sensoy, A. and Yoon, S.M. (2016). Analysing dynamic linkages and hedging strategies between Islamic and conventional sector equity indexes. *Applied Economics*, DOI: 10.1080/00036846.2016.1240349.

Miller and Ratti, (2009). Crude oil and stock markets: stability, instability, and bubbles. *Energy Economics*, 31, 559-568.

Naifar, N. (2016). Do global risk factors and macroeconomic conditions affect global Islamic index dynamics? A quantile regression approach. *The Quarterly Review of Economics and Finance*, 61, 29-39.

Naifar, N., Hammoudeh, S. and Al dohaiman, M.S. (2016). Dependence structure between sukuk (Islamic bonds) and stock market conditions: An empirical analysis with Archimedean copulas. *Journal of International Financial Markets, Institutions and Money*, 44, 148-165.

Nazlioglu, S., Hammoudeh, S. and Gupta, R. (2015). Volatility transmission between Islamic and conventional equity markets: evidence from causality-in-variance test. *Applied Economics*, 47, 4996-5011.

Pesaran, H.H. and Shin, Y. (1998). Generalized impulse response analysis in linear multivariate models. *Economics Letters*, 58, 17-29.

Rizvi, S.A.R. and Arshad, S. (2014). An empirical study of Islamic equity as a better alternative during crisis using multivariate GARCH DCC. *Islamic Economic Studies*, 22, 159-184.

Rizvi, S.A.R., Arshad, S. and Alam, N. (2015). Crises and contagion in Asia Pacific-Islamic v/s conventional markets. *Pacific-Basin Finance Journal*, 34, 315-326.

Sadorsky, P. (1999). Oil price shocks and stock market activity. *Energy Economics*, 21, 449-469.

Shamsuddin, A. (2014). Are Dow Jones Islamic equity indices exposed to interest rate risk? *Economic Modelling*, 39, 273-281.

Sosvilla-Rivero, S. and Rodríguez, P.N. (2010). Linkages in international stock markets: Evidence from a classification procedure. *Applied Economics*, 42, 2081-2089.

Tsai, I.-C. (2014). Spillover of fear: Evidence from the stock markets of five developed countries. *International Review of Financial Analysis*, 33, 281-288.

Yarovaya, L., Brzeszczynski, J. and Lau, C.K.M. (2016). Intra- and inter-regional return and volatility spillovers across emerging and developed markets: Evidence from stock indices and stock index futures. *International Review of Financial Analysis*, 43, 96-114.

Yilmaz, M.K., Sensoy, A., Ozturk, K. and Hacihasanoglu, E. (2015). Cross-sectoral interactions in Islamic equity markets. *Pacific-Basin Finance Journal*, 32, 1-20.

Zakoian, J.M. (1994). Threshold heteroskedastic models. *Journal of Economic Dynamics and Control*, 18, 931-944.

Table

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Table 1. Descriptive statistics for stock returns and major global risk factors

	DJIM	DJ US	DJ UK	DJ Japan	VIX	Uncert. Index	10-yr Treas.	WTI oil
Panel A: Full Sample								
Mean	0.00022	0.00024	0.00008	-0.00001	2.9826	3.5794	-0.00107	0.00010
Std. Dev.	0.01060	0.01241	0.01397	0.01443	0.3468	1.0769	0.05917	0.02502
Maximum	0.09775	0.10774	0.12186	0.11692	4.3927	7.5018	0.35190	0.16413
Minimum	-0.08185	-0.09634	-0.10597	-0.09286	2.2915	1.5686	-0.47020	-0.17091
Skewness	-0.34987	-0.29360	-0.16355	-0.04329	0.5230	0.4077	0.07289	-0.11228
Kurtosis	9.34930	10.26341	10.74243	7.10813	3.3301	2.6667	5.15215	7.43142
J-B	8544.8***	11120.4***	12575.9***	3535.8***	251.92***	162.469***	974.42***	4122.9***
Q(12)	124.80***	53.912***	76.085***	31.508***	2012.76***	1896.39***	20.824*	28.357***
Q^2(12)	4875.2***	4769.2***	3713.2***	1371.8***	5152.13***	2102.15***	531.91***	1235.2***
ARCH(12)	1356.3***	1659.8***	1409.2***	912.16***	923.515***	402.194***	810.15***	820.78***
Panel B: Pre-crisis (15 July 1996 to 31 July 2007)								
Mean	0.00032	0.00030	0.00030	0.00003	2.973422	3.755588	-0.00076	0.00036
Std. Dev.	0.00977	0.01101	0.01171	0.01413	0.3257	1.084615	0.05635	0.02451
No. of Obs.	2780	2780	2780	2780	2780	2780	2780	2780
Panel C: Global financial crisis (1 August 2007 to 30 June 2009)								
Mean	-0.00074	-0.00092	-0.00124	-0.00083	3.391474	3.862501	-0.00260	-0.00024
Std. Dev.	0.01787	0.02257	0.02529	0.02117	0.378182	1.044542	0.08595	0.03685
No. of Obs.	483	483	483	483	483	483	483	483
Panel D: Post-crisis (1 July 2009 to 30 June 2016)								
Mean	0.00032	0.00047	0.00011	0.00013	2.885091	3.224219	-0.00115	-0.00021
Std. Dev.	0.00907	0.01040	0.01285	0.01249	0.284575	0.977471	0.05437	0.02159
No. of Obs.	1763	1763	1763	1763	1763	1763	1763	1763

