Dynamic correlations and volatility linkages between stocks and *sukuk*: Evidence from international markets

Alex Sclip [b,1], Alberto Dreassi [c,2], Stefano Miani [b,3], Andrea Paltrinieri [a,*]

[a] *Banking and Finance, University of Udine, Via Tomadini 30/A, 33100 Udine, Italy*
[b] *University of Udine, Italy*
[c] *University of Trieste, Italy*

JEL classification:
G11
G12

Keywords:
Sukuk
Dynamic correlations
Volatility linkages
Asset allocation
DCC GARCH

A B S T R A C T

An understanding of volatility and co-movements in financial markets is important for portfolio allocation and risk management practices. The current financial crisis caused a shrinkage in values of most assets, an increased volatility and a threat to the survival of several institutional investors. Managing risks and returns within the classic portfolio theory, when correlations across securities soar, is increasingly challenging. In this paper, we investigate the volatility behavior and the co-movements between *sukuk* and international stock indexes. Symmetric multivariate GARCH models with dynamic conditional correlations (DCC) were estimated under Student-*t* distribution. We provide evidence of high correlations between *sukuk* and US and EU stock markets, without finding the well-known *flight to quality* behavior affecting Islamic bonds. We also show that volatility linkages between *sukuk* and regional market indexes are higher during financial crisis. We argue that investors could obtain diversification benefits including *sukuk* in a well-diversified equity portfolio, given their lower volatility compared to equity. But higher volatility linkages and dynamic correlations during financial crises show that they are hybrid instruments between bonds and equity. Our findings are relevant for institutional investors and asset managers that include Islamic bonds in a diversified portfolio.

1. Introduction

The recent global crises showed how cross-country and cross-sector integration increases contagion, in particular in financial markets. Since the pioneer works of Markowitz (1952, 1959) and even more recently, portfolio diversification has been crucial for researchers and practitioners: assets with low correlations, especially during turmoil, are increasingly attractive for investors looking for systemic risk protection.

This partly explains the growing attention on Islamic finance and *sukuk* (or "Islamic bonds"): "certificates representing a proportional undivided ownership right in tangible assets, or a pool of predominantly tangible assets, or a business venture" (IFSB, 2009), belonging to the *Shariah*-compliant financial instruments.

In this paper, we investigate post-crisis volatility linkages and co-movements between *sukuk* and conventional stock markets. We build a cross-country market capitalization weighted index of high-quality *sukuk* and we explore dynamic correlations and volatility linkages with global and emerging market stock indexes in the period 2010–2014.

To the best of our knowledge, this is the first paper assessing co-movements between Islamic bonds and conventional stocks, in spite of being already part of the literature on portfolio diversification (Campbell & Ammer, 1993; Keim & Stambaugh, 1986; Kwan, 1996). Few papers explore co-movements between different Islamic assets (Aloui, Hammoudeh, & Hamida, 2015a, 2015b), or analyze cointegration in Islamic stock markets (Majid, Yusof, & Razal, 2007; Marashdeh, 2005). Few others investigate diversification benefits of *Shariah* compliant stocks or indexes when compared to conventional ones (Achsani, Effendi, & Abidin, 2007; Karim, Kassim, & Arip, 2010; Majid, Meera, Omar, & Aziz, 2009). Only Akhtar et al. (2012) comprehensively examine volatility linkages between Islamic and conventional stocks, bonds and money markets for the period 2007–2010. Our paper differs because we investigate volatility linkages and co-movements between *sukuk* and conventional stock indexes, covering a wider period including European financial crisis (2010–2014).

Sukuk are increasingly part of global institutional investors' portfolios and represent the fastest growing Islamic finance sector: from 8 to 300 billion USD in the period 2003–2014 and is expected to double their current asset value (1 trillion USD) over the next few years (Moody's, 2014). Recently, non-Islamic countries also hosted *sukuk*

* Corresponding author. Tel.: +39 0432249317.
E-mail addresses: sclip.alex@spes.uniud.it (A. Sclip), adreassi@units.it (A. Dreassi), stefano.miani@uniud.it (S. Miani), andrea.paltrinieri@uniud.it (A. Paltrinieri).
[1] Tel.: +39 043224 9317.
[2] Tel.: +39 043224 9350.
[3] Tel.: +39 043224 9320.

http://dx.doi.org/10.1016/j.rfe.2016.06.005

issuances: in mid-2014, the UK became the first western country to host such assets, followed by Luxembourg and Hong Kong (Bloomberg, 2015).

Is this growth attributable to a low correlation with conventional stocks similar to investment grade bonds? Have *sukuk* experienced a *flight to quality* during the European debt crisis? Is there a volatility linkage with emerging market stock indexes? These are our main research questions, investigated adopting the dynamic conditional correlation (DCC) GARCH model of Engle (2002) and Engle and Sheppard (2008) methodology.

Our results suggest that, during the periods of high market volatility, *sukuk* exhibit high correlations with US and EU stock indexes, without experiencing the well-known *flight to quality*. Moreover, we find that volatility linkages between *sukuk* and regional market indexes are stronger during turmoil periods.

Overall, we argue that investors could obtain portfolios' benefits including *sukuk* in a well-diversified equity portfolio, given their lower volatility. This is also coherent with *sukuk* not being exposed to derivatives. Moreover, higher volatility linkages and dynamic correlations during financial crises show that *sukuk* behave as hybrids between bonds and equity and therefore can be considered as an alternative asset class.

Together with the lack of a flight to quality, these findings are relevant for institutional investors and asset managers. Finally, considering *sukuk*'s low liquidity and higher bid-ask spread, they are more suitable for long-term investors, such as pension and hedge funds.

The remainder of the paper is organized as follows. Section 2 provides a short summary of *sukuk* features, whereas Section 3 reviews the literature and explains our hypothesis. Section 4 describes our data and Section 5 reviews our econometric methodology. Section 6 presents and discusses our findings, whereas Section 7 concludes with our final remarks and suggestions for future research.

2. Overview of *sukuk* features

Sukuk, as expressions of Islamic societies, should comply with religious principles (*Shariah*) that govern economic, social and ethical aspects of individuals and institutions (Iqbal & Mirakhor, 2007). Five principles mainly distinguish Islamic financial products: the prohibition on explicit interest rates (*riba*), on transactions subject to excessive uncertainty (*gharar*), on specific markets or products (pork, alcohol, weapons), a required sharing of profit and loss between contractual parties and a direct link of each operation with the real economy.

We can classify *sukuk* into two categories, with effects on their credit risk exposure:

1. *Asset-backed sukuk*, represent a true sale of assets since the underlying has been validly transferred to the Special Purpose Vehicle (SPV). In the event of default, therefore, the underlying assets will remain completely separate from the originator. The *sukuk* holders have full claim over the underlying asset, without any risk of the sale subsequently being inverted by local or *Shariah* courts.
2. *Asset-based sukuk*, where investors only have a beneficial ownership in the underlying asset instead of legal ownership over the underlying asset. In this structure, assets are generally sold by the originator to the SPV in the form of a trust. The trustee issues certificates showing the investor's ownership interest, while the proceeds are used to purchase the assets. The investor receives a distribution income representing a share of the return generated by the underlying assets or from other sources within the originator. Theoretically, in the event of bankruptcy, investors should have a claim or right to the corporate assets. However, it is unsecured and ranked together with other unsecured creditors, without any priority and rated accordingly.

3. Literature review

3.1. Literature on conventional portfolio diversification

The interrelationship between markets is a key feature of investor asset allocation because it is instrumental in determining the risk. Estimating the correlation structure and using this to select superior portfolios is a central key point for portfolio and risk managers. Furthermore, monetary policy authorities use information contained in assets prices with the aim of developing expectations in terms of inflation and business cycle conditions. So understanding the co-movements between stocks and bonds may be useful for their purposes.

