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Is there a role for Islamic bonds in global diversification strategies?

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Abstract

Purpose – The purpose of this paper is to examine the international diversification benefits of Islamic bonds (Sukuk) for equity investors in conventional stock markets. The authors compare the diversification benefits of these securities with their conventional alternatives from advanced and emerging markets. Compared to conventional bonds, Sukuk are backed by tangible assets and carry both bond and stock-like features. Furthermore, the Sharia-based limitations limit the risk in these securities as a result of ethical investing rules. The regime-based model provides insight to possible segmentation (or integration) of these securities from global markets during different market states.

Design/methodology/approach – Risk spillover effects across conventional and Islamic stock and bond markets are examined using a Markov regime-switching GARCH model with dynamic conditional correlations (MS-DCC-GARCH). Weekly return series for conventional (advanced and emerging) and Islamic stock and bond indices are examined within a regime-dependent specification that takes into account low, high, and extreme volatility states. The DCC are then used to establish alternative diversified portfolios formed by supplementing conventional and Islamic equities with conventional and Islamic bonds one at a time.

Findings – Asymmetric shocks are observed from conventional stocks and bonds into Islamic bonds (Sukuk). Compared to emerging market bonds, Sukuk are found to display a different pattern in the transmission of global market shocks. The analysis of dynamic correlations suggests a low degree of association between Islamic bonds and global stock markets with episodes of negative correlations observed, particularly during market crisis periods. Portfolio performance analysis suggests that Islamic bonds provide valuable diversification benefits that are not possible to obtain from conventional bonds.

Originality/value – This study provides comprehensive analysis of volatility interactions and dynamic correlations across Islamic and conventional markets within a regime-based framework and provides insight to whether these securities could serve as safe havens or diversifiers for global investors. The findings have significant implications for global diversification strategies, particularly during market crisis periods.

Keywords Volatility spillover, International diversification, Dynamic correlations, Islamic bonds

Paper type Research paper

1. Introduction

Recent years have witnessed a proliferation of Islamic finance in the Middle-East and Southeast Asian countries. While Islamic equities and mutual funds have attracted much global attention with a number of Islamic equity indexes now offered by global index

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providers, the market in Islamic bonds (Sukuk) has also experienced extraordinary growth with the total issuance value growing from \$5 bn in 2003 to over \$130 bn in 2013 (*Wall Street Journal*, 2013). Although sovereigns have been the main driver of Sukuk issues, Islamic banks and corporations in the Middle-East and Southeastern Asia have played an increasingly active role in the supply of these securities in order to expand their capital positions and increase the duration of their funding sources. At the same time, persistently low yields in conventional bond markets coupled with advantageous credit fundamentals offered by Sukuk due to Sharia-based restrictions have fueled interest in these securities beyond the Middle-East and Southeastern Asia with a number of sovereigns and corporations globally slated to tap into this emerging market segment in the next several years (Mensah, 2014).

Sukuk represent a distinct class of securities with both bond and stock-like features. Unlike conventional bonds, cash payments from Sukuk are based on some form of profit-sharing formula, rather than pre-determined fixed interest rates. Furthermore, Sukuk are backed by tangible assets underlying the security and thus represent ownership in real assets that are permissible to invest in under Sharia guidelines. Additionally, the Sharia-based limitations on the nature of assets (or businesses) underlying these securities further limit the fundamental sources of risk in these securities as a result of ethical investing rules. To that end, it can be suggested that these securities exhibit segmentation from conventional markets and thus are generally immune to shocks in conventional equity and bond markets. Clearly, such a proposition would have significant portfolio diversification and hedging implications.

Despite numerous studies focussing on the performance of Islamic equities and mutual funds (e.g. Hoepner *et al.*, 2011; Hayat and Kraussl, 2011; Jawadi *et al.*, 2014 and more recently, Balcilar *et al.*, 2015) and on the co-movement between Islamic equity and bond markets (e.g. Aloui *et al.*, 2015a, b), the topic of volatility interactions across the conventional equity and bond markets and Sukuk is understudied. From an investment perspective, debt securities are an indispensable part of any diversification strategy and numerous studies in the literature have examined the relationship between conventional stock and bond markets in the context of portfolio diversification (e.g. Connolly *et al.*, 2005). Considering the asset backed nature of Sukuk and Sharia-based limitations on the type of investments underlying these securities, it can be argued that these securities would exhibit different risk/return dynamics compared to conventional bonds. Furthermore, recent evidence suggests that Islamic bonds are negatively correlated with Islamic stocks, particularly during periods of high volatility (Aloui *et al.*, 2015b), while Hammoudeh *et al.* (2014) find that Islamic stocks exhibit significant dependence with major global equity markets in the USA, Europe, and Asia. It can thus be argued that Islamic bonds would exhibit negative correlation with global equity markets, further motivating a study of diversification benefits of these securities for global equity portfolios. Therefore, given these recent findings in the Islamic finance literature, a natural research question is whether these securities could be a viable alternative to conventional bonds as a diversification tool for stock portfolios.

This study has several contributions to the emerging literature on Islamic finance as well as international finance. First, we examine the risk transmissions from global debt and equity markets as well as Islamic equities to the market for Islamic bonds by employing a Markov regime-switching GARCH model with dynamic conditional correlations (MS-DCC-GARCH). Jung and Maderitsch (2014) note two channels through which volatility transmission across financial markets can occur. While the first channel relates to potentially (auto) correlated information flows, the second channel reflects spillovers of market uncertainty. To that end, extending volatility spillover tests to conventional and "Sharia-restricted" Sukuk markets provides insight to the transmission of shocks from a different perspective.

Second, utilizing a MS-DCC model, we examine the dynamic correlations between Islamic bonds and conventional equity markets. The MS-DCC model allows us to formally address the time-variation in volatility and correlation dynamics during different market regimes and allows us to make inferences on the potential diversification benefits of these securities for conventional equity portfolios. Finally, we examine the in- and out-of-sample performance of alternative diversification strategies by supplementing conventional and Islamic equity portfolios with conventional and Islamic bonds one at a time. By doing so, we explore whether Islamic bonds can be a viable alternative to conventional bonds in global diversification strategies.

The findings show that volatility in global debt and equity markets has opposite spillover effects on Islamic bonds. We find positive spillover effects from global equities on Islamic bonds while a negative volatility spillover is observed from global bonds into Islamic bonds. While the finding of positive spillover effects from global stock markets is consistent with the presence of common market uncertainties driving risk globally, the negative spillover effect observed from global bonds suggests that good and bad news in global debt markets have an opposite impact on return dynamics in Islamic bonds. Nevertheless, the unconventional negative spillover effect from global bonds suggests some degree of segmentation of Islamic bonds from their conventional counterparts.

The analysis of dynamic correlations generally suggests a low degree of association between Islamic bonds and global stock markets with episodes of negative correlations observed, particularly during market crisis periods. Employing alternative portfolio strategies based on the moments obtained from the MS-DCC-GARCH model, we find that developed and emerging market stock portfolios supplemented with positions in Islamic bonds yield significantly higher risk adjusted returns compared to portfolios supplemented with either emerging or developed market bonds. While the in-sample analysis yields superior diversification benefits from conventional bonds for stock portfolios in advanced and emerging markets, the out-of-sample analysis suggests that Islamic bonds can indeed serve as better diversifiers for conventional stock portfolios compared to conventional bonds. Overall, the findings suggest that Islamic bonds can provide valuable diversification benefits for conventional stock portfolios that are not possible to obtain from conventional bonds, underscoring the significance of Islamic bonds as a viable alternative to its conventional counterparts.

The remainder of the paper is organized as follows. Section 2 provides a review of the literature on Islamic bonds with a focus on investment performance of these securities. Section 3 describes the two-factor MS-DCC-GARCH model used in the analysis. Section 4 presents the volatility spillover tests and dynamic correlation analysis. Section 5 provides portfolio performance comparisons and Section 6 concludes the paper.

2. Literature review

Dynamics of market volatility and risk transmission in conventional stock and bond markets have been extensively studied in the literature. Starting with the pioneering works of Ramchand and Susmel (1998) and Ng (2000) that utilize regime-switching models in volatility models, numerous subsequent studies including Baele (2005), Gebka and Serwa (2006) and Jung and Maderitsch (2014) have examined the role of regime-dependence and structural breaks in market volatility and risk spillovers in conventional advanced and emerging markets.

The strand of the literature that focusses on portfolio diversification issues has mainly examined the correlation between stock and government bond returns in order to provide insight to the diversification benefits of bonds for equity portfolios. Earlier studies including Fleming *et al.* (1998) and Scruggs and Glabadanidis (2003) argue that government bonds can serve as safe havens, while Cappiello *et al.* (2006) note the presence of asymmetries in conditional correlations between stock and bonds returns, particularly during market downturns. Similarly, examining multiple markets, Kim *et al.* (2006) detect a downward trend in time-varying stock/bond correlations in advanced stock markets, while regime-based applications of Connolly *et al.* (2005) and Guidolin and Timmermann (2006) document negative stock/bond correlations during periods of high market volatility. In more recent studies, Chan *et al.* (2011), Ciner *et al.* (2013), and Flavin *et al.* (2014) further support safe haven benefits of US Treasury bonds for equity investors during periods of market stress.