</div>

Note: This table reports descriptive statistics and unit root tests for the daily data series. DJIM denotes the return of the Dow Jones Islamic market index, while DJ US, DJ UK and DJ Japan are the returns of conventional stock indices of the US, the UK and Japan, respectively. In turn, VIX, Uncert. Index, 10-year Treas. and WTI oil represent the VIX, the US equity-market related uncertainty index, the changes in the US 10-year Treasury bond yield and the changes in the WTI oil price, respectively. The results are shown for the whole sample period (July 1996 to June 2016) and for three sub-periods: Pre-crisis (January 1996 to July 2007), Financial crisis (August 2007 to June 2009) and Post-crisis (July 2009 to June 2016). J-B is the statistic of the Jarque-Bera test for normality. ADF and PP denote the empirical statistics of the Augmented Dickey-Fuller and Phillips-Perron unit root tests, respectively. Q(12) and Q^2(12) refer to the Ljung-Box Q-test statistics for autocorrelation in the residuals and squared residuals, respectively, computed with 12 lags. In addition, ARCH (12) represents the Engle's LM test for ARCH effects computed using 12 lags. As usual, the asterisks ***, ** and * indicate statistical significance at 1%, 5% and 10% level, respectively.

Table 2. Results of the standard ADF and PP unit root tests and the nonlinear FADF test

	Standard unit root tests		Nonlinear FADF unit root test					
	ADF	PP	$\tilde{k}$	SSR	$\tilde{l}$	AIC	F($\tilde{k}$)	τ_{DF}
DJIM	-50.121***	-61.892***	2	0.5510	10	-6.2762	1.0067	-33.163***
DJ US	-53.781***	-74.901***	1	0.7657	6	-5.9456	1.1361	-29.301***
DJ UK	-45.332***	-73.117***	2	0.9683	13	-5.7111	0.7484	-29.282***
DJ Japan	-74.960***	-75.563***	2	1.0389	13	-5.6407	0.8554	-28.911***
VIX	-4.8145***	-5.5545***	2	3.8811	16	-4.3221	0.3508	-32.061***
Uncert. Index	-9.2858***	-73.654***	2	6.8902	15	-0.8723	0.0403	-41.507***
10-yr Treas.	-70.028***	-70.080***	2	1.5617	7	-2.8160	0.2038	-51.823***
WTI oil	-72.099***	-72.248***	2	3.1237	2	-4.5394	1.1839	-28.890***

Notes: This table presents the results of standard ADF and PP unit root tests and the nonlinear Fourier ADF (FADF) unit root test for each variable. ADF and PP denote the statistics of the conventional Augmented Dickey-Fuller and Phillips-Perron unit root tests, respectively. The optimal frequency ($\tilde{k}$) in the FADF test is selected by using the data-driven grid-search method suggested by Enders and Lee (2012), which minimizes the Sum of Squared Residual (SSR) from Equation (1). In turn, the optimal lag length ($\tilde{l}$) is chosen by minimizing the Akaike Information Criterion (AIC). F($\tilde{k}$) represents the *F*-statistic used to test the existence of a nonlinear trend in the data generating process, while τ_{DF} is the statistic of the FADF unit root test which tests the null hypothesis of a unit root. The critical values for the F-statistics and τ_{DF} statistics are taken from Table 1b in Enders and Lee. (2012). The data generating process of all the variables includes an intercept. As usual, *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Table 3. Parameter estimates of the univariate ARMA-TGARCH model with skewed-*t* distribution

	DJIM	DJ US	DJ UK	DJ Japan	VIX	Uncert. Index	10-yr Treas.	WTI oil
Mean Equation								
$\emptyset_0$	0.0003**	0.0002*	0.0002	0.0000	-0.0001	-0.0003	-0.0012*	0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0006)	(0.0008)	(0.0003)
$\emptyset_1$	-0.1190	0.3956	0.7299***	0.5786**	0.6821***	0.1940***	-0.4766**	0.0496
	(0.0808)	(0.3704)	(0.0560)	(0.2589)	(0.0376)	(0.0181)	(0.2166)	(0.3035)
θ_1	0.2640***	-0.4281	-0.7666***	-0.6269**	-0.8024***	-0.9113***	0.4919**	-0.0745
	(0.0791)	(0.3821)	(0.0535)	(0.2496)	(0.0342)	(0.0093)	(0.2075)	(0.3082)
Variance Equation								
ω	0.0144***	0.0187***	0.0243***	0.0486***	0.4193***	0.0637**	0.2066***	0.0327***
	(0.0030)	(0.0036)	(0.0053)	(0.0109)	(0.0837)	(0.0260)	(0.0749)	(0.0119)
α_1	-0.0056	-0.0227***	0.0164**	0.0377***	0.1382***	0.1379***	0.0298***	0.0265***
	(0.0065)	(0.0070)	(0.0081)	(0.0078)	(0.0206)	(0.0325)	(0.0066)	(0.0076)
β_1	0.9152***	0.9167***	0.9086***	0.8987***	0.8642***	0.4371**	0.9585***	0.9488***
	(0.0107)	(0.0101)	(0.0116)	(0.0125)	(0.0206)	(0.2036)	(0.0065)	(0.0081)
λ_h	0.1483***	0.1797***	0.1190***	0.0795***	-0.1318***	-0.1002***	0.0124*	0.0396***
	(0.0189)	(0.0234)	(0.0177)	(0.0160)	(0.0228)	(0.0387)	(0.0075)	(0.0100)
Asymmetry	-0.1111***	-0.1578***	-0.1049***	-0.0514**	0.2395***	0.1941***	0.0454**	-0.0640***
	(0.0195)	(0.0189)	(0.0197)	(0.0200)	(0.0197)	(0.0224)	(0.0213)	(0.0199)
Tail	10.2960***	10.3369***	12.3178***	10.3652***	7.2133***	36.2063	9.6013***	6.8530***
	(1.5200)	(1.5405)	(2.0449)	(1.4555)	(0.7035)	(26.4240)	(1.1261)	(0.6516)
LL	16782.68	16111.97	15371.31	14664.62	11423.5	-2016.44	7413.43	12086.48