Several papers have analyzed the cross-linkage between conventional stock and bond markets. Earlier studies assume a constant relationship between stock and bonds over time. Shiller and Beltratti (1992) find a lower correlation between the two asset classes caused by discount rates. In accordance with the previously mentioned authors, Campbell and Ammer (1993) provide evidence of a similar lower positive correlation, explained by news about future excess stock returns and inflation. The following research provided a refinement by analyzing the time-varying correlations (Andersson, Krylova, & Vähämaa, 2008; Cappiello, Engle & Sheppard 2006; Chiang, Li, & Yang, 2015; Dimic, Kiviaho, Piljak, & Aijo, 2016; Li, 2004, among others), showing that stock and bond prices tend to move in the same direction, even if there are periods of negative correlations.

Despite the large literature, academic researchers have not reached a consensus about the driving forces behind correlations. Connnoly, Stivers, and Sun (2005) claim that stock–bond market correlation decreases with the increase of stock market uncertainty, suggesting that bonds may be a better hedge against stock market downturns. Kim, Moshirian, and Wu (2006), by analyzing the stock–bond market integration in EMU countries, confirm the negative relationship between stock market uncertainty and stock–bond market correlations. Also, another strand of literature investigating the flight-to-quality phenomenon from bonds to stocks shows negative correlations between those asset classes. Baur and Lucey (2009) reveal that flights occur across countries; enhancing the diversification benefits when they are needed most.

Focusing on macroeconomic driving forces, Li (2004) demonstrates that the uncertainty about expected inflation rates is the primary driver of co-movements between stocks and bonds; while unexpected inflation and real interest rates are less influent. Also Andersson et al. (2008) confirm that stock and bond prices tend to move together during periods of high inflation expectations; while lower level of inflation seems to move prices in opposite direction. Moreover, the authors provide further evidence of a negative relationship between stock market volatility and correlations. Yang, Zhou, and Wang (2009), by using a large time span that covers 150 years of data at a monthly frequency, recognize that higher stock–bond correlations tend to follow higher short rates or higher inflation rates. Aslanidis and Christiansen (2014) find that macroeconomic fundamentals are the most useful explanatory variables when the stock–bond correlation is largely negative, while Dimic et al. (2016) argue that the most important factor influencing stock–bond correlation in the short-term is the monetary policy; whereas in the long-term, inflation and stock market uncertainty are the major drivers. Christopher, Kim, and Wu (2012) stress the importance of sovereign credit ratings on time-varying stock and bond market correlations, while Chiang et al. (2015) find evidence that stock–bond correlations are negatively correlated with stock market uncertainty, as measured by the conditional variance and the implied volatility of the S&P 500 index, but positively related to bond market uncertainty.

3.2. Literature review on Islamic finance portfolio diversification

Despite the exponential growth of *Shariah*-compliant debt instruments, the literature has not yet documented the interdependence

between *sukuk* and conventional stocks and the diversification benefits provided by these types of instruments during stock market downturns.

A significant number of studies focus on *sukuk* (Abdulkader & Nathif, 2004; Iqbal & Mirakhor, 2007; Vishwanath & Sabahuddin, 2009), analyzing their structure, features and their different exposure to risks. Rusgianto and Ahmad (2013) examine their volatility through the Dow Jones Citigroup Sukuk Index and their relationship with subprime financial crisis shock. They find that pre- and during-crisis volatility is more sensitive to market events than later. Other authors compare the risk/return profile of *sukuk* with conventional bonds (Fathurahman & Fitriati, 2013; Mosaid & Boutti, 2014; Zin et al., 2011), also through a case study analysis (Cakir & Raei, 2007). Najeeb, Bacha, and Masih (2014) analyze the portfolio diversification opportunities, including *sukuk* in a well-diversified portfolio. They find that returns of local (GCC and Malaysian) currency *sukuk* have low levels of long-term correlations, allowing gains in portfolio diversification; but international currency *sukuk* exhibit high level of long-term correlations.

Recently, several papers explore the interdependencies between *sukuk* and *Shariah*-compliant stocks. Aloui et al. (2015a) assess co-movements between *Shariah stocks* and *sukuk* in the Gulf Cooperation Council countries, finding a strong dependence between them. They also show that Islamic assets don't seem to have a different behavior compared to conventional stock and bond counterparts, with overall portfolio diversification varying across frequencies and time. In a subsequent paper, the same authors (Aloui et al., 2015b), investigating the global factors driving the co-movement, show that oil prices and credit event information had a positive relationship during the 2008–2013 period. Kim and Kang (2012), using a multivariate GARCH model, document the existence of unidirectional volatility spillovers from *Shariah* stocks to *sukuk* during subprime financial crisis.

Those studies are important because they analyze co-movements and dynamic correlations between two different asset classes within Islamic capital markets. Previous literature only investigates the degree of inter-asset class cointegration among Islamic country stock markets. (Bley & Chen, 2006; Majid et al., 2007; Marashdeh, 2005) and the diversification benefits of including *Shariah*-compliant stock indexes in an international stock portfolio (Achsani et al., 2007; Karim et al., 2010; Majid et al., 2009; Rahman & Sidek, 2011, among others).

Finally Akhtar et al. (2012), argue that Islamic assets provide substantial diversification benefits during financial crises. In particular, for the period 2007–2010, volatility linkages between Islamic stocks and bonds are lower than volatility linkages between conventional stocks and bonds. Moreover, the characteristics of Islamic financial markets reduce volatility linkages also between Islamic stocks and conventional bills.

Based on the literature, our hypothesis is that *sukuk* have high volatility linkages and high dynamic correlations with conventional stocks, especially during financial crisis, considering their special structure. In fact, the majority of Islamic bonds are issued with an asset based mode, rather than asset backed. We consider them as a hybrid financial instrument between conventional bonds and stocks. They shouldn't therefore experience the *flight to quality* phenomenon, considering their diversity compared to investment grade conventional bonds, and they could have higher co-movements with equity indexes than conventional bonds. But we also expect that dynamic correlations between *sukuk* and conventional stocks are lower than those among stocks, with Islamic bonds providing some diversification benefits.

4. Sample characteristics and statistical properties

We collect daily data for the 68 most liquid *sukuk*, listed in the major Islamic bond markets, such as Bursa Malaysia, Nasdaq Dubai and London Stock Exchange, from the Bloomberg Professional Service.

In order to test our hypothesis, we decided to build a market capitalization-weighted index by using the same construction methodology and multiple criteria provided by MSCI (2012). We consider only highly liquid *sukuk* with an outstanding amount in excess of 200 million USD that, in terms of credit risk, received at least one credit rating from Moody's, S&P, RAM or MARC. We focus only on dollar-denominated *sukuk*, the majority within this market, excluding those with less than 12 months before maturity. Rebalancing of the index took place every three months, with new issues satisfying the selection criteria included while those with less than one year of maturity are automatically removed. Our *sukuk* index is composed of four contractual forms, well recognized by the literature (Abdulkader & Nathif, 2004; Iqbal & Mirakhor, 2007; Islamic Financial Services Board, 2009): (1) *al mudarabah*, the capital provider and the manager share profits, whereas the former bears all losses except those attributable to misconduct, negligence or breach of contract from the latter; (2) *al ijara*, involving the lease of a specific asset; (3) *al musharakah*, the capital provider and manager share profits as established in the contract and losses in proportion to the quota held; (4) *al wakala*, similar to an agency agreement, where the manager acts on behalf of the capital provider. The number of *al musharakah-mudharabah sukuk* is 27 out of 116, while the others are fixed coupon *sukuk*, in particular *al ijara*. Table 1 summarizes our sample.