On the other hand, the literature on Islamic financial markets is still emerging with a heavy focus on the investment performance of Islamic equity indexes and mutual funds compared to their conventional counterparts. Studies that focus on Islamic equity indices suggest that these securities provide superior performance compared to their conventional counterparts, particularly during periods of market downturns and crisis periods (e.g. Ashraf and Mohammad, 2014; Al-Khazali *et al.*, 2014; Ho *et al.*, 2014). In the strand of the literature focussing on Islamic bonds, studies including Miller *et al.* (2007) and Wilson (2008) suggest that Islamic bonds are structured in a way that is comparable to their conventional counterparts, which makes it easier to assess their risks and come up with risk ratings on these securities. On the other hand, Cakır and Raei (2007) offer a conflicting perspective, suggesting that these securities are different from their conventional counterparts and document significant diversification benefits of these securities in conventional bond portfolios.

The recent literature on Islamic bonds focusses on the co-movements between the equity and bond segments of Islamic financial markets. Studies including Kim and Kang (2012) and Aloui *et al.* (2015a) document significant dependence between these two Islamic market segments in Malaysian, and the Gulf Cooperation Council markets, respectively. However, the literature has not yet provided a comprehensive analysis of volatility interactions across conventional stock/bond markets and the market for Islamic bonds that could provide valuable insight to the potential diversification benefits of these securities suggested by Cakır and Raei (2007). From an economic perspective, the fact that Sukuk are backed by tangible assets and thus represent ownership in real assets that are permissible to invest in under Sharia guidelines differentiates these securities from their conventional counterparts. As the Sharia-based limitations on the nature of assets (or businesses) underlying these securities eliminate any businesses with involvement in activities such as alcohol, tobacco, pork-related products, gambling, entertainment, weapons, and conventional financial services and disallow activities involving speculation and short-selling (Balcilar *et al.*, 2015), Islamic bonds can be expected to provide superior diversification compared to conventional bonds due to the limited nature of risk in these securities.

3. Methodology

The DCC model proposed in this study is constructed along the lines of Billio and Caporin (2005), Lee (2010), Chang *et al.* (2011), and more recently, Balcilar *et al.* (2016). Let $R_t = [R_{su,t}, R_{bd,t}, R_{be,t}, R_{sd,t}, R_{se,t}, R_{si}, R_{vd,t}, R_{ve,t}, R_{Tb,t}]'$ be the (9×1) vector of returns where $R_{su,t}$ is global Sukuk total bond return; $R_{bd,t}$ ($R_{be,t}$) is the developed (emerging) market government bond return; $R_{sd,t}$ ($R_{se,t}$) is the developed (emerging) market stock return; $R_{si,t}$ is the Islamic (Sharia compliant) market stock return; $R_{vd,t}$ ($R_{ve,t}$) is the return on developed (emerging) market volatility index; and $R_{Tb,t}$ is the ten-year US Treasury Bill rate, respectively. The GARCH specification for the volatility spillover model follows Ling and McAleer (2003) and is specified as:

$$R_t = \Phi_0 + \sum_{i=1}^{p} \Phi_i R_{t-i} + \varepsilon_t$$

$$\varepsilon_t = D_t z_t \tag{1}$$

where $D_t = \text{diag}\left(h_{su,t}^{1/2}, h_{bd,t}^{1/2}, h_{be,t}^{1/2}, h_{sd,t}^{1/2}, h_{se,t}^{1/2}, h_{si,t}^{1/2}, h_{vd,t}^{1/2}, h_{ve,t}^{1/2}, h_{Tb,t}^{1/2}\right)$ is the vector of the conditional volatility terms. The conditional mean of the return vector R_t is specified as a vector autoregressive process of order p with (9×9) parameter matrices Φ_i, $i=1,2, \ldots, p$. The unexplained component ε_t follows a GARCH specification described as $\varepsilon_t|\psi_{t-1} \sim ID(0, P_t)$ where P_t is the time-varying variance-covariance matrix. Denoting the conditional variance matrix as $H_t = [h_{su,t}, h_{bd,t}, h_{be,t}, h_{sd,t}, h_{se,t}, h_{si,t}, h_{vd,t}, h_{ve,t}, h_{Tb,t}]'$, we impose the following specification which allows for volatility spillover in the model:

$$H_t = c + A\varepsilon_{t-1}^{(2)} + BH_{t-1} \tag{2}$$

where c is a (9×1) vector of constants; A and B are (9×9) matrices for the ARCH and GARCH effects and $\varepsilon_t^{(2)} = \left[\varepsilon_{su,t}^2, \varepsilon_{bd,t}^2, \varepsilon_{be,t}^2, \varepsilon_{sd,t}^2, \varepsilon_{se,t}^2, \varepsilon_{si,t}^2, \varepsilon_{vd,t}^2, \varepsilon_{ve,t}^2, \varepsilon_{Tb,t}^2\right]'$. Note that the non-diagonal forms of the matrices A and B allow volatility spillovers across the series. Following Engle (2002), we allow conditional correlations to vary over time by specifying the variance-covariance matrix $P_t = D_t \Gamma_t D_t$ where Γ_t is the conditional correlation matrix.

A distinct feature of the model is that the conditional correlation matrix, Γ_t, follows regime-switching as governed by a discrete Markov process and is defined as $\Gamma_t = \text{diag}\{Q_t\}^{-1/2} Q_t \text{diag}\{Q_t\}^{-1/2}$. In order to incorporate regime shifts into the DCC model specified in Equations (1) and (2), we follow Billio and Caporin (2005) and introduce a Markov regime-switching dynamic correlation model by specifying Q_t as:

$$Q_t = [1 - \alpha(s_t) - \beta(s_t)]\overline{Q} + \alpha(s_t)\varepsilon_{t-1}^{(2)} + \beta(s_t)Q_{t-1} \tag{3}$$

where $\overline{Q}$ is the unconditional covariance matrix of the standardized residuals. In Equation (3), $\alpha(s_t)$ and $\beta(s_t)$ are the regime-dependent parameters that control the regime-switching system dynamics where $s_t \in \{1, 2, 3\}$ is the state or regime variable following a first-order, three-state discrete Markov process. Note that the variances in this specification are regime-independent whereas the covariances (or correlations) are both time-varying and regime-switching[1]. As Billio and Caporin (2005) note, the specification in which all parameters are regime dependent is highly unstable due to the large number of switching parameters. Therefore, we restrict the regime dependent structure to the time-varying correlations only. Thus, the model allows both volatility spillover and regime-switching dynamic correlations. The specification is then completed by defining the transition probabilities of the Markov process as $p_{ij} = P(s_{t+1} = i | s_t = j)$ where p_{ij} is the probability of being in regime i at time t+1 given that the market was in regime j at time t with regimes i and j taking values in {1, 2, 3}. Finally, the transition probabilities satisfy $\sum_{i=1}^{2} p_{ij} = 1$.

4. Empirical results

4.1 Data

The dataset consists of weekly closing prices for conventional and Islamic stock and bond market indices as well as additional risk and liquidity variables obtained from Bloomberg and Datastream for the period January 2, 2006-December 19, 2014, totaling 468 weekly observations. We differentiate between developed and emerging markets in order to separately assess volatility interactions of these markets with their Islamic counterparts. Conventional stock markets are represented by Dow Jones developed markets global stock index (DEVSTOCK) and Dow Jones emerging markets global stock index (EMRSTOCK). Conventional bond markets are represented by JP Morgan developed markets government bond total return index (DEVBOND) and JP Morgan emerging markets government bond total return index (EMRBOND). Similarly, Dow Jones Islamic stock index (ISLSTOCK) and Dow Jones Sukuk global total return index (SUKUK) are used to represent Shariah compliant stock and bond markets, respectively. Finally, global risk and liquidity related variables are represented by the CBOE volatility index (USVIX), CBOE emerging markets volatility index (EMRVIX), and ten-year US Treasury Bill rate (USTB10).

Table I provides several descriptive statistics for the variables employed in the analysis. Panel A reports the statistics for log returns and Panels B and C report the Pearson correlation coefficient estimates for the full sample and subprime mortgage crises period (December 2007-June 2009), respectively. We observe in Panel A that emerging market stocks exhibit the largest volatility in returns compared to their developed and Islamic counterparts with 2.920, 2.222, and 2.161 percent return volatility for emerging, developed, and Islamic stocks, respectively. A similar pattern is observed in the bond market with emerging market bonds experiencing the largest volatility in returns of 1.471 percent. Interestingly, Islamic stocks and bonds have the lowest return volatility compared to conventional counterparts while Islamic stocks dominate their conventional counterparts in both risk and return.