Note: The table presents the results of the estimation of univariate skewed-*t* TGARCH models for the different time series under examination. Standard errors are in parentheses. The parameters of the TGARCH model have been estimated using the Maximum Likelihood method and LL denotes the value of the log-likelihood function. The asymmetric coefficient λ_h captures the impact of negative vs. positive shocks on volatility. The number of lags in the conditional mean and variance equations has been selected according to the Akaike information criterion. As usual, ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.
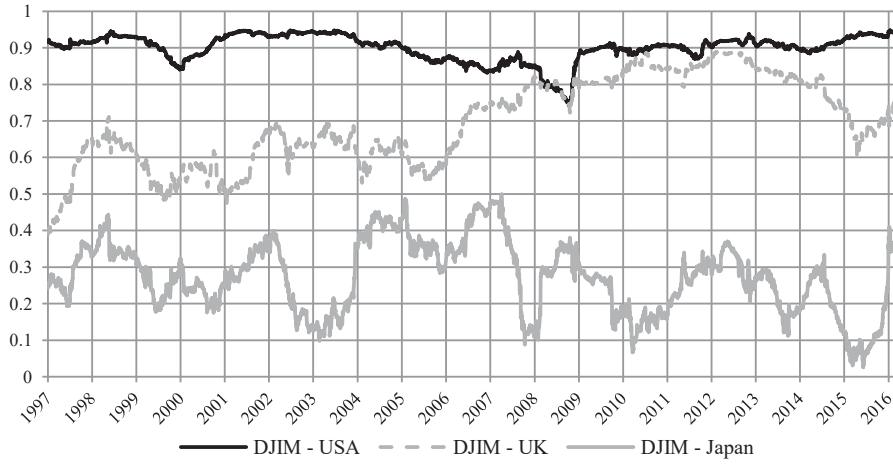
Figure

Figure 1. **Daily time evolution of the Islamic and conventional equity markets and the global risk factors**

Note: This table shows the time evolution of the daily data series during the sample period. DJIM denotes the Dow Jones Islamic market index, while Dow Jones US, Dow Jones UK and Dow Jones Japan are the conventional stock indices for the US, the UK and Japan, respectively. In turn, VIX, Uncertainty Index, US 10-year Treasury bond yield and WTI oil represent the VIX, the US equity-market related uncertainty index, the US 10-year Treasury bond yield and the WTI crude oil price, respectively.

Figure 2. Unconditional rolling correlation coefficients

Panel A. Return rolling correlation

Panel B. Volatility rolling correlation
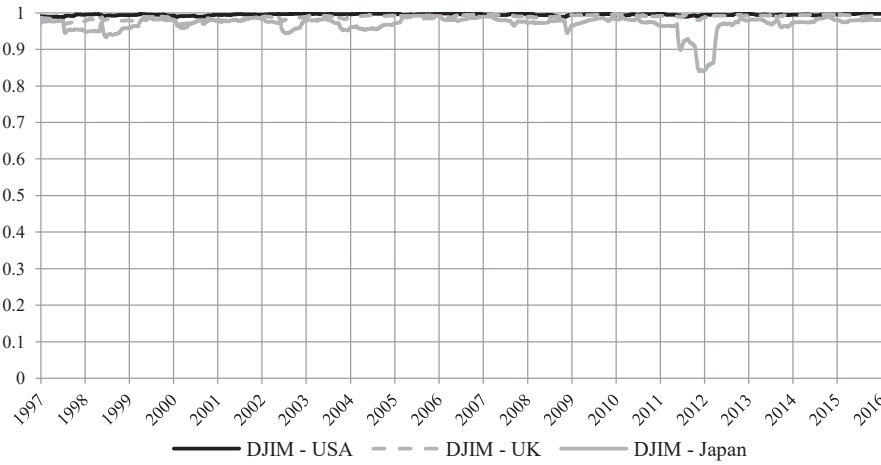
Note: This figure shows the pairwise unconditional rolling correlation over the full sample period between the DJIM index and the conventional Dow Jones stock indices for the US, the UK and Japan. Panel A shows the pairwise rolling correlation in terms of returns while Panel B presents the same information in terms of volatilities. This correlation starts on 22 April 1997 since a 200-day rolling window is used to obtain its evolution over time.