Regarding the equity indexes, we gather daily prices of a list of 5 global and 5 emerging MSCI indexes (Table 2), from the Bloomberg professional service.

The daily returns y_t of both equity indexes and the *sukuk* index are computed using logarithmic price changes:

$$y_t = (\ln P_t - \ln P_{t-1}) \tag{1}$$

The sample period is from January 1, 2010 to December 31, 2014. By using daily returns data we are able to capture all the possible interactions; weekly or monthly data block out interactions that last for only a few days. Table 3 provides the time series properties in terms of mean, standard deviation, skewness and kurtosis of the price changes in the indexes selected.

From the reported statistics, we can see that the mean daily returns are positive for all indexes. Stock indexes exhibit higher volatility than the *sukuk* index. Furthermore, the latter is skewed to the right, while eight of ten stock indexes are skewed to the left. All price changes exhibit high values of kurtosis, suggesting that the behavior of selected indexes presents some extreme values. Indeed, as the results in Table 3 show, the Jarque–Bera test rejects the null hypothesis of normality for all series. In an undisplayed figure, daily returns are plotted. From the graphs, we see evidence of volatility clustering. The Ljung–Box autocorrelation test on the first twenty-five lag of the sample autocorrelation function

Table 1
Sample description.
The table illustrates the main characteristics of the asset selected within the sukuk index; in terms of type, size, market value, rating, coupon, time-to-maturity, effective duration, yield-to-maturity and option-adjusted spread.

Features	2010	2011	2012	2013	2014
Issue type					
al mudarabah	3	4	4	4	4
al ijiara	7	8	16	20	19
al musharakah	3	2	1	1	1
al wakala	1	3	5	6	4
Total	14	17	26	31	28
Mean values					
Issue size ('000 USD)	880	825	750	750	750
Market value ('000 USD)	101,617	138,855	185,562	252,943	201,587
Rating	A+	A+	A	A+	A+
Coupon	5.13	5.02	4.78	4.15	3.88
Time-to-maturity	3.74	3.63	4.05	3.91	3.76
Effective duration	3.1	3.09	3.28	3.5	3.62
Yield-to-maturity	7.17	4.59	2.97	2.54	2.34
Option-adjusted spread	253.21	236.51	252.95	184.38	134.81

Table 2
List of MSCI stock indexes selected.
The table lists the MSCI stock indexes included in our sample, together with their Bloomberg professional service code.

Index	Code
Global stock indexes	
MSCI Europe	MXEU
MSCI United States	MXUS
MSCI Emerging Markets	MXEF
MSCI Frontier Markets	MXFEM
MSCI Asia Pacific	MXAP
Emerging markets stock indexes	
MSCI Turkey	MXTR
MSCI Qatar	MXQA
MSCI United Arab Emirates	MXAE
MSCI Malaysia	MXMY
MSCI Indonesia	MXID

(LM test) far all the daily price changes show significant autocorrelation at the 1% level.

The unconditional correlations between the asset series are given in the following Table 4. The *sukuk* index and all the stock indexes are positively correlated. Preliminary analysis suggest (unconditionally) higher correlations between the *sukuk* index and the emerging market stock indexes, which could be an indication that bonds in emerging markets are more equity alike than in developed countries.

5. Econometric methodology

Multivariate GARCH models are designed with the aim of study volatilities and correlations co-movements between markets, in order to provide better decision tools in portfolio selection, asset pricing and risk management techniques. The literature has provided several multivariate GARCH models, such as the VECH, BEKK, CCC and DCC models. Among the several multivariate models, we decided to use the DCC model of Engle (2002), the choice of methodology follows Engle and Sheppard (2008): even using standard univariate GARCH specifications, DCC offers better performance in terms of portfolio allocation among the families applicable to large panel models and therefore is more powerful than the constant correlation estimator developed by Bollerslev (1990).

Table 3
Main descriptive statistics of daily price changes in sukuk and stock indexes.
The table illustrates descriptive statistics, normality test and the Ljung–Box autocorrelation test of daily price changes for our indexes selected for the period 2010–2014.

	Mean	St. Dev.	Skewness	Kurtosis	Normality test	LM test
Sukuk	0.036%	0.165%	1.401	18.040	2.2e-16***	28.60***
Global						
MSCI Europe	0.040%	1.028%	−0.063	3.751	2.2e-16***	30.56***
MSCI United States	0.059%	0.986%	−0.407	4.891	2.2e-16***	63.70***
MSCI Emerging Markets	0.013%	1.017%	−0.324	2.914	2.2e-16***	104.90***
MSCI Frontier Markets	0.029%	0.577%	−0.677	3.235	2.2e-16***	121.87***
MSCI Asia Pacific	0.025%	0.957%	−0.362	1.858	2.2e-16***	30.36***
Emerging Markets						
MSCI Turkey	0.054%	1.522%	−0.346	3.387	2.2e-16***	30.14***
MSCI Qatar	0.061%	0.912%	0.724	15.038	2.2e-16***	42.28***
MSCI United Arab Emirates	0.076%	1.477%	0.118	8.815	2.2e-16***	41.35***
MSCI Malaysia	0.034%	0.572%	−0.249	3.922	2.2e-16***	53.55***
MSCI Indonesia	0.059%	1.378%	−0.381	5.473	2.2e-16***	71.98***

Significance codes: '***' denotes coefficients statistically different from zero at the 1% level.

Table 4
Unconditional correlations between indexes.
The table illustrates unconditional correlations at the global and regional level.

Unconditional correlations at the Global level

	SUKUK	MXEU	MXUS	MXEF	MXFEM	MXAP
SUKUK	1	22.07%	10.06%	34.33%	33.44%	34.81%
MXEU		1	69.76%	68.18%	54.62%	41.99%
MXUS			1	50.95%	49.22%	23.84%
MXEF				1	74.82%	81.01%
MXFEM					1	60.61%
MXAP						1

Unconditional correlations at the regional level

	SUKUK	MXTR	MXQA	MXAE	MXMY	MXID
SUKUK	1	21.14%	23.36%	30.94%	29.89%	29.60%
MXTR		1	12.83%	17.61%	19.83%	30.78%
MXQA			1	53.24%	27.46%	28.19%
MXAE				1	26.73%	31.07%
MXMY					1	54.13%
MXID						1

SUKUK is the *sukuk* index. MXEU is MSCI EUROPE stock index. MXUS is MSCI United States stock index. MXEF is the MSCI Emerging Markets stock index. MXFEM is the MSCI frontier markets index. MXAP is the MSCI Asia Pacific stock index. MXTR is the MSCI Turkey stock index. MXQA is the MSCI Qatar stock index. MXAE is the MSCI United Arab Emirates stock index. MXMY is the MSCI Malaysia stock index. MXID is the MSCI Indonesia stock index.

We implement our DCC model in three steps. Firstly, univariate volatilities are selected by using the Bayesian information criterion (BIC) from a class of GARCH models capable of capturing the common features of financial asset returns variances. We include the following models, all with one lag of innovation and one lag of volatility: (1) GARCH (Bollerslev, 1986); (2) EGARCH (Nelson, 1991); (3) GJR-GARCH (Glosten, Jagannathan, & Runkle, 1993).

Once the univariate models are estimated, the standardized residuals are used to estimate the correlation parameters and the persistence parameters α and β. We implement the asymmetric DCC model; in order to take into accounts the asymmetric return volatility of equity time series (Cappiello et al., 2006).

5.1. The univariate GARCH model and asymmetric extensions

The GARCH model introduced by Bollerslev (1986) expressed conditional variance as a linear function of the square past values of the series. A generic GARCH (p,q) model can be described as follows:

$$h_t = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 \tag{2}$$

where the α_i and β_j are non-negative constants and ω is a positive constant.