Pearson correlation coefficient estimates reported in Panels B and C of Table I indicate that both emerging and developed stock markets exhibit high correlations with all return series except Islamic and developed market bonds as well as the US Treasury Bill returns. Interestingly, emerging market bond returns are highly correlated with emerging, developed, and Islamic equity returns while developed market bonds have relatively lower correlations with equity returns in general. On the other hand, Islamic bonds exhibit significantly low correlations with all equity indices both in the full sample (Panel B) and during the subprime crises period (Panel C). The observed low correlations among Islamic bonds and equities indicate potential diversification benefits of these securities for equity investors in general.

We observe generally higher correlations among security returns during the subprime crises period (Panel C). Out of the 36 pairwise correlations reported in Table I, we observe that 22 of them increase during the subprime crises period, with the largest increase observed in the case of emerging market stock/bond correlation. Interestingly, the only exception is Islamic bonds with lower correlations observed between Islamic bonds and equity returns during this period. Overall, the analysis of correlations suggest that Islamic bonds display possible segmentation from equity markets in general, more significantly during market crisis periods.

4.2 Estimation results

In order to identify the best fitting MS(k)-DCC-GARCH, a battery of specification tests have been performed using the filtering procedure of Hamilton (1990), with the

Table I.
Descriptive statistics and correlations

Panel A: descriptive statistics for log returns (%)

	Mean (%)	SD (%)	Min (%)	Max (%)	Skew ness (%)	Kurtosis (%)	JB	Q(1)	Q(4)	ARCH(1)	ARCH(4)
SUKUK	0.086	0.943	−12.535	6.170	−6.164	87.748	154,134.625***	22.101***	50.838***	0.794	1.319
DEVBOND	0.083	0.733	−2.312	4.746	0.482	3.435	251.444***	46.669***	57.137***	0.086	29.649***
EMRBOND	0.094	1.471	−8.926	4.475	−0.979	4.399	457.109***	24.357***	29.715***	17.633***	112.555***
DEVSTOCK	0.062	2.222	−15.465	7.350	−1.215	6.217	877.423***	13.934***	17.304***	44.191***	52.553***
EMRSTOCK	0.061	2.920	−19.838	10.993	−1.085	6.192	847.680***	20.037***	29.119***	13.680***	96.213***
ISLSTOCK	0.089	2.161	−15.269	6.406	−1.239	6.348	914.345***	14.900***	17.220***	45.372***	53.097***
USVIX	0.114	10.148	−35.018	43.723	0.461	1.669	72.208***	0.23	1.582	7.001***	10.407**
EMRVIX	0.094	5.851	−15.562	49.286	1.975	12.028	3,151.192***	16.220***	17.183***	2.253	12.477**
USTB10	3.226	1.024	1.474	5.216	0.220	−1.057	25.170***	462.916***	1,800.992***	453.087***	450.819***

Panel B: Pearson correlation coefficient estimates for the full sample

	RSUKUK	RDEVBOND	REMRBOND	RDEVSTOCK	REMRSTOCK	RISLSTOCK	RUSVIX	REMRVIX	RUSTB10
SUKUK	1.0000								
DEVBOND	0.0699	1.0000							
EMRBOND	0.0387	0.3522	1.0000						
DEVSTOCK	0.0252	0.0389	0.7200	1.0000					
EMRSTOCK	0.0203	0.0790	0.7946	0.8911	1.0000				
ISLSTOCK	0.0282	0.0415	0.7204	0.9843	0.9051	1.0000			
USVIX	0.0011	0.1389	−0.4839	−0.7042	−0.5818	−0.7029	1.0000		
EMRVIX	−0.0055	0.0109	−0.6658	−0.6568	−0.6999	−0.6728	0.6505	1.0000	
USTB10	−0.0271	−0.5679	0.0875	0.3749	0.2939	0.3792	−0.3604	−0.2184	1.0000

(*continued*)

Panel C: Pearson correlation coefficient estimates for the subprime mortgage crises period (December 2007-June 2009)

	RSUKUK	RDEVBOND	REMRBOND	RDEVSTOCK	REMRSTOCK	RISLSTOCK	RUSVIX	REMRVIX	RUSTB10
SUKUK	1.0000								
DEVBOND	0.0204	1.0000							
EMRBOND	−0.0537	0.3475	1.0000						
DEVSTOCK	0.0002	0.0840	0.7661	1.0000					
EMRSTOCK	−0.0465	0.0744	0.8063	0.9249	1.0000				
ISLSTOCK	0.0037	0.0804	0.7619	0.9836	0.9282	1.0000			
USVIX	0.0511	0.0601	−0.5710	−0.7714	−0.7219	−0.7698	1.0000		
EMRVIX	0.1011	0.0690	−0.6821	−0.6673	−0.7452	−0.6920	0.6450	1.0000	
USTB10	0.0972	−0.6599	0.0266	0.2357	0.2552	0.2611	−0.1866	−0.1630	1.0000

Notes: Panel A provides the descriptive statistics for log returns. The ten-year US Treasury Bill rate (USTB10) is reported in terms of log percentage levels in Panel A and in percentage in Panel B. The sample period covers January 2, 2006-December 19, 2014 with $n = 468$ weekly observations. SUKUK stands for the Dow Jones Sukuk global total return index for Shariah compliant bonds, DEVBON for the JP Morgan developed markets government bond total return index, EMRBOND for the JP Morgan emerging markets government bond total return index, DEVSTOCK is the Dow Jones developed markets global stock index, EMRSTOCK is the Dow Jones emerging markets global stock index, ISLSTOCK is the Dow Jones Islamic (Shariah compliant) stock index, USVIX for the CBOE volatility index, EMRVIX for the CBOE emerging markets volatility index, and USTB10 for the ten-year US Treasury Bill rate. In addition to the mean, the standard deviation (SD), minimum (min), maximum (max), skewness, and kurtosis statistics, the table reports the Jarque-Bera normality test (JB), the Ljung-Box first (Q(1)) and the fourth (Q(4) autocorrelation tests, and the first (ARCH(1)) and the fourth (ARCH(4)) order Lagrange multiplier (LM) tests for the autoregressive conditional heteroskedasticity (ARCH). Panels B and C provide the Pearson correlation coefficient estimates for the full sample and for the subprime mortgage crises period of December 2007-June 2009, respectively. *,**,***Significant at 10, 5 and 1 percent levels, respectively

Table I.

modification suggested by Billio and Caporin (2005), followed by the smoothing algorithm of Kim (1994). We further use the Akaike, Bayesian, and Hannan-Quinn information criteria in order to compare the static DCC-GARCH as well as two-regime and three-regime MS-DCC-GARCH alternatives. Both formal tests (Panel F of Table II) and information criterion (Panel D of Table II) consistently favor a three-regime model over the static DCC-GARCH and two-regime MS-DCC-GARCH alternatives, establishing strong support for the presence of three regimes implied by the data[2].

Panel C in Table II presents several statistics describing the properties of the three market regimes. The smoothed probability estimates presented in Figure 1 suggest that the first regime largely corresponds to periods of low market volatility, while the second regime corresponds to high volatility periods surrounding large market downturns or crashes in global markets. On the other hand, the third regime, the crash regime, matches the largest crash in the Islamic bond market following the credit crunch of 2007/2008 and the global recession. Further discussion of regime properties is provided in the Appendix due to space limitation[3].

Examining the volatility spillover parameters ($a_{i,j}$, $b_{i,j}$) relating to Equation (2) reported in Panel A of Table II, we observe a highly significant and negative spillover effect from developed bonds to Islamic bonds whereas a positive spillover effect is observed from emerging market bonds. This suggests that positive fundamentals in bond markets from advanced nations decrease conditional volatility in the market for Islamic bonds. On the other hand, uncertainty surrounding emerging bond market returns spills over to the market for Islamic bonds, implying an association of risk across emerging conventional and Islamic bond markets. In the case of volatility spillovers from stock markets to Islamic bonds, we find a significant positive spillover effect from developed stock markets to Islamic bonds whereas negative volatility spillovers are observed from emerging market stocks as well as Islamic stocks to the market for Islamic bonds. It is possible that good news in emerging equity markets (including Islamic equities) diverts global capital to these equity market segments, crowding out funds in the market for Islamic bonds, thus leading to a negative spillover effect. Formal volatility spillover tests (reported in Table AI) further support these findings, implying significant volatility spillovers from conventional developed markets to the market for Islamic bonds while spillover tests for emerging markets provide mixed evidence. The Appendix provides further discussion of volatility spillovers.

Focussing on the DCC between Islamic bonds and conventional counterparts reported in Figure 2, we observe a significant structural break in late-2008 with the correlations displaying a positive trend after this period. On the other hand, examining the correlations between Islamic bonds and equities, we observe fairly low correlation values not exceeding 20 percent in most cases. Interestingly, we observe negative correlations between Islamic bonds and conventional stock markets more significantly during the 2008 global crisis period, suggesting that Islamic bonds could have served as a safe haven for equity investors during that period. Overall, our analysis of DCC clearly suggest a low degree of association between Islamic bonds and stock market returns with episodes of negative correlations observed, particularly during market crisis periods.