Figure 3. **Total return spillover index**

This figure displays the time-varying behaviour of the total return spillover index across the DJIM, Dow Jones US, Dow Jones UK and Dow Jones Japan stock market indices and the set of major global risk factors considered (VIX index, US equity market-related uncertainty index, changes in 10-year Treasury yield and oil price fluctuations). The total return spillover index shows on average the percentage of the forecast error variance in all the return series that comes from spillovers. This index starts on 22 April 1997 since a 200-day rolling window is used to obtain its evolution over time.
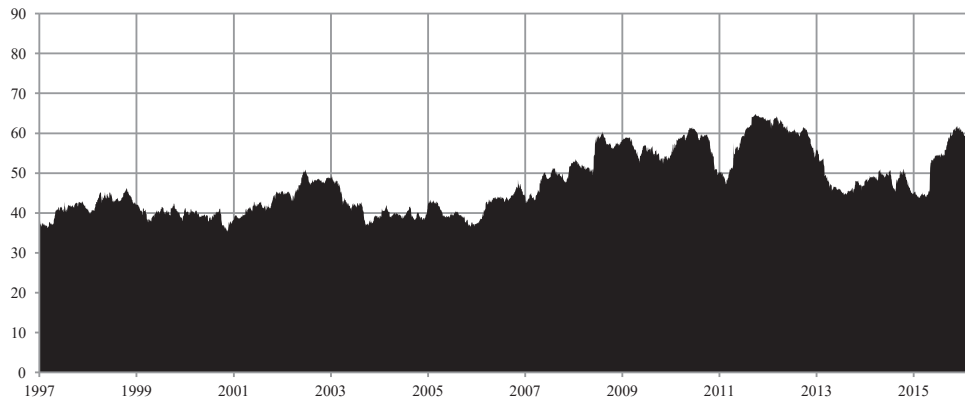
Figure 4. Net directional return spillover indices

This figure shows the time-varying behaviour of the net directional return spillover index across the DJIM, Dow Jones US, Dow Jones UK and Dow Jones Japan stock indices and the set of major global risk factors considered (VIX index, US equity market-related uncertainty index, changes in 10-year Treasury yield and oil price fluctuations). The net directional return spillover index measures the spillover transmitted by each return variable to all other returns. Positive (negative) values indicate that the corresponding variable is in net terms a transmitter (receiver) of return spillover effects to all others. This index starts on 22 April 1997 since a 200-day rolling window is used to obtain its evolution over time.

Panel A: DJIM
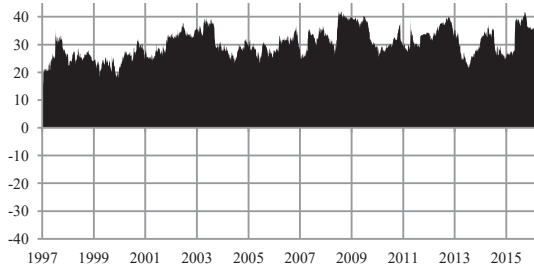
Panel B: DJ US
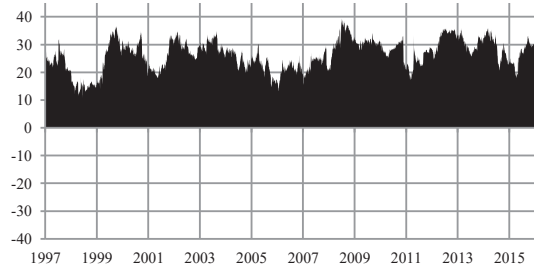
Panel C: DJ UK
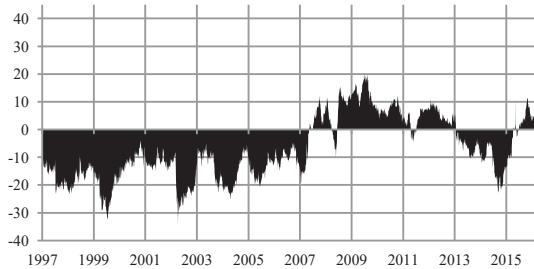
Panel D: DJ Japan
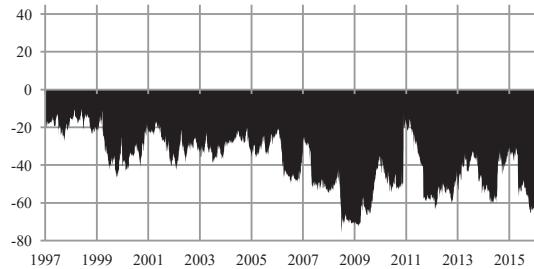
Panel E: VIX
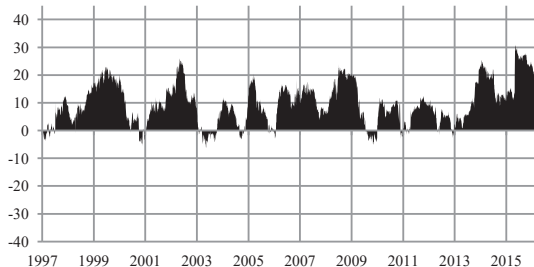
Panel F: Uncert. Index
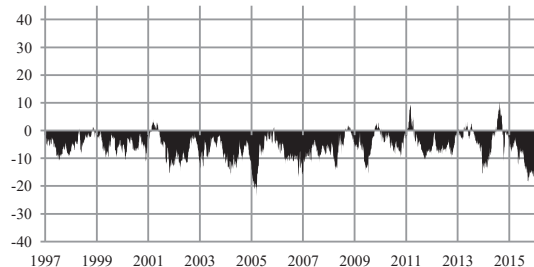
Panel G: Treasury bond yields
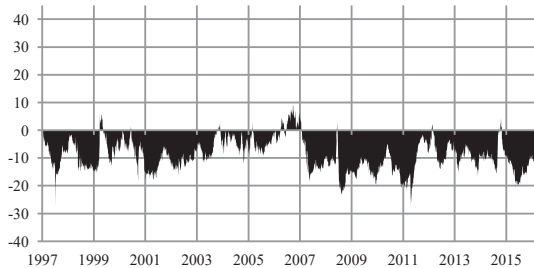
Panel H: WTI Oil
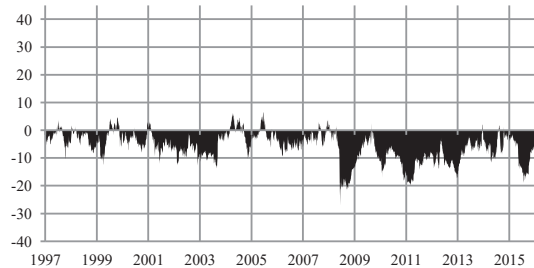
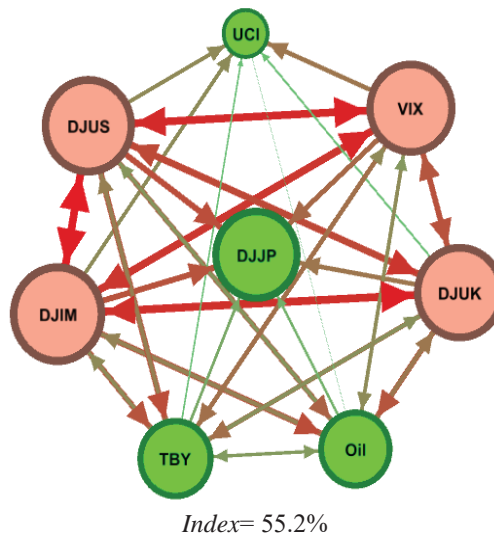**Figure 5. Network diagram of pairwise directional return spillovers**