Since the conditional variance in Eq. (2) is a function of the lagged residuals and not their signs, the model enforces a symmetric response of volatility to positive and negative shocks.

The exponential GARCH model is the first to investigate the leverage effects; which refer to the fact that down-movement are more influential for predicting volatility than the upward movements. Nelson's (1991) EGARCH attempts to model fat tails in stock index returns by using a generalized exponential distribution; in formula, the model can be represented as follows:

$$log(h_t) = \omega + \sum_{i=1}^{q} \alpha_i \frac{|\varepsilon_{t-i}|}{\sigma_{t-i}} + \sum_{i=1}^{q} \gamma_i \frac{\varepsilon_{t-i}}{\sigma_{t-i}} + \sum_{j=1}^{q} \beta_j \, log\sigma_{t-j}^2 \tag{3}$$

Eq. (3) allows negative values of ε_t to have different impacts on volatility. Since the coefficient γ_i is typically negative, the model claims an asymmetric behavior in volatility.

The GJR model of Glosten et al. (1993) introduces asymmetry as a function of the positive and negative parts of the past innovations; and can be defined as

$$h_t = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \gamma_i \varepsilon_{t-i}^2 \mathbb{I}_{\{\varepsilon_{t-i}>0\}} + c\sum_{j=1}^{p} \beta_j \sigma_j^2 \quad (4)$$

In this model, good news ($\varepsilon_t^2>0$) and bad news ($\varepsilon_t^2<0$) have a different impact on the conditional variance. More specifically, good news has an impact of α, while bad news has an impact of $(\alpha+\gamma)$. Hence, the leverage effect is present when $\gamma>0$.

The univariate GARCH models were estimated through the maximum likelihood approach of Bollerslev and Wooldridge (1992), where the log-likelihood function from the Gaussian normal distribution.

5.2. The multivariate GARCH model

The dynamic conditional correlation (DCC) model of Engle (2002) is a generalization of the CCC model, which allows the correlation matrix to vary over time rather than requiring them to be constant.

The DCC model of Engle is defined as

$$H_t = D_t R_t D_t \quad (5)$$

where

H_t is a $n \times n$ matrix of conditional variances;

D_t is a $n \times n$ diagonal matrix of time-varying standard deviations from univariate GARCH models (h_t), in formula:

$$D_t = diag\left(h_{11t}^{\frac{1}{2}} \ldots\ldots h_{NNt}^{\frac{1}{2}}\right) \quad (6)$$

R_t is the correlation matrix, defined as

$$R_t = diag[Q_t]^{-1} Q_t diag[Q_t]^{-1} \quad (7)$$

where the $n \times n$ symmetric positive definite matrix $Q_t = (q_{ij,t})$ is given by

$$Q_t = (1-\alpha-\beta)\overline{Q} + \alpha u_{t-1} u_{t-1}' + \beta Q_{t-1} + \gamma\left(g_t g_t'\right) \quad (8)$$

with the standardized residuals $u_t = \varepsilon_{it}/\sqrt{h_{iit}}$, α and β are non-negative scalar parameters satisfying $\alpha+\beta<1$, and the vectors g_t are defined as the negative parts of u_t as follows:

$$g_{i,t} \equiv \begin{cases} u_{i,t} \text{ if } u_{i,t}<0 \\ 0 \text{ if } u_{i,t} \geq 0 \end{cases}, i = 1, \ldots, N.$$

DCC parameters are estimated by quasi-maximum likelihood by construction: because the model is implemented in three different steps, even though in each of these stages, a log-likelihood function is estimated. In the third step, given the results of the Jarque–Bera test of normality, we relax the normality assumption and we adopt a Student-t multivariate distribution for the time series returns, which is more suitable and gives better estimation results.

We use a three-stage approach rather than estimating all the volatility models and correlation models simultaneously because, in practice, it is more feasible for large portfolios even if the estimator is less efficient.

6. Empirical results

6.1. The univariate models

The first step of the DCC model consist of fitting univariate GARCH specification to each of the time series and selecting the best one according to the BIC criterion. Table 5 summarizes information of the GARCH process selected ant the estimated parameters. In accordance with Cappiello, Engle, and Sheppard (2006), which claims that equity returns show strong evidence of asymmetries in conditional volatility, we find that six of the 10 GARCH models selected contain an asymmetric term. More precisely, the symmetric GARCH model is more suited to capturing volatility dynamics of the *sukuk* market, Europe, United States, United Arab Emirates and Indonesia indexes; while the asymmetric counterparts (EGARCH and GJR-GARCH) perform better in capturing volatilities of the MSCI Emerging Markets, Frontiers, Asia Pacific, Turkey, Qatar and Malaysia indexes.

As shown from Table 5, for the case of the US and European indexes, the α parameter is relatively large suggesting that volatility is very sensitive to market events. Regarding the other three global indexes, we find a large leverage effect. Moving on emerging market indexes, we find that the parameter γ measuring the leverage effect is highly significant in Turkey, Qatar and Malaysia. The α parameters, measuring the reaction of conditional volatility to market shocks, are significant in emerging market stock indexes.

On comparing the results and its implication for the *sukuk* market, we find that the *sukuk* index exhibits a lower α value and an higher β value than the stock indexes; suggesting a lower reaction to market shocks and an higher persistence in conditional volatility. Furthermore, there is no leverage effect in the *sukuk* market.

Concerning the goodness of fit tests the weighted Ljung–Box test on standardized residuals, computed with 10 lags, show for all the univariate specifications no serial correlation and no remaining ARCH test. Thus, the different models are correctly set for all the time series, since there is no evidence of statistical misspecification.

6.2. DCC specifications

We run two asymmetric DCC models, the first for all the global indexes and the *sukuk* index, in order to analyze volatilities and dynamic correlations at the global level. The second between the *sukuk* index and the emerging market stock indexes selected, with the aim of analyzing linkages at the regional level. Table 6 summarizes the results. According

Table 5
Univariate GARCH models.
The table reports the selected specifications and parameter estimates for the univariate GARCH models.

Assets	Model selected	ω	α	δ or γ	β
Sukuk	GARCH	0.000007**	0.0721***		0.9275***
Global indexes					
MSCI Europe	GARCH	0.000002**	0.0914***		0.8287***
MSCI United States	GARCH	0.000003*	0.1351***		0.8307***
MSCI Emerging Markets	EGARCH	−0.1137***	−0.0866***	0.0659***	0.9877***
MSCI Frontier Markets	EGARCH	−0.4205	−0.0967*	0.1242***	0.9596***
MSCI Asia Pacific	EGARCH	−0.1784***	−0.0923***	0.1044***	0.9811***
Emerging markets indexes					
MSCI Turkey	GJR-GARCH	0.00001***	0.0242***	0.1242***	0.8614***
MSCI Qatar	GJR-GARCH	0.000001*	0.0411**	0.0454***	0.9151***
MSCI United Arab Emirates	GARCH	0.000004**	0.0604***		0.9221***
MSCI Malaysia	EGARCH	0.000002**	−0.1218***	0.1967***	0.9351***
MSCI Indonesia	GARCH	0.000009***	0.1595***		0.8028***

Significance codes: '***' express significance at the 0.999 level, '**' at 0.99, '*' at 0.95.

Table 6
DCC GARCH models.
This table reports parameters estimates and log-likelihood values for the two asymmetric DCC GARCH models.