5. Diversification benefits of Islamic bonds

5.1 Mean-variance spanning tests

In order to provide preliminary insight to the diversification potential of Islamic bonds for global equities, we first employ the mean-variance spanning tests originally proposed by Huberman and Kandel (1987) and examine whether adding Islamic bonds to equity

Panel A: variance parameters					
	SUKUK	DEVBOND	EMRBOND	DEVSTOCK	EMRSTOCK
c_i	0.0161 (0.0012)***	0.3714 (0.0111)***	0.4512 (0.0523)***	0.2919 (0.0476)***	1.4021 (0.2540)***
a_{i1}	0.2470 (0.0024)***	−0.0251 (0.0386)	0.0657 (0.0179)***	−0.0286 (0.0273)	0.0881 (0.0428)**
a_{i2}	−0.1106 (0.0037)***	0.1174 (0.0341)***	0.0168 (0.0648)	0.0130 (0.0577)	−0.3321 (0.1555)**
a_{i3}	0.0838 (0.0026)***	−0.0808 (0.0209)***	−0.0656 (0.0100)***	−0.0368 (0.0226)	0.0947 (0.0343)***
a_{i4}	0.1230 (0.0038)***	−0.1710 (0.0056)***	0.0977 (0.0046)***	−0.2289 (0.0095)***	−0.0478 (0.0215)**
a_{i5}	−0.0103 (0.0017)***	0.0083 (0.0019)***	−0.1239 (0.0054)***	0.1026 (0.0050)***	−0.0349 (0.0086)***
a_{i6}	−0.1801 (0.0030)***	0.1642 (0.0048)***	0.0854 (0.0036)***	0.2021 (0.0076)***	0.1523 (0.0129)***
a_{i7}	0.0013 (0.0008)	−0.0084 (0.0027)***	0.0049 (0.0024)**	−0.0156 (0.0041)***	0.0020 (0.0048)
a_{i8}	−0.002 (0.0012)*	0.0040 (0.0044)	−0.0388 (0.0028)***	0.0222 (0.0042)***	0.0027 (0.0078)
a_{i9}	0.0012 (0.0029)	0.0140 (0.0084)*	−0.0390 (0.0117)***	0.0043 (0.0099)	−0.0066 (0.0101)
b_{i1}	0.7905 (0.0001)***	−0.7461 (0.0234)***	0.0528 (0.0436)	−0.5214 (0.0266)***	−0.3775 (0.0861)***
b_{i2}	−0.2369 (0.0229)***	−0.3509 (0.0201)***	−0.2395 (0.2031)	−0.8487 (0.3390)**	−0.0609 (0.5082)
b_{i3}	0.7243 (0.0257)***	−0.1997 (0.0158)***	0.4571 (0.0184)***	0.1808 (0.0529)***	−1.5608 (0.0457)***
b_{i4}	0.4009 (0.0183)***	−0.0978 (0.0211)***	0.0666 (0.0047)***	0.5837 (0.0065)***	0.5031 (0.0160)***
b_{i5}	−0.1685 (0.0146)***	−0.1209 (0.0085)***	0.1044 (0.0024)***	0.0872 (0.0093)***	0.7264 (0.0117)***
b_{i6}	−0.4499 (0.0148)***	−0.1267 (0.0133)***	0.1299 (0.0034)***	0.1932 (0.0084)***	0.3126 (0.0136)***
b_{i7}	0.1373 (0.0042)***	−0.1254 (0.0088)***	0.0969 (0.0046)***	0.0310 (0.0041)***	0.0670 (0.0092)***
b_{i8}	−0.1287 (0.0037)***	0.2045 (0.0202)***	−0.0916 (0.0019)***	0.0382 (0.0027)***	−0.1911 (0.0151)***
b_{i9}	0.3930 (0.0241)***	−0.3278 (0.0072)***	0.0410 (0.0331)	0.0468 (0.0158)***	−0.1148 (0.0352)***
	ISLSTOCK	USVIX	EMRVIX	USTB10	
c_i	0.2781 (0.0465)***	84.1460 (4.8962)***	−3.5523 (1.6914)**	−0.4328 (0.0890)***	
a_{i1}	−0.0025 (0.0114)	1.0173 (0.1234)***	−0.6904 (0.0230)***	0.1274 (0.1447)	
a_{i2}	−0.0178 (0.0514)	−0.0708 (0.5503)	0.3151 (0.0776)***	−0.1346 (0.0489)***	
a_{i3}	0.0120 (0.0183)	0.1206 (0.1711)	−0.8557 (0.0401)***	0.1920 (0.0809)**	
a_{i4}	0.1492 (0.0048)***	0.6036 (0.0784)***	0.0819 (0.0050)***	0.5146 (0.0036)***	
a_{i5}	0.0994 (0.0034)***	0.0117 (0.0541)	0.0482 (0.0043)***	0.0844 (0.0184)***	
a_{i6}	−0.1966 (0.0103)***	−0.8782 (0.0388)***	−0.0238 (0.0044)***	−0.6183 (0.0490)***	
a_{i7}	−0.0184 (0.0017)***	0.0478 (0.0248)*	0.0505 (0.0067)***	−0.0148 (0.0103)	
a_{i8}	0.0346 (0.0032)***	−0.0641 (0.0301)**	0.0522 (0.0144)***	0.0838 (0.0167)***	
a_{i9}	0.0084 (0.0089)	−0.0529 (0.0569)	−0.0194 (0.0327)	0.0728 (0.0197)***	
b_{i1}	−0.6066 (0.0129)***	2.9026 (0.1814)***	−2.7967 (0.1709)***	0.3208 (0.2061)	
b_{i2}	0.3840 (0.1983)*	−3.6005 (1.5709)**	0.5021 (0.9562)	−0.2142 (0.1069)**	
b_{i3}	−0.4545 (0.0237)***	9.5631 (0.5990)***	−2.2089 (0.1015)***	−0.2401 (0.1595)	
b_{i4}	0.0834 (0.0033)***	1.4441 (0.1060)***	0.2253 (0.1267)*	1.0795 (0.0612)***	
b_{i5}	0.3309 (0.0094)***	1.0966 (0.0676)***	−0.8537 (0.0732)***	0.9759 (0.0538)***	
b_{i6}	0.5281 (0.0043)***	−2.7716 (0.0834)***	−0.9749 (0.0702)***	−2.4568 (0.1086)***	
b_{i7}	0.0237 (0.0043)***	0.1581 (0.0229)***	0.7213 (0.0230)***	−0.1905 (0.0221)***	
b_{i8}	0.0005 (0.0067)	0.7730 (0.0528)***	−0.5620 (0.0359)***	−0.0784 (0.0031)***	
b_{i9}	0.1443 (0.0103)***	−1.6528 (0.1622)***	0.9386 (0.2251)***	0.7668 (0.0242)***	

Panel B: DCC parameters			Panel C: regime properties		
			n_i	Prob.	Duration
$\alpha(s_t=1)$	0.0308 (0.0021)***				
$\beta(s_t=1)$	0.9429 (0.0090)***				
$\alpha(s_t=2)$	0.0166 (0.0078)**	Regime 1	280.60	0.60	7.36
$\beta(s_t=2)$	0.8813 (0.0864)***	Regime 2	141.70	0.31	2.80
$\alpha(s_t=3)$	0.0884 (1.4083)	Regime 3	43.80	0.09	3.15
$\beta(s_t=3)$	0.6979 (0.2955)**				

Panel D: model diagnostics	MS(3)-DCC-GARCH	MS(2)-DCC-GARCH	DCC-GARCH
log L	−6,435.646	−6,572.781	−7,378.9501
AIC	28.612	28.991	32.2487
HQ	29.421	29.628	32.7212
BIC	30.6665	30.609	33.4493

(*continued*)

Table II.
Estimates of the MS-DCC-GARCH Model

Panel E: transition probabilities			
	Regime 1	Regime 1	Regime 1
Regime 1	0.864	0.132	0.004
Regime 2	0.266	0.643	0.091
Regime 3	0.002	0.315	0.683

Panel F: linearity tests		
H_0: MS(3)-DCC-GARCH	H_0: MS(2)-DCC-GARCH	H_0: MS(3)-DCC-GARCH
H1: DCC-GARCH	*H1*: DCC-GARCH	*H1*: MS(2)-DCC-GARCH
1,886.608 (0.0000)*** [0.0000]	1,612.338 (0.0000)*** [0.0000]	274.270 (0.0000)*** [0.0000]