a). Pre-crisis

Index= 35.3%
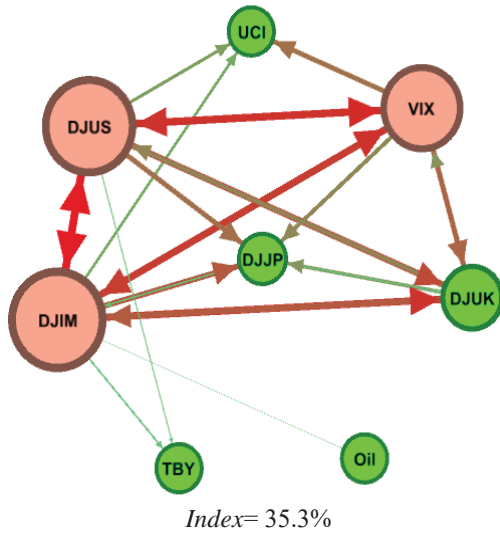
b). Financial Crisis
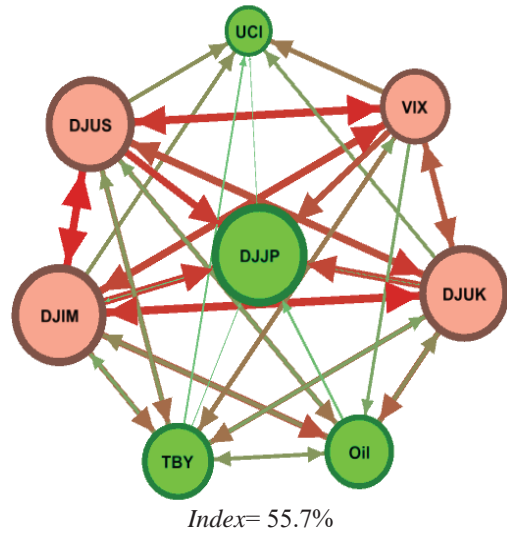
Index= 55.7%

c). Post-crisis

Index= 55.2%

Note: This figure presents the network plot of the average pairwise directional return spillovers among all possible pairs formed by the eight variables included in our analysis for the three following sub-periods: pre-crisis (from 15 July 1996 to 31 July 2007), financial crisis (from 1 August 2007 to 30 June 30 2009) and post-crisis (from 1 July 2009 to 30 June 2016). The size of the node indicates the overall magnitude of transmission/reception of return spillovers for each variable. The bigger node size implies higher transmission/reception of spillover effects. The colour of each node indicates whether a variable is a net transmitter/receiver of return spillovers. Net transmitters are in pink colour and net receivers are in green colour. The thickness of the arrows reflects the strength of the return spillover between a pair of variables. Thicker arrows indicate stronger pairwise return spillovers. DJIM, DJ US, DJ UK, DJ JP, VIX, UCI, TBY and OIL denote the DJIM index, the Dow Jones US stock index, the Dow Jones UK stock index, the Dow Jones Japan stock index, the VIX index, the US equity market-related uncertainty index, changes in 10-year Treasury yield and oil price fluctuations, respectively. *Index* refers to the average magnitude of the total return spillover index across the eight variables examined during each of the sub-periods.

Figure 6. **Total volatility spillover index**

This figure plots the time-varying behaviour of the total volatility spillover index across the DJIM, Dow Jones US, Dow Jones UK and Dow Jones Japan stock market indices and the set of major global risk factors considered (VIX index, US equity market-related uncertainty index, changes in 10-year Treasury yield and oil price fluctuations). The total volatility spillover index shows on average the percentage of the forecast error variance in all the volatility series that comes from spillovers. This index starts on 22 April 1997 since a 200-day rolling window is used to obtain its evolution over time.
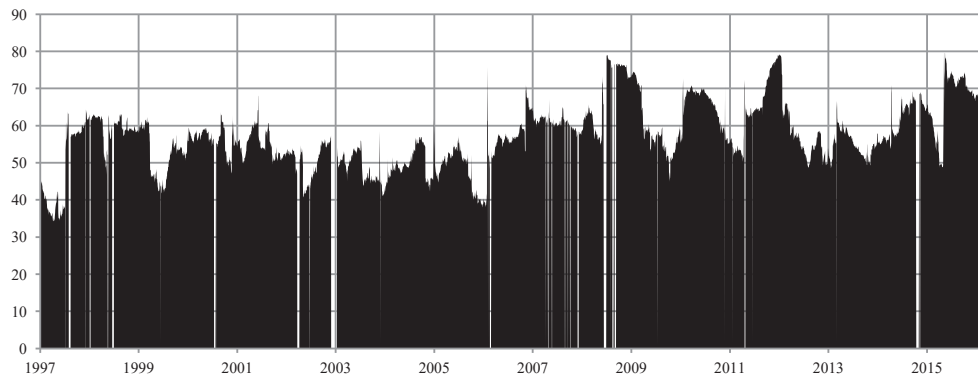
Figure 7. Net directional volatility spillover indices