Global indexes				
Assets	ω	α	δ or γ	β
Sukuk	0.000001*	0.0708**		0.9212***
MSCI Europe	0.000003*	0.0933*		0.8804***
MSCI United States	0.000003*	0.1353***		0.8302***
MSCI Emerging Markets	−0.000066***	−0.1147***	−0.0891***	0.9876***
MSCI Frontier Markets	0.00019**	−0.0945***	−0.0415***	0.9600***
MSCI Asia Pacific	−0.0001***	−0.0891***	0.1066***	0.9813***
Log-likelihood	31,030.87			
Emerging Markets				
Assets	ω	α	δ or γ	β
Sukuk	0.000001*	0.0708**		0.9212***
MSCI Turkey	0.000011***	0.0237**	0.1207***	0.8654***
MSCI Qatar	0.000001*	0.0441*	0.0406*	0.9345***
MSCI United Arab Emirates	0.000004***	0.0592***		0.9231***
MSCI Malaysia	0.00019***	−0.1185***	0.1932***	0.9347***
MSCI Indonesia	0.000008**	0.1422***		0.8223***
Log-likelihood	28,733.2			

Significance codes: '***' express significance at the 0.999 level, '**' at 0.99, '*' at 0.95.

to the information criteria, and likelihood ratio test, we set a multivariate Student-*t* distribution, which is more appropriate than the Gaussian counterpart.

Focusing on global indexes, as in the univariate models, in all cases, coefficients are highly significant. For the six indexes, the β parameter is highly significant, suggesting a high degree of persistence in volatility. Moreover, the asymmetric terms γ are highly significant, suggesting the presence of leverage effects.

Results of the univariate models were confirmed also for emerging markets indexes. In particular, all the parameters are significant. The beta parameter is highly significant only in Qatar, UAE and Malaysia; on the contrary in all the other countries volatilities are not persistent. The model confirms the higher significance of the leverage effect in emerging and frontiers stock indexes. Regarding the goodness-of-fit tests for the two DCC models, we run the Ljung–Box computed with 20 lags and we do not find serial correlation and remaining ARCH effect; suggesting no evidence of statistical misspecification.

6.3. Volatility linkages

A simple criterion to analyze volatility linkages is the unconditional correlation between estimated variances.

Conditional variances between equity indexes and the *sukuk* index are moderately correlated at a global level, whereas volatility linkages are much stronger at the regional level (see Table 7).

Fig. 1 plots the univariate conditional volatility series. In absolute terms, the *sukuk* index volatility is nearly ten times lower than that observed in all of the stock indexes. Volatility tends to be lower in Islamic market debt due to the rules of Islamic finance, such as the prohibition of speculation and short selling. A further reason for the lower volatility can be the weak secondary market in most of Islamic countries (Tariq, Dar, & Dar, 2007) and the subsequent higher *bid-ask spread* in the Islamic debt market. Hence, the prevailing behavior of *sukuk* investors to hold these instruments until maturity, without selling them to third counterparts.

However, as expected, the volatility of emerging markets stock indexes is usually higher in absolute terms than that observed at the global level. In particular, volatility in Turkey and UAE stock indexes is twice the average observed in global stock indexes.

Table 7
Unconditional correlations between estimated variances.
This table illustrates the unconditional correlations across indexes estimated variances.

Assets	All	2010	2011	2012	2013	2014
Global						
Sukuk-Europe	0.373	0.118	0.406	0.131	0.385	0.485
Sukuk-United States	0.360	−0.097	0.434	−0.057	0.148	0.372
Sukuk-Emerging Markets	0.396	0.200	0.311	0.342	0.740	0.434
Sukuk-Frontiers	0.358	0.052	0.387	0.347	0.696	0.650
Sukuk-Asia Pacific	0.401	0.136	0.353	0.380	0.650	0.267
Regional						
Sukuk-Turkey	0.250	0.307	0.439	0.520	0.463	0.426
Sukuk-Qatar	0.084	0.251	0.043	0.673	0.488	0.332
Sukuk-UAE	0.199	0.464	0.240	0.476	0.621	0.633
Sukuk-Malaysia	0.246	0.153	0.410	0.313	0.276	0.536
Sukuk-Indonesia	0.307	0.335	0.528	0.230	0.752	0.014

As shown from the plots, at the global level the volatility linkage between the *sukuk* index and both the European and US stocks is most evident during certain tumultuous periods, such as the sovereign European debt crisis in the second half of the 2011; while in periods of bull stock markets, volatility linkages are less stronger. Moreover, by comparing the volatility behavior of the *sukuk* index with the other three global stock indexes, we find a much more similar behavior than that observed previously. In particular, the convergence of volatilities during 2013 could reflect the downturn and the increase in volatility sparked by speculations that the Federal Reserve was looking to reduce stimulus efforts. The first tapering *rumors* during mid-2013 caused an increase in volatility in *sukuk*, emerging and frontier markets equity, considering that investors were ready to draw financial resources from emerging markets to invest in US dollar assets, expecting an appreciation of the US currency.

Looking at the regional level (Fig. 2), as mentioned above, the volatility linkage is much more pronounced, especially in those countries more sensitive to financial crisis and capital flows such as Turkey and UAE. In particular, we find a strong linkage between the *sukuk* index and the UAE stock index, more evident during the last two years. This is consistent with the literature findings and it is related to the fact that volatility linkages in Islamic countries, especially in the Mena region, are stronger than in non-Islamic countries (Akhtar, Jahromi, John, & Moise, 2012; Bley & Chen, 2006).

6.4. Dynamic conditional correlations

Figs. 3 and 4 plot the estimated DCCs between the global MSCI indexes and the *sukuk* index during the sample period. Conditional correlations between *sukuk* and global stock indexes are time-varying and remained positive and relatively low during the time span.

First of all, we compare the correlation between US and EU stock indexes and the *sukuk* index. As Fig. 3 shows, conditional correlations increase during periods of high stock market volatility, such as in the second half of the 2011. We notice the same behavior in the first half of both 2012 and 2013, although volatility linkages experienced a downturn during those years. This result is in contrast with the *flight-to quality* and *flight-from quality* phenomena, documented by Baur and Lucey (2009) and Connnoly et al. (2005) among others, which suggest a negative correlation between bonds and stocks during periods of high stock market volatility.

As shown in Fig. 3, dynamic correlations between Emerging Markets, Frontiers and Asia Pacific stock indexes and the *sukuk* index experienced a different behavior. Indeed, we denote evidence of greater co-movements between these assets in the first three years. Our results are consistent with Kelly, Martins, and Carlson (1998), who revealed greater degrees of co-movement between stocks and bonds in emerging