Notes: HQ, Hannan-Quinn information criterion; BIC, Bayesian information criterion; log *L*, log likelihood. This table reports the estimates of the *k*-regime MS(*k*)-DCC-GARCH model given in Equations (1)-(3). The parameter estimates of the VAR are not reported to save space. The VAR lag order is selected by the Bayesian Information Criterion (BIC) as 1 while GARCH(1,1) specification is utilized. The MS-DCC-GARCH model is estimated using the maximum likelihood (ML) method. The likelihood ratio statistic tests the constant parameter DCC-GARCH model under the null against the alternative MS(*k*)-DCC-GARCH model for $k=2,3$ and the 2-regime model against the 3-regime model. The test statistic is computed as the likelihood ratio (LR) test. The LR test is nonstandard since there are unidentified parameters under the null. The χ^2 *p*-values (in parentheses) with degrees of freedom equal to the number of restrictions as well as the number of restrictions plus the numbers of parameters unidentified under the null are given. The *p*-value of the Davies (1987) test is also given in the square brackets. Panel C reports the ergodic probability of a regime (long-run average probabilities of the Markov process), the number of observations falling in a regime (n_i) based on regime probabilities, and the average duration of a regime. The models are estimated over the full sample period January 3, 2006-December 19, 2014 with 467 observations. Standard errors of the estimates are given in parentheses. *,**,***Significant at 10, 5, and 1 percent levels, respectively

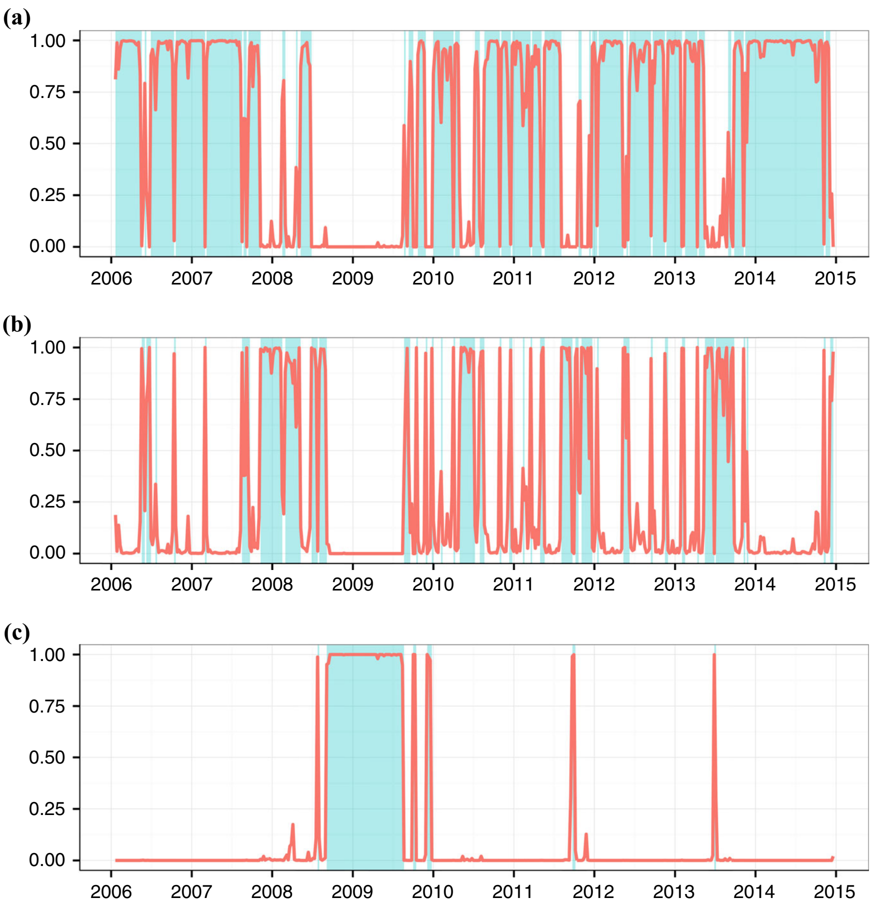
Table II.

portfolios can improve the minimum-variance frontier[4]. For this purpose, we consider three benchmark portfolios represented by developed, emerging, and developed plus emerging stock market portfolios and test each of these portfolios against the portfolio that is supplemented with Islamic bonds. We consider seven variants of mean-variance spanning tests that include the following: Lagrange multiplier (LM), likelihood ratio, and Wald tests (W) are regression-based tests based on Huberman and Kandel (1987). Wa is the heteroskedasticity and autocorrelation consistent version of the Wald test and is computed using the Newey-West (1987) method. J1 and J2 are the tests based on the stochastic discount factor (SDF) approach of Bekaert and Urias (1996). J3 is the SDF-based test proposed by DeSantis (1993). The findings are reported in Table III.

Panels A-C in Table III report the results for the full sample period as well as the pre- and post-2010 periods, respectively. Pre- and post-2010 panels are included in order to check the robustness of the findings. We observe that, at 5 percent significance level, all seven variants of the spanning tests reject the null hypothesis that the benchmark portfolio spans the portfolio that is supplemented by Islamic bonds. This result uniformly holds in the full sample and the post-2010 sample. However, it must be noted that spanning tests are static global tests of one portfolio against the same portfolio supplemented by other assets. Therefore, they should not be expected to hold in every sub-period. Another shortcoming of the spanning tests is their in-sample nature. To that end, our dynamic analysis presented in the next section provides a more comprehensive insight as we examine both the in-sample and out-of-sample diversification benefits of Islamic bonds using dynamic correlations in a regime switching environment.

5.2 Dynamic portfolio analysis

The dynamic portfolio analysis considers three alternative stock portfolios in order to represent the "undiversified" investor, i.e. the conventional developed stock market

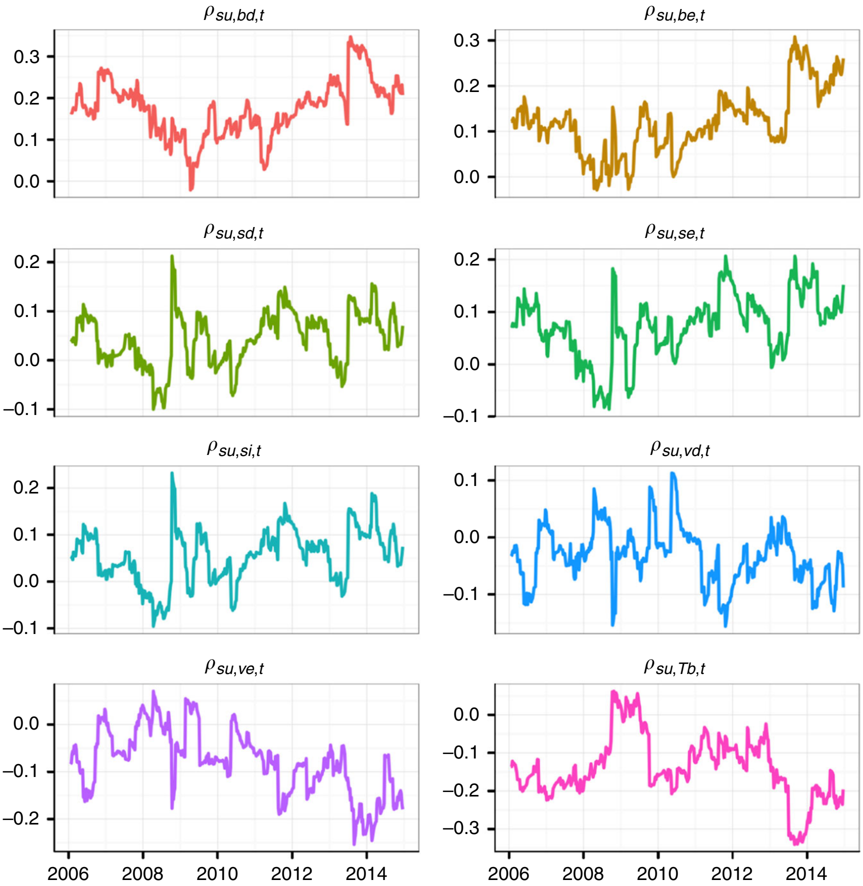


Notes: Smoothed probablity of low volatility regime (regime 1); Smoothed probablity of high volatility regime (regime 2); Smoothed probablity of extreme (crash) volatility regime (regime 3). The figures plot the smoothed probability estimates of the low volatility regime (regime 1), the high volatility regime (regime 2), and extreme (crash) volatility regime (regime 3). The smoothed probabilities are obtained from the MS-DCC-GARCH model in Equations (1)-(3). The shaded regions in the figures correspond to the periods where the smoothed probability of the corresponding regime is the maximum

Figure 1. Smoothed probability estimates

portfolio, the conventional emerging stock market portfolio, and Islamic stock portfolio. Following a number of papers including Hammoudeh *et al.* (2010), Lee (2010), and Chang *et al.* (2011), we form bivariate portfolios by supplementing each "undiversified" stock portfolio with Islamic bonds and conventional bonds one at a time and examine the risk adjusted returns corresponding to each diversified portfolio. Two alternative portfolio strategies are considered: the risk-minimizing portfolio position of Kroner and Sultan (1993)[5]; and the optimal portfolio weight of Kroner and Ng (1998)[6].