This figure shows the time-varying behaviour of the net directional volatility spillover index across the DJIM, Dow Jones US, Dow Jones UK and Dow Jones Japan stock market indices and the set of major global risk factors considered (VIX index, US equity market-related uncertainty index, changes in 10-year Treasury yield and oil price fluctuations). The net directional return spillover index measures the spillover transmitted by each volatility variable to all other volatilities. Positive (negative) values indicate that the corresponding volatility variable is in net terms a transmitter (receiver) of volatility spillover effects to the volatility of all other variables. This index starts on 22 April 1997 since a 200-day rolling window is used to obtain its evolution over time.
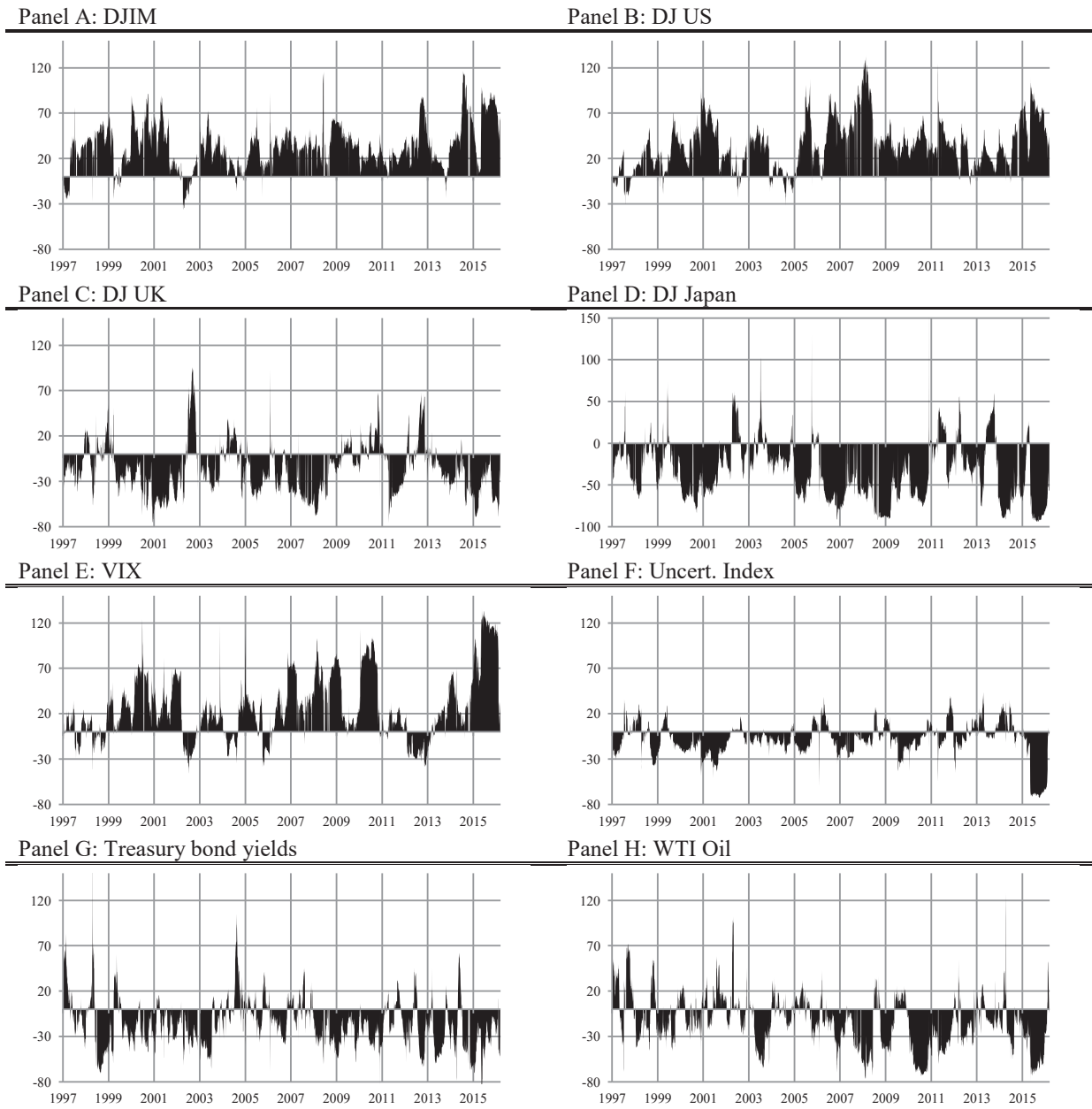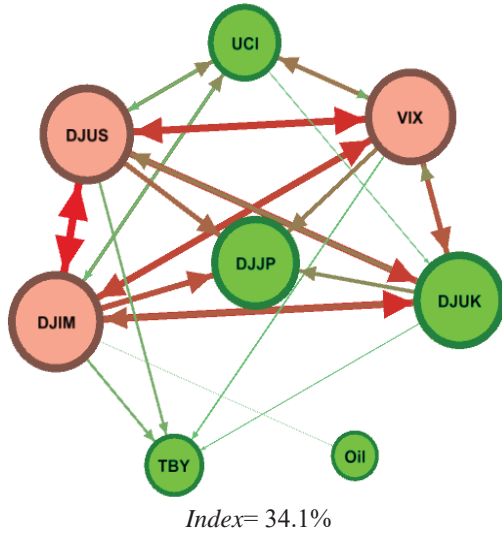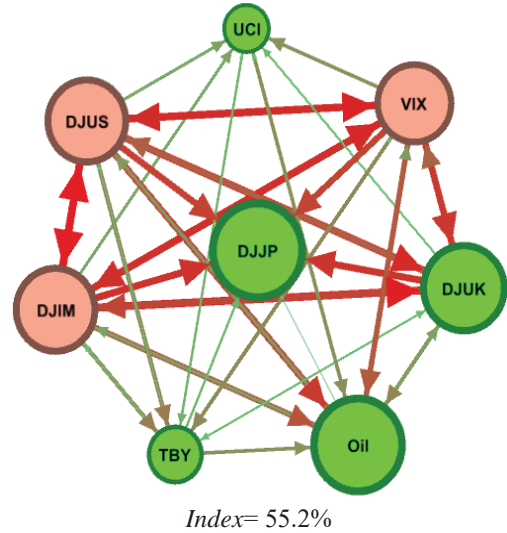
Panel A: DJIM