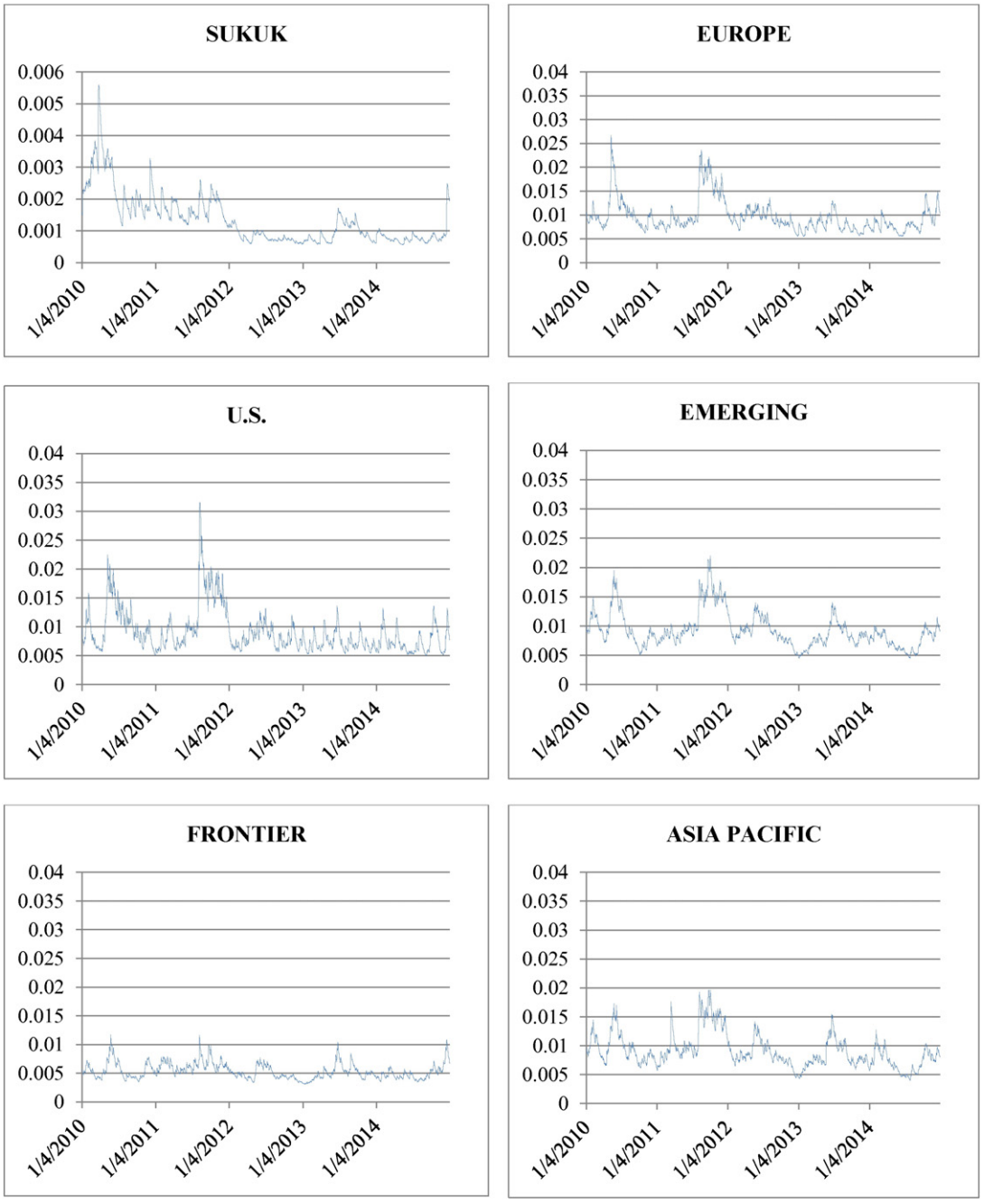

Fig. 1. *Sukuk* and global index volatility.

markets than in mature markets. According to the authors, the reason is related to country risk, which is more relevant in emerging economics and makes domestic bond returns more similar to equities. Focusing on the last two years (2013, 2014), despite the slight increase in volatility linkages, the plot shows a small decrease in dynamic conditional correlations.

Fig. 4 presents correlations between the *sukuk* index and five stock markets: Turkey, Qatar, UAE, Malaysia and Indonesia. The correlation between *sukuk*, Turkey, Malaysia and Indonesia slightly increased after the burst of the European sovereign debt crisis, from a value of 0.25 to 0.35. Moreover, even the volatility linkage had increased in size. At the same time, we do not notice the same upturn in both correlations and volatility linkages with UAE and Qatar stock indexes. The main explanation for this different behavior is related to the fact that equity indexes from UAE and Qatar are less affected by global factors during the sample period, as suggested from the increased returns experienced in that period.

In 2012 and in the first half of 2013, emerging stocks faced an exponential increase in returns, just when we could notice a 0.1 decrease in conditional correlations between *sukuk* and all the emerging market indexes. Conditional correlations between *sukuk*, Turkey, UAE, Qatar and Malaysia stock indexes rose during the market correction experienced after the speculations about the FED tapering.

To sum up, by analyzing the conditional correlations at the regional level, we confirm the same co-movements observed at the global level with emerging markets, frontiers and the *sukuk* index during the time span. In contrast with previous literature, we would rather therefore consider *sukuk* as an alternative asset class more than an asset-backed security. Indeed, *Shariah*-compliant bonds have unique characteristics as they hybrid financial instruments between conventional bonds and

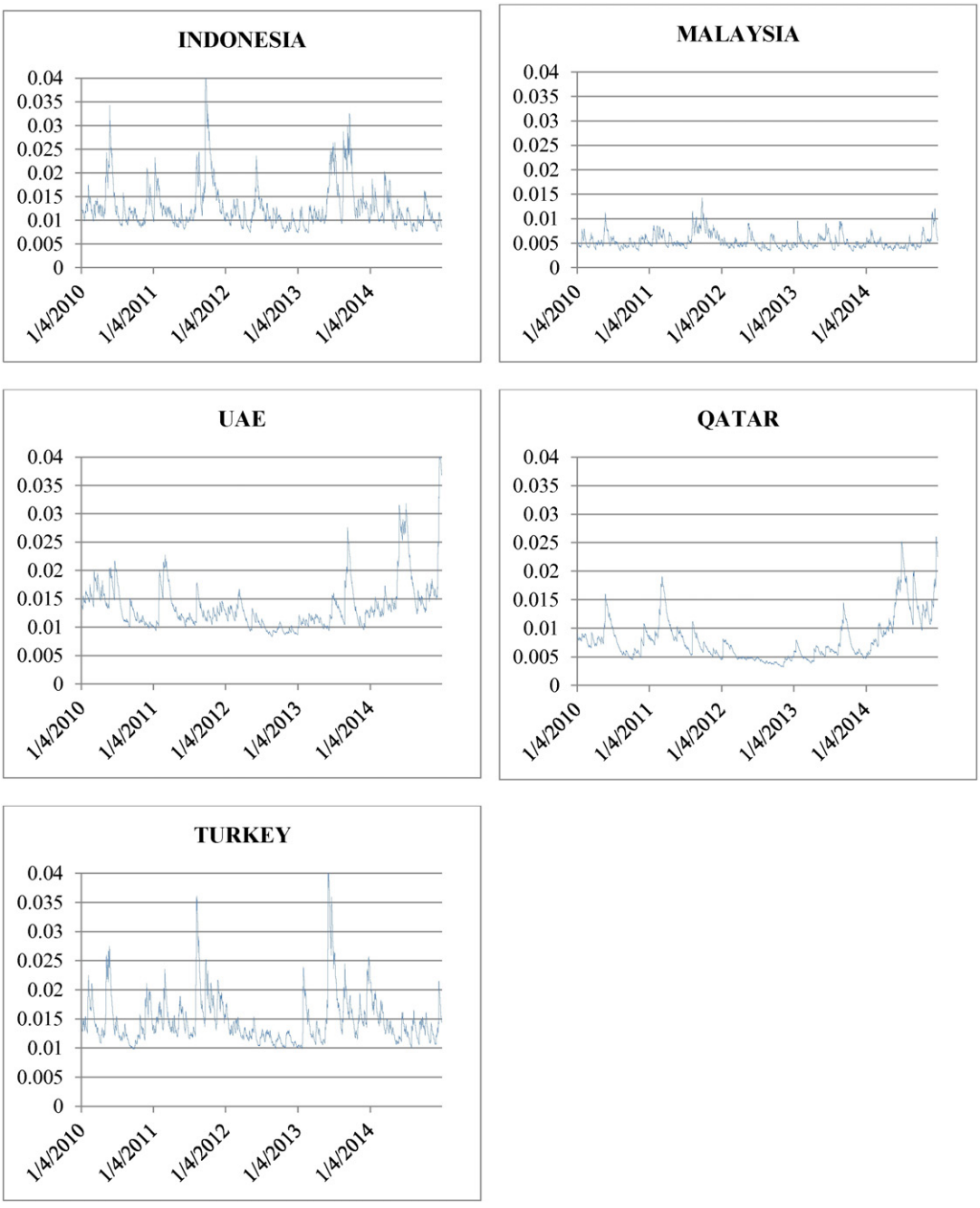

Fig. 2. Regional index volatility.

stocks, following both movements. In terms of diversification benefits, we argue that investors could obtain portfolios' benefits including *sukuk* in a well-diversified equity portfolio, given their lower volatility compared to equity. But since volatility linkages between *sukuk* and regional market indexes are stronger during turmoil periods and the co-movements between volatilities and correlations tend to increase risk in the long run, institutional investors have to be careful in dealing with Islamic bonds, also considering the relatively lower liquidity and higher *bid-ask spreads* of secondary markets in which they are traded.