Table IV provides the summary statistics for the in-sample period covering January 3, 2006-December 13, 2013 with 414 weekly portfolio points. Panels A-C present the



Notes: The figure plots the dynamic correlation estimates from the three-regime MS-DCC-GARCH model given in Equations (1)-(3). The symbol $\rho_{su,j,t}$ stands for the dynamic correlation between Islamic bond return series and series j at time t, $i,j \in \{bd,be,sd,se,si,vd,ve,Tb\}$, where *bd* (*be*) stands for the developed (emerging) markets bond returns, *sd* (*se*,*si*) stands for the developed (emerging, Islamic) markets stock returns, *vd* (*ve*) stands for the developed (emerging) markets volatility index returns, and Tb stands for the ten-year US Treasury bond rate. The correlation coefficients are regime-dependent and are directly obtained from Equations (1)-(4) using the ML estimation. Since the correlations are regime-dependent and the three sets of correlations $\rho_{ij,1,t}$, $\rho_{ij,2,t}$, and $\rho_{ij,3,t}$ are estimated for regimes 1, 2, and 3, we obtain $\rho_{ij,t}$ as $\rho_{ij,t}=p_{1,t}\rho_{ij,1,t}+p_{2,t}\rho_{ij,2,t}+p_{3,t}\rho_{ij,3,t}$, where $p_{k,t}=P(s_t=k|\psi_{t-1})$, $k=1,2,3$, is the predictive probability of being in regime k at time t

Figure 2.
Dynamic correlation estimates from the MS-DCC-GARCH model

findings for "undiversified" stock portfolios representing an investor who is currently fully invested in advanced, emerging, or Islamic stock markets, respectively. For example, in Panel A, the shaded row labeled "undiversified" provides the summary statistics for an undiversified investor who is currently fully invested in advanced stock markets with a mean return of 0.056 percent and standard deviation of 2.314 percent.

	Developed markets			Emerging markets			Developed plus emerging markets	
	Statistic	*p*-value		Statistic	*p*-value		Statistic	*p*-value
Panel A: full sample								
LM	146.153	< 0.001	LM	304.083	< 0.001	LM	142.201	< 0.001
LR	175.295	< 0.001	LR	491.792	< 0.001	LR	169.578	< 0.001
W	212.728	< 0.001	W	871.650	< 0.001	W	204.457	< 0.001
Wa	280.357	< 0.001	Wa	618.354	< 0.001	Wa	291.859	< 0.001
J1	9.238	0.010	J1	9.365	0.009	J1	8.582	0.014
J2	9.226	0.010	J2	9.337	0.009	J2	8.589	0.014
J3	7.233	0.027	J3	6.589	0.037	J3	6.827	0.033
Panel B: pre-2010 sample								
LM	52.091	< 0.001	LM	110.136	< 0.001	LM	49.307	< 0.001
LR	60.005	< 0.001	LR	157.198	< 0.001	LR	56.318	< 0.001
W	69.607	< 0.001	W	235.362	< 0.001	W	64.723	< 0.001
Wa	147.457	< 0.001	Wa	205.427	< 0.001	Wa	134.369	< 0.001
J1	9.225	0.010	J1	9.199	0.010	J1	7.388	0.025
J2	9.211	0.010	J2	9.182	0.010	J2	7.421	0.025
J3	6.390	0.041	J3	6.558	0.038	J3	6.625	0.036
Panel C: post-2010 sample								
LM	192.780	< 0.001	LM	245.961	< 0.001	LM	201.665	< 0.001
LR	351.704	< 0.001	LR	758.894	< 0.001	LR	388.565	< 0.001
W	745.650	< 0.001	W	4,555.065	< 0.001	W	898.825	< 0.001
Wa	303.362	< 0.001	Wa	1,946.453	< 0.001	Wa	329.918	< 0.001
J1	25.160	< 0.001	J1	25.590	< 0.001	J1	23.478	< 0.001
J2	26.551	< 0.001	J2	26.036	< 0.001	J2	25.368	< 0.001
J3	29.268	< 0.001	J3	30.717	< 0.001	J3	31.136	< 0.001

Notes: The table reports the findings from seven alternative mean-variance spanning tests applied to three benchmark portfolios. The three benchmark portfolios include developed markets, emerging markets, and developed plus emerging market portfolios. Each of these portfolios is tested against the alternative that is supplemented with Islamic bonds. The mean-variance spanning tests reported in the table include the following: Lagrange multiplier (LM), likelihood ratio (LR), and Wald tests (W) are regression-based tests based on the approach of Huberman and Kandel (1987). Wa is the heteroskedasticity and autocorrelation consistent (HAC) version of the Wald test and is computed using the Newey-West (1987) method. J1 and J2 are the tests based on stochastic discount factor (SDF) approach of Bekaert and Urias (1996). J3 is the SDF-based test proposed by DeSantis (1993). Panels A-C report the results for the full sample period and the pre- and post-2010 periods, respectively. The symbol " < " signifies less than the number it precedes

Table III. Mean-variance spanning tests

Comparing alternative diversification strategies in Panel A, we see that Islamic bonds fail to provide significant diversification compared to advanced and emerging market bonds, implied by lower Sharpe ratios. Despite the fact that supplementing the stock portfolio with Islamic bonds generally improves risk adjusted returns, advanced, and emerging market bonds consistently offer better diversification for the global stock investor. Similar results are observed for emerging and Islamic stock market investors presented in Panels B and C, respectively. In each case, supplementing stock portfolios with Islamic bonds fail to provide as much diversification as offered by conventional bond portfolios. The underperformance of Islamic bonds compared to its conventional counterparts during the in-sample period is most likely due to the prolonged crash observed in the Islamic bond market during the 2008-2010 period.

Table IV.
Summary statistics for in-sample portfolios

	Mean	SD	Min	Max	Sharpe ratio
Panel A: developed stock market portfolio					
Undiversified	0.056	2.314	−15.465	7.350	0.024
Developed stock market portfolio supplemented with developed market bond					
MR portfolio	0.053	2.339	−15.513	7.963	0.023
OW portfolio	0.095	0.714	−2.141	4.584	0.133
Developed stock market portfolio supplemented with emerging market bond					
MR portfolio	0.192	3.783	−24.710	13.265	0.051
OW portfolio	0.141	1.503	−8.926	4.475	0.094
Developed stock market portfolio supplemented with Islamic market bond					
MR portfolio	0.055	2.315	−15.629	7.296	0.024
OW portfolio	0.038	1.086	−10.621	5.594	0.035
Panel B:emerging stock market portfolio					
Undiversified	0.072	3.052	−19.838	10.993	0.024
Emerging stock market portfolio supplemented with developed market bond					
MR portfolio	0.089	3.083	−19.450	10.994	0.029
OW portfolio	0.090	0.746	−2.195	4.776	0.121
Emerging stock market portfolio supplemented with emerging market bond					
MR portfolio	0.244	5.407	−38.967	18.535	0.045
OW portfolio	0.121	1.506	−8.926	4.475	0.080
Emerging stock market portfolio supplemented with Islamic market bond					
MR portfolio	0.085	3.050	−20.087	9.890	0.028
OW portfolio	0.065	1.024	−10.866	5.766	0.063
Panel C: Islamic stock market portfolio					
Undiversified	0.082	2.247	−15.269	6.406	0.036
Islamic stock market portfolio supplemented with developed market bond					
MR portfolio	0.085	2.270	−15.043	6.943	0.037
OW portfolio	0.095	0.716	−2.129	4.672	0.133
Islamic stock market portfolio supplemented with emerging market bond					
MR portfolio	0.232	3.777	−26.813	13.617	0.061
OW portfolio	0.129	1.501	−8.926	4.475	0.086
Islamic stock market portfolio supplemented with Islamic market bond					
MR portfolio	0.087	2.257	−15.477	6.623	0.039
OW portfolio	0.042	1.021	−9.508	5.641	0.041

Notes: The table reports the results of the in-sample portfolio analysis. The in-sample period covers January 3, 2006-December 13, 2013 with 414 weekly portfolio points. MR and OW portfolios correspond to the risk-minimizing portfolio position of Kroner and Sultan (1993) and optimal portfolio of Kroner and Ng (1998), respectively. The shaded row in each panel represents an undiversified investor who is fully invested in the corresponding equity portfolio

The out-of-sample performance statistics reported in Table V, however, provide more encouraging results in favor of Islamic bonds, suggesting that Islamic bonds indeed have the potential to provide superior diversification benefits compared to conventional bonds. The out-of-sample period covers December 14, 2013-December 19, 2014 with 52 weekly portfolio points with the estimates obtained as one-step forecasts recursively during the out-of-sample period. The findings in Panels A and B in Table V clearly suggest that supplementing stock positions in conventional markets with positions in Islamic bonds could provide much higher risk adjusted returns compared to those supplemented by conventional bonds. For example, in Panel A, while the undiversified