Panel B: DJ US

Panel C: DJ UK

Panel D: DJ Japan

Panel E: VIX

Panel F: Uncert. Index

Panel G: Treasury bond yields

Panel H: WTI Oil

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Figure 8. Network diagram of pairwise directional volatility spillovers

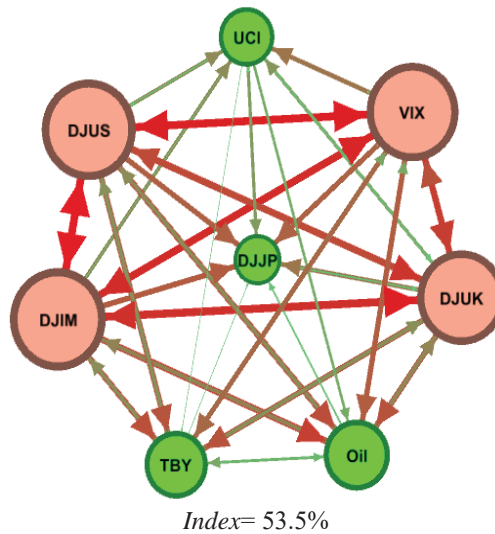**a).** Pre-crisis

Index= 34.1%

b). Crisis

Index= 55.2%

c). Post-crisis

Index= 53.5%

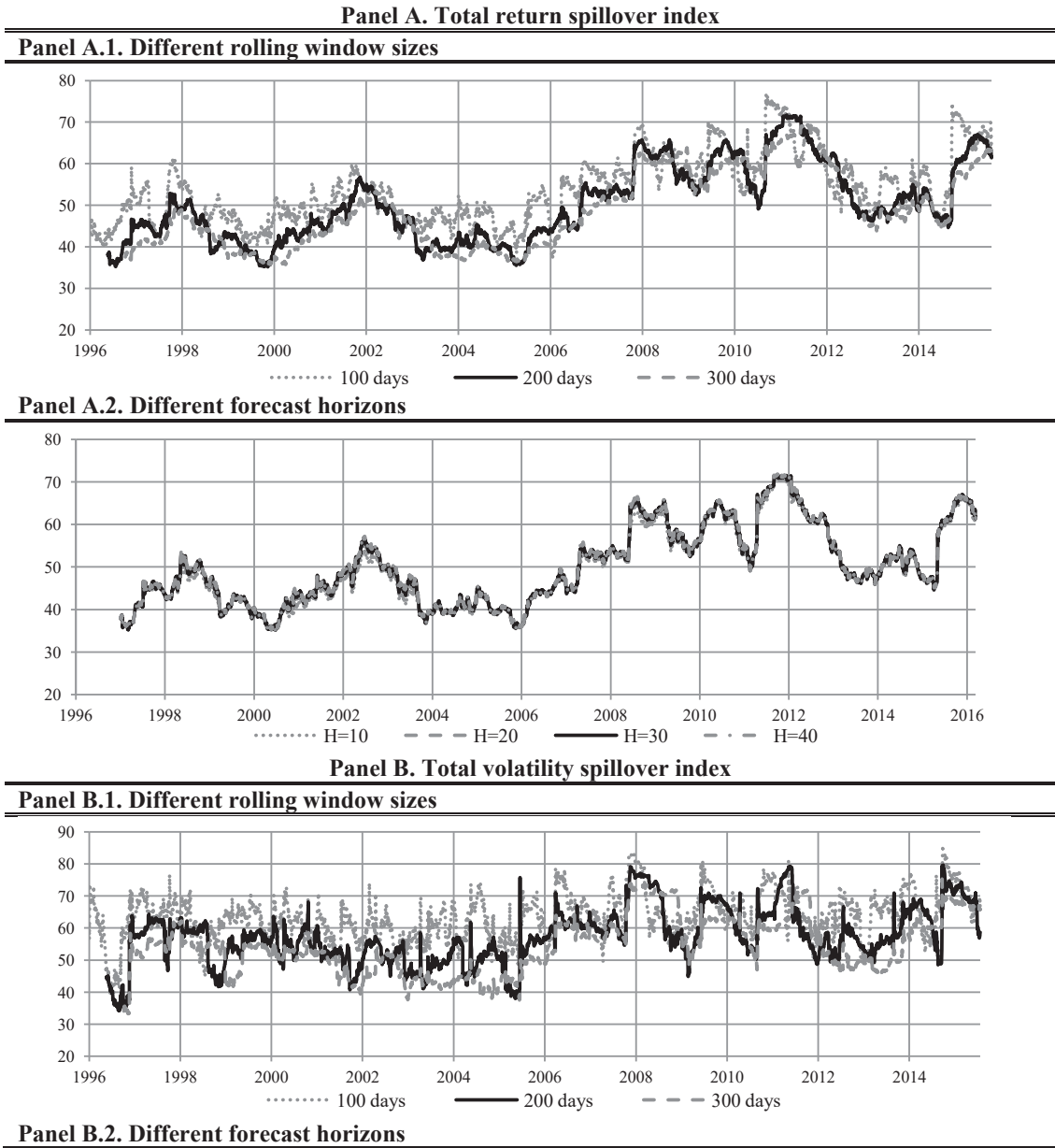*Note*: This figure presents the network plot of the average pairwise directional volatility spillovers among all possible pairs formed by the eight variables included in our analysis for the three following sub-periods: pre-crisis (from 15 July 1996 to 31 July 2007), financial crisis (from 1 August 2007 to 30 June 2009) and post-crisis (from 1 July 2009 to 30 June 2016). The size of the node indicates the overall magnitude of transmission/reception of volatility spillovers for each variable. The bigger node size implies higher transmission/reception of spillover effects. The colour of each node indicates whether a variable is a net transmitter/receiver of volatility spillovers. Net transmitters are in pink colour and net receivers are in green colour. The thickness of the arrows reflects the strength of the volatility spillover between a pair of variables. Thicker arrows indicate stronger pairwise volatility spillovers. DJIM, DJ US, DJ UK, DJ JP, VIX, UCI, TBY and OIL denote the DJIM index, the Dow Jones US stock index, the Dow Jones UK stock index, the Dow Jones Japan stock index, the VIX index, the US equity market-related uncertainty index, changes in 10-year Treasury yield and oil price fluctuations, respectively. *Index* refers to the