7. Conclusions

The aim of this paper is to investigate volatility linkages and co-movements between *sukuk* and international conventional stock markets in the aftermath of the global crisis. We also explore, using the DCC GARCH model, the dynamic correlations between a cross-country market capitalization weighted index of *sukuk* listed in developed and developing countries and ten global and emerging market stock indexes during the period 2010–2014.

We extend the literature on *sukuk* and on portfolio benefits obtained by including *Shariah* compliant financial instruments, since this is the first paper investigating the relationship between *sukuk* and conventional stock market indexes. Our main hypothesis, indeed, is that *sukuk* are hybrid bonds, with similar characteristics to both equities and conventional bonds, due to the specific Islamic Finance framework.

Our results suggest that, during the periods of high market volatility, *sukuk* exhibit high correlations with US and EU stock indexes, without experiencing the well-known *flight to quality* phenomenon that

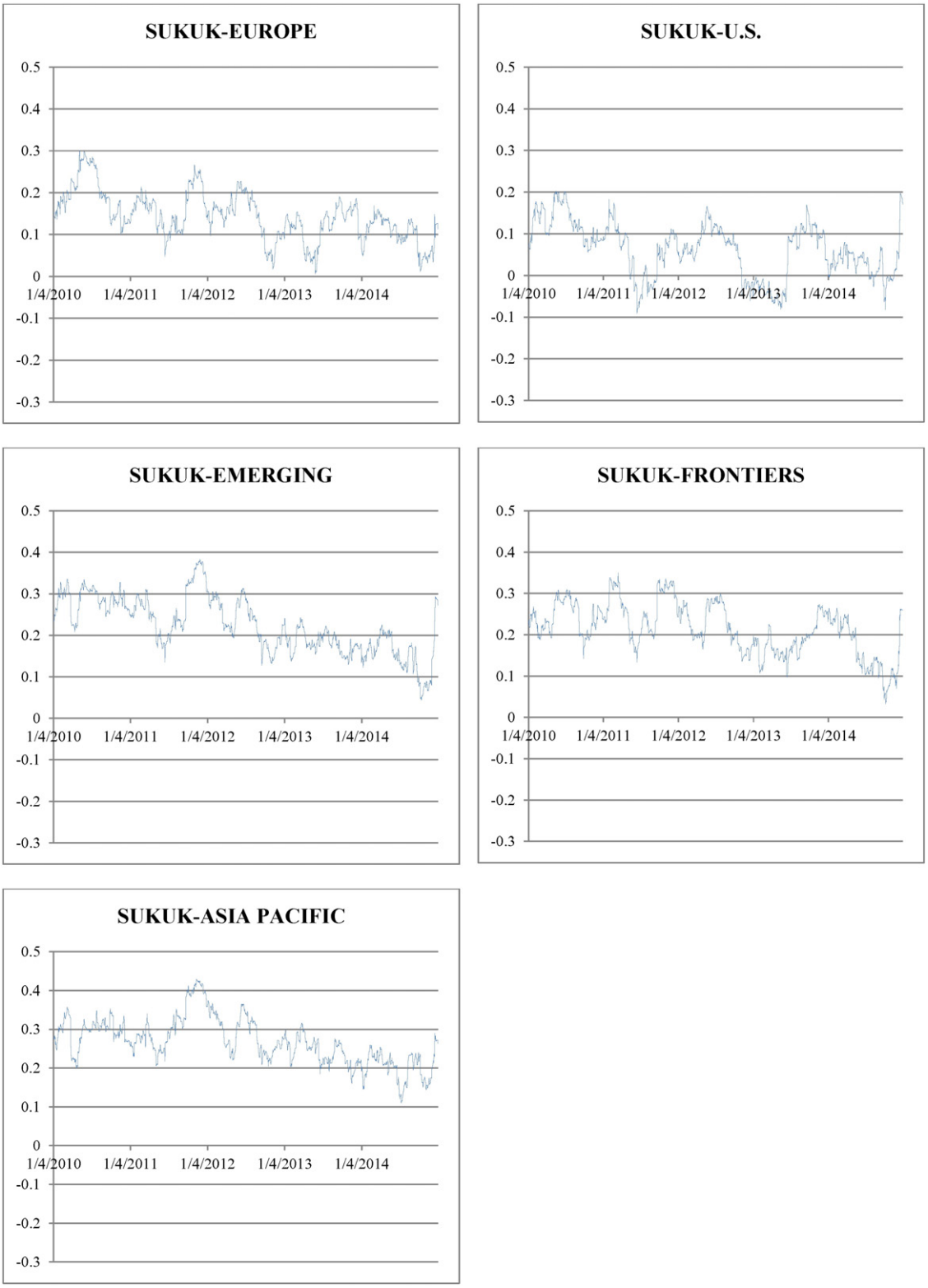

Fig. 3. Global index dynamic correlations.

happens with conventional bonds according to the literature. We also provide evidence that volatility linkages between *sukuk* and regional market indexes are stronger during turmoil periods.

Our findings are relevant for institutional investors and asset managers, that could obtain benefits by including *sukuk* in a well-diversified equity portfolio, given their lower volatility compared to equity. This result could be explained by the fact that *sukuk*, regardless of the contractual form (asset-based or asset-backed) are not exposed to financial instruments that could feed the overall volatility of the instrument.

Since volatility linkages between *sukuk* and regional market indexes are stronger during financial crisis, institutional investors have to be careful in dealing with Islamic bonds. They also have to consider the specific characteristics of the markets in which *sukuk* are traded,