	Mean	SD	Min	Max	Sharpe ratio
Panel A: developed stock market portfolio					
Undiversified	0.077	1.307	−3.214	3.260	0.059
Developed stock market portfolio supplemented with developed market bond					
MR portfolio	0.080	1.339	−3.313	3.260	0.060
OW portfolio	0.025	0.377	−1.206	0.556	0.066
Developed stock market portfolio supplemented with emerging market bond					
MR portfolio	0.001	1.702	−3.863	4.072	0.001
OW portfolio	−0.076	0.984	−2.376	1.552	−0.077
Developed stock market portfolio supplemented with Islamic market bond					
MR portfolio	0.103	1.328	−3.160	3.430	0.078
OW portfolio	0.092	0.248	−0.889	0.553	0.371
Panel B: emerging stock market portfolio					
Undiversified	−0.091	1.506	−3.478	3.113	−0.060
Emerging stock market portfolio supplemented with developed market bond					
MR portfolio	−0.090	1.487	−3.365	3.108	−0.061
OW portfolio	0.011	0.442	−1.480	0.972	0.025
Emerging stock market portfolio supplemented with emerging market bond					
MR portfolio	−0.238	2.691	−6.704	4.948	−0.088
OW portfolio	−0.149	1.136	−2.733	1.726	−0.131
Emerging stock market portfolio supplemented with Islamic market bond					
MR portfolio	−0.032	1.584	−4.124	3.199	−0.020
OW portfolio	0.098	0.242	−0.897	0.481	0.405
Panel C: Islamic stock market portfolio					
Undiversified	0.082	2.247	−15.269	6.406	0.036
Islamic stock market portfolio supplemented with developed market bond					
MR portfolio	0.085	2.270	−15.043	6.943	0.037
OW portfolio	0.095	0.716	−2.129	4.672	0.133
Islamic stock market portfolio supplemented with emerging market bond					
MR portfolio	0.232	3.777	−26.813	13.617	0.061
OW portfolio	0.129	1.501	−8.926	4.475	0.086
Islamic stock market portfolio supplemented with Islamic market bond					
MR portfolio	0.087	2.257	−15.477	6.623	0.039
OW portfolio	0.042	1.021	−9.508	5.641	0.041

Notes: The table reports the results of the out-of-sample portfolio analysis. The out-of-sample period covers December 14, 2013-December 19, 2014 with 52 weekly portfolio points. The out-of-sample estimates are obtained as one step forecasts recursively over the out-sample period. MR and OW portfolios correspond to the risk-minimizing portfolio position of Kroner and Sultan (1993) and optimal portfolio of Kroner and Ng (1998), respectively. The shaded row in each panel represents an undiversified investor who is fully invested in the corresponding equity portfolio

Table V.
Summary statistics for the out-of-sample portfolios

stock portfolio offers a Sharpe ratio of 0.059, diversifying by developed, emerging market bonds, and Islamic bonds, based on the Kroner and Ng (1998) strategy, yields risk adjusted returns of 0.066, −0.077, and 0.371, respectively.

A similar finding is observed in the case of the emerging market stock portfolio with Islamic bonds offering the highest risk adjusted returns compared to conventional bonds. Interestingly, the findings in Panel C suggest that Islamic bonds are not necessarily good diversifiers for Islamic stock portfolios, indicated by lower risk adjusted returns compared to those for conventional bonds. It is possible that common fundamentals driving Islamic financial markets restrict the diversification benefits of

Islamic bonds for stock portfolios in this market segment. Overall, our findings suggest that Islamic bonds can indeed serve as better diversifiers for conventional stock portfolios compared to conventional bonds. However, conflicting performance outcomes observed for the in- and out-of-sample periods underscore the importance of dynamic diversification strategies that utilize these securities[7].

6. Conclusion

The market for Islamic bonds (Sukuk) has experienced significant growth over the past decade with a number of sovereigns and corporations globally slated to tap into this emerging market segment in the next several years. A number of papers in the Islamic finance literature argue that the Sharia-based limitations on the nature of assets (or businesses) underlying Islamic bonds limit the fundamental sources of risk in these securities as a result of ethical investing rules. To that end, it can be argued that these securities exhibit segmentation from conventional markets and thus are generally immune to shocks in conventional equity and bond markets. The first contribution of this study is to examine the risk transmissions from global debt and equity markets as well as Islamic equities to the market for Islamic bonds. We next estimate a Markov regime-switching GARCH model with DCC (MS-DCC-GARCH) and examine DCC between Islamic bonds and conventional financial markets. Finally, we compare the diversification benefits of Islamic bonds with its conventional counterparts and explore whether Islamic bonds could be an alternative diversification tool for stock portfolios globally.

Our analysis suggests that Islamic bonds are not immune from shock and volatility spillovers from global conventional markets. Interestingly, however, volatility in global debt and equity markets has opposite spillover effects on Islamic bonds. We find positive spillover effects from global equities on Islamic bonds while a negative volatility spillover is observed from global bonds into Islamic bonds. While the finding of positive spillover effects from global stock markets is consistent with the presence of common financial market uncertainties driving risks globally, the negative spillover effect observed from global bonds suggests that good and bad news in global debt markets have an opposite impact on return dynamics in Islamic bonds. Nevertheless, the unconventional negative spillover effect from global bonds suggests some degree of segmentation of Islamic bonds from their conventional counterparts.

The analysis of dynamic correlations suggests a low degree of association between Islamic bonds and global stock markets with episodes of negative correlations observed, particularly during market crisis periods. The low degree of correlation plays a significant role in the performance of these securities as diversifiers for global stock portfolios. While the in-sample analysis yields superior diversification benefits by conventional bonds for stock portfolios in advanced and emerging markets, the out-of-sample analysis suggests that Islamic bonds can indeed serve as better diversifiers for conventional stock portfolios compared to conventional bonds. Interestingly, Islamic bonds do not provide significant diversification benefits for Islamic stocks possibly due to common fundamentals driving Islamic financial markets in general. However, Islamic bonds can provide valuable diversification benefits for conventional stock portfolios that are not possible to obtain from conventional bonds. Overall, our findings clearly underscore the significance of Islamic bonds as a viable alternative to its conventional counterparts.

Notes

1. We estimate the MS-DCC-GARCH model using the two-step approach of Engle and Sheppard (2001) and Engle (2002). In the second step, we use the modified Hamilton filter proposed by Billio and Caporin (2005) to solve the path-dependence problem (Cai, 1994; Hamilton and Susmel, 1994; Gray, 1996) and estimate the regime-switching conditional covariances accordingly.
2. The details on model specification tests are not provided due to space considerations and are available upon request.
3. Appendix available at: www.siue.edu/~rdemire/MFOnlineAppendix.pdf
4. We thank an anonymous referee for suggesting the mean-variance spanning tests to supplement our analysis.
5. For two return series that is related as $R_{st} = \mu + \theta R_{bt} + \varepsilon_t$, where ε_t is a white noise, the risk-minimizing portfolio ratio is defined as $\theta_t^* = h_{sb,t}/h_{b,t}$,where $h_{b,t} = var(R_{b,t})$ and $h_{sb,t} = cov(R_{s,t}, R_{b,t})$ estimated by Equations (1)-(3).
6. The regime independent covariances used in the computation of portfolio positions are obtained as the probability weighted average of regime-dependent covariances where the weights are corresponding predictive regime probabilities.
7. Following the suggestion of an anonymous referee, we also examined US Treasury Bonds as an alternative diversifier to equity portfolios. We observe that diversification with Islamic bonds yield greater Sharpe ratios compared to US Treasury Bonds both for the in- and out-of-sample portfolios. These findings are available upon request.
8. This online appendix provides the technical discussions that are not included in the text due to space limitation. Please refer to the paper for the Tables and Figures referenced in this appendix.
9. Regime switching parameters of the MS-DCC-GARCH model relate to correlations. It is rather difficult to specify the regimes based on correlations since correlations are dynamic and do not follow a systematic pattern across the regimes. As a matter of practical convenience, we specify the regimes based on the periods that the maximum of the smoothed probability estimates correspond to. These periods differ markedly in terms of their volatility levels.
10. The use of the ten-year US Treasury Bill rate as a proxy for global liquidity follows Eichengreen and Mody (1998).

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Appendix

1. Regime properties[8]

Panel C in Table II presents several statistics describing the properties of the three market regimes identified by formal tests explained earlier. We observe that the first regime is the most persistent regime with an average duration of 7.36 weeks. The smoothed probability estimates presented in Figure 1 indicate that the first regime largely corresponds to periods of lowest historical volatility (2006-2008, mid 2010-mid 2011, 2012-mid 2013, and the post-2013 period). The second regime is the least persistent regime with an average duration of 2.80 weeks and the smoothed probability estimates in Figure 1 suggest that this regime mainly corresponds to high volatility periods surrounding large market downturns or crashes in global markets. On the other hand, the third regime, which is more persistent than the high volatility regime, corresponds to the period from mid-2008 to the end of 2009, exactly matching the largest crash in the Islamic bond market following the credit crunch of 2007/2008 and the global recession[9]. We find that the average duration for the crash regime is 3.15 weeks while the smoothed probability estimates for this regime equal 1 due to the prolonged crash period. Further examining the regime statistics in Panel C of Table II, we observe long-run probabilities of 60, 31, and 9 percent for the low, high, and extreme (or crash) volatility regimes, respectively. Overall, the analysis of regime properties provides further support for the three-regime specification and suggests that the third regime is not a statistical artifact, but in fact, proxies a structural break in return dynamics.