average magnitude of the total volatility spillover index across the eight variables examined during each of the sub-periods.
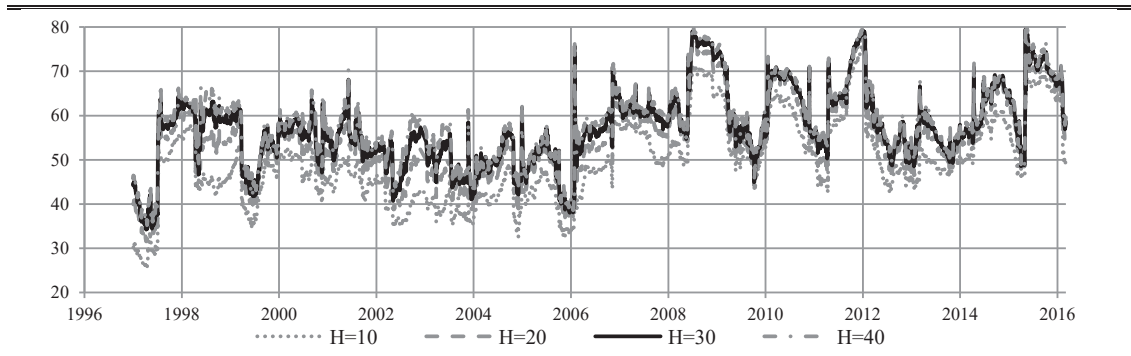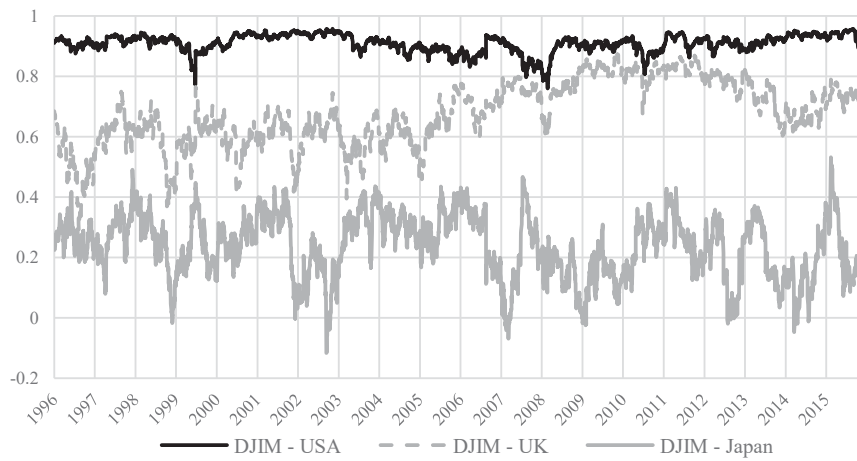
Figure 9. Robustness tests

Panel A. Total return spillover index

Panel A.1. Different rolling window sizes

Panel A.2. Different forecast horizons

Panel B. Total volatility spillover index

Panel B.1. Different rolling window sizes

Panel B.2. Different forecast horizons

Figure 10. Dynamic conditional correlations between Islamic and conventional stock markets

Note: This figure displays the pairwise dynamic conditional correlation estimates between the return of the DJIM index and the return of each of the conventional Dow Jones stock indices for the US, the UK and Japan over the whole sample period. The conditional correlations have been estimated using the asymmetric generalized dynamic conditional correlation (AGDCC-GARCH) model developed by Cappiello et al. (2006), which accounts for asymmetries in both volatilities and the conditional correlation.