Panel B presents the estimates for parameters $\alpha(s_t)$ and $\beta(s_t)$, $s_t \in \{1,2,3\}$, that generate regime-specific conditional correlations in the MS-DCC-GARCH model. We observe that $\alpha(s_t)$ and $\beta(s_t)$ estimates are highly significant at 1 percent level for all three regimes, indicating significant time-varying or regime-dependent dynamic correlations among the series in all regimes. However, observing different estimates for $\alpha(s_t)+\beta(s_t)$ across the different regimes, i.e. 0.97, 0.90, and 0.78 for the low, high, and extreme volatility regimes, respectively, suggests that these regimes are characterized by very different dynamic correlation structures. Since these parameters control correlation persistence implied by the model, we conclude that the correlations are more persistent in the low volatility regime than in the high and extreme volatility regimes. Moreover, higher values of $\alpha(s_t)+\beta(s_t)$ for the low and high volatility regimes imply that the correlation persistence is more pronounced in these regimes.

2. Volatility spillover analysis

The generalized multivariate specification in Equations (1) and (2) allows eight possible volatility transmission channels to Islamic bonds, i.e. from conventional and Islamic stock markets (developed, emerging, and Islamic), from conventional bond markets (developed and emerging), as well as from proxies of global risk sentiment and liquidity represented by the US and emerging market volatility indexes (VIX) and US Treasuries, respectively[10]. It must be noted, however, that the spillover parameters estimated by the multivariate model measure the partial effects as the model considers all interactions among the return series. It is therefore possible to obtain different results in a bivariate framework. However, the bivariate specification would fail to consider interactions among these markets in a broad context. Thus, the multivariate specification allows us to discover a more accurate picture of the volatility interactions which would not be possible to explore in a bivariate framework.

Panel A in Table II reports the parameter estimates of the MS-DCC-GARCH model for Islamic bond returns. The volatility spillover parameters $(a_{i,j}, b_{i,j})$ relating to Equation (2) are generally found to be highly significant, implying significant risk transmission from conventional stock and bond markets to Islamic bonds. We observe a highly significant and negative spillover effect from developed bonds whereas a positive spillover effect is observed from emerging market bonds. This suggests that positive fundamentals in bond markets from advanced nations would decrease conditional volatility in the market for Islamic bonds. On the other hand, uncertainty surrounding emerging bond market returns spills over to the market for Islamic bonds, implying an association of risk across emerging conventional and Islamic bond markets. Similarly, our findings do not yield any risk transmission from Islamic bonds to developed bonds whereas a positive spillover effect is observed from Islamic bonds to emerging market bonds. The bi-directional risk transmission between Islamic and emerging market bonds suggests the presence of common fundamentals affecting emerging and Sharia-compliant bond markets.

In the case of volatility spillovers from stock markets to Islamic bonds, we find a significant positive spillover effect from developed stock markets to Islamic bonds whereas negative volatility spillovers are observed from emerging market stocks as well as Islamic stocks to the market for Islamic bonds. It is possible that good news in emerging equity markets (including Islamic equities) diverts global capital to these equity market segments, crowding out funds in the market for Islamic bonds, thus leading to a negative spillover effect. As will be discussed in the next section, the regime-switching dynamic correlations also support the negative association between Islamic bonds and Islamic and emerging market stocks.

Table AI presents the results of volatility spillover tests. We report three formal tests in this table. The first is a multivariate Wald (MV-Wald) test involving two zero restrictions on the relevant elements of matrices A and B. For example, the null hypothesis of no volatility spillover from the emerging market bonds to Islamic bonds is tested by imposing the restriction $a_{13} = b_{13} = 0$. The second is the bivariate causality in variance test (HH) of Hafner and Herwartz (2006). This test is an LM test and avoids estimation of a possibly complicated model under the alternative. The third volatility spillover test is the bivariate robust LM causality in variance test (NT) of Nakatani and Teräsvirta (2010) which is also an LM test based on a univariate GARCH model that is robust to mis-specified zero conditional correlations. In the last row of Table AI, we also present a joint volatility spillover test from all other variables to Islamic bonds.

The direct test of volatility spillover based on the MV-Wald test does not reject volatility spillover from any of the markets examined to Islamic bonds at 1 percent significance level. This suggests that the MV-WALD test indicates significant volatility spillovers from conventional bond and stock markets as well as from proxies of global risk and liquidity conditions. Not surprisingly, the MV-WALD test also suggests significant risk transmission from Islamic stocks to the market for Islamic bonds. The joint volatility test further supports the individual tests, suggesting volatility spillovers to Islamic bonds.

Examining the findings for the causality in variance tests, we observe that the HH test rejects the no causality in variance hypothesis for any of the variables examined at 1 percent level, further supporting the findings from the MV-Wald tests. On the other hand, we observe that the

Table AI.
Volatility spillover tests

Cause variable	MV-Wald	HH	NT-NR
DEVBOND	996.089***	14.397***	16.380***
EMRBOND	1,537.635***	15.734***	2.542
DEVSTOCK	1,070.775***	121.275***	12.302**
EMRSTOCK	147.987***	128.358***	4.587
ISLSTOCK	3,784.835***	94.638***	11.375**
USVIX	1,921.626***	32.025***	7.833*
EMRVIX	1,205.291***	23.226***	0.827
USTB10	1,196.118***	16.203***	13.992***
Joint	24,878.878***	264.221***	229.016***

Notes: The table reports the test results for the null hypothesis of no volatility spillover from the variables in the first column to Islamic bonds as well as a joint volatility spillover test from all other variables to Islamic bonds. The multivariate Wald (MV-Wald) tests are reported for the no volatility spillover restrictions imposed on Equation (1). The MV-Wald test is distributed as χ^2 with two degrees of freedom. HH test is the Hafner and Herwartz (2006) LM test of causality on conditional variance. NT is the Nakatani and Teräsvirta (2010) robust test of the causality in conditional variance. HH and NT tests are LM tests and GARCH(1,1) is used for univariate specification of conditional variances. *,**,***Significant at 10, 5 and 1 percent levels, respectively robust NT test does not reject the null of no causality in variance hypothesis for emerging market related variables, i.e. bonds, stocks, and the volatility index, whereas the test results for all other markets are consistent with the first two formal spillover tests. Overall, our analysis yields significant evidence of volatility spillovers from conventional developed markets to the market for Islamic bonds. Spillover tests for emerging markets provide mixed evidence, however, with the NT causality in variance test suggesting no significant spillover effect from emerging markets while the MV-Wald and HH tests indicate otherwise.

3. Dynamic conditional correlations

The specification in Equations (1) through (3) allows for regime-specific conditional correlations where regime-switching is governed by a discrete Markov process. A battery of tests discussed in Section 4.2 clearly point to a three-regime model in which three distinct market regimes are identified in terms of the level of return volatility. As shown in Panel (c) in Figure 1, the extreme (crash) volatility regime, accounts largely for the global financial crisis period with the maximum regime probability observed for this regime during the second half of 2008 and late-2009. This suggests that the third regime is not simply a statistical artifact, but proxies a true market regime observed during the crisis period. Similarly, high volatility regime is observed during late-2007 and early-2008 while episodes of high volatility regime are also observed during the first and second Greek bailout periods in mid-2010 as well as during late 2011.

Figure 2 presents the plots for the dynamic correlations between Islamic bond returns and the other variables included in the analysis. Since the correlations are estimated as regime-specific correlations, we compute the regime independent correlation between markets *i* and *j* for period *t* as $\rho_{ij,t}=p_{1,t}\rho_{ij,1,t}+p_{2,t}\rho_{ij,2,t}+p_{3,t}\rho_{ij,3,t}$ where $p_{k,t}=P(s_t=k|\psi_{t-1})$ and $k=1,2,3$, is the predictive probability of being in regime *k* at time *t*. We observe that the dynamic correlation estimates presented in Figure 2 are highly time-varying, providing support for the DCC specification against a constant correlation specification. Examining the correlations between Islamic bonds and conventional counterparts, we observe a significant structural break in late-2008 with the correlations displaying a positive trend after this period. On the other hand, examining the correlations between Islamic bonds and stock markets, we observe fairly low correlation values not exceeding 20 percent in most cases. This implies the presence of diversification potential of these bonds for conventional as well as Islamic stock portfolios. Interestingly, we observe negative correlations between Islamic bonds and conventional stock markets more significantly during the 2008 global crisis period, suggesting that Islamic bonds could have served as a safe haven for stock market investors during that period. The finding of negative dynamic correlations between Islamic stock and bond markets is consistent with Aloui *et al.* (2015b) who point to the "flight to quality" phenomenon that drives comovement dynamics across stock and bond markets. Overall, our analysis of dynamic conditional correlations clearly suggest a low degree of association between Islamic bonds and stock market returns with episodes of negative correlations observed, particularly during market crisis periods.

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