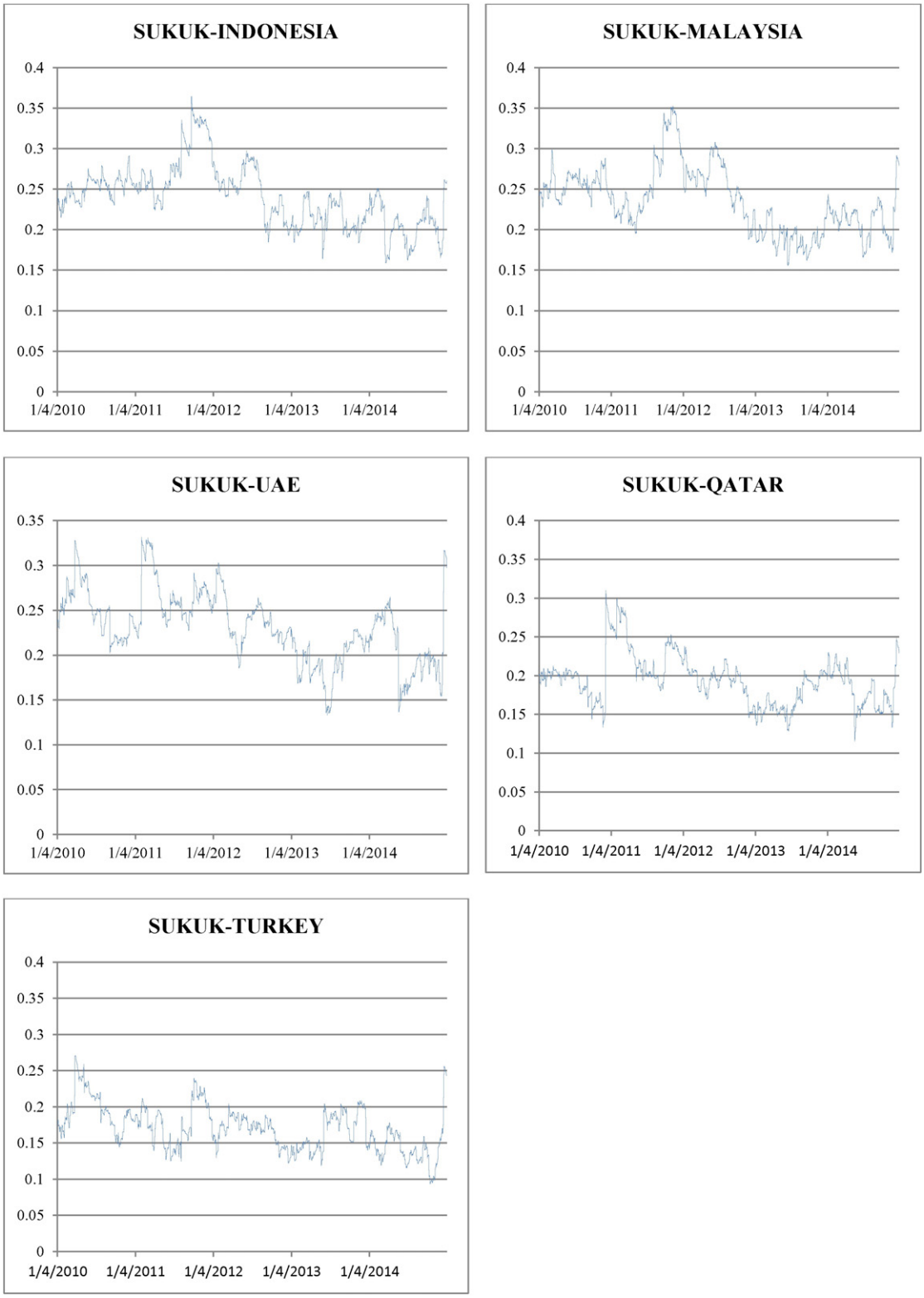

Fig. 4. Regional index dynamic correlations.

especially the lower liquidity and higher bid-ask spreads, which could force investors to hold the *Shariah*-compliant bonds until maturity.

From our analysis, *sukuk* appear as an alternative asset class that long-term investors, such as pension funds, hedge funds, insurance companies and sovereign wealth funds may consider in terms of diversification.

We have to frame all these remarks within the sample period (2010–2014) considering that *sukuk* phenomenon hasn't been relevant worldwide before 2010. During this period, we have witnessed low inflation, low GDP, interest rates tending to zero in most developed countries, and in general low interest rates also in the emerging markets due to dovish monetary policies and quantitative easing in US and Japan (in

Europe, we also had some bond buying over the sample period). Correlations intra- and inter-asset classes could be easily affected by this environment and show higher values than in previous periods (for example, before US subprime financial crisis).

Therefore, future research on *sukuk* is required to verify if this behavior would also persistin future economic cycles. Moreover, with more *sukuk* issued, it could be possible to compare them with regional stocks (e.g. within Europe or within specific emerging markets), in order to achieve more robust results.

References

Abdulkader, T., & Nathif, A. (2004). Islamic bonds: Your guide to structuring, issuing and investing in sukuk. *Working paper: Economy Institutional Investors.*

Achsani, N. M., Effendi, J., & Abidin, Z. (2007). Dynamic interdependence among international Islamic stock market indices: evidence from 2000 to 2007. *Proceeding of the International Conference of the Islamic Capital Markets. Jakarta, Indonesia: organized by the Islamic Research and Training Institute: Islamic Development Bank.*

Akhtar, S. M., Jahromi, M., John, K., & Moise, C. E. (2012). Intensity of volatility linkages in Islamic and conventional markets. *Working paper: AFA 2012 Chicago Meetings Paper.*

Aloui, C., Hammoudeh, S., & Hamida, H. B. (2015a). Co-movement between Shariah stocks and sukuk in the GCC markets: A time–frequency analysis. *Journal of International Financial Markets Institutions and Money*, *34*, 69–79.

Aloui, C., Hammoudeh, S., & Hamida, H. B. (2015b). Global factors driving structural changes in the co-movement between Shariah stocks and sukuk in the Gulf Cooperation Council countries. *North American Journal of Economics and Finance*, *31*, 311–329.

Andersson, M., Krylova, E., & Vähämaa, S. (2008). Why does the correlation between stock and bond returns vary over time? *Applied Financial Economics*, *18*, 139–151.

Aslanidis, N., & Christiansen, C. (2014). Quantiles of the realized stock–bond correlation and links to the macroeconomy. *Journal of Empirical Finance*, *28*, 321–331.

Baur, D. G., & Lucey, B. M. (2009). Flights and contagion—An empirical analysis of stock–bond correlations. *Journal of Financial Stability*, *5*(4), 339–352.

Bley, J., & Chen, K. H. (2006). Gulf Cooperation Council (GCC) stock markets: The dawn of a new era. *Global Finance Journal*, *17*, 75–91.

Bloomberg (2015). http://www.bloomberg.com/news/articles/2015-03-09/euro-debt-gains-favor-astelekom-malaysia-sells-islamic-finance

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

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

Bollerslev, T., & Wooldridge, J. (1992). Quasi-maximum likelihood estimation and inference in dynamic models with time-varying covariances. *Econometric Reviews*, *11*, 79–143.

Cakir, S., & Raei, F. (2007). Sukuk vs Eurobonds: Is there a difference in value-at-risk? *Working Paper: IMF WP/07/237.*

Campbell, J., & Ammer, J. (1993). What moves the stock and bond market? A variance decomposition for long-term asset returns. *Journal of Finance*, *48*, 3–37.

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

Chiang, T. C., Li, J., & Yang, S. Y. (2015). Dynamic stock–bond return correlations and financial market uncertainty. *Review of Quantitative Finance and Accounting*, *45*, 59–88.

Christopher, R., Kim, S. J., & Wu, E. (2012). Do sovereign credit ratings influence regional stock and bond market interdependencies in emerging countries? *Journal of International Financial Markets Institutions and Money*, *22*, 1070–1089.

Connnoly, R., Stivers, C., & Sun, L. (2005). Stock market uncertainty and the stock–bond return relation. *Journal of Financial and Quantitative Analysis*, *40*, 161–194.

Dimic, N., Kiviaho, J., Piljak, V., & Aijo, J. (2016). Impact of financial market uncertainty and macroeconomic factors on stock–bond correlation in emerging markets. *Research in International Business and Finance*, *36*, 41–51.

Engle, R. (2002). Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business & Economic Statistics*, *20*(3), 339–350.

Engle, R., & Sheppard, K. (2008). Evaluating the specification of covariance models for large portfolios. *Working paper: New York University.*

Fathurahman, H., & Fitriati, R. (2013). Comparative analysis of return on sukuk and conventional bonds. *American Journal of Economics*, *3*, 159–163.

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

IFSB (2009). Capital adequacy requirements for sukuk securitization and real estate investment. http://www.ifsb.org/standard/eng_%20IFSB7%20Capital%20Adequacy%20Requirements%20for%20Sukuk,%20Securitasations%20and%20Real%20Estate%20investment%20(Jan2009).pdf

Iqbal, M., & Mirakhor, A. (2007). *An introduction to Islamic finance: Theory and practice.* Chichester: John Wiley & Sons.

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

Keim, D. B., & Stambaugh, R. F. (1986). Predicting returns in the stock and bond markets. *Journal of Financial Economics*, *17*, 357–390.

Kelly, J. M., Martins, L. F., & Carlson, J. H. (1998). The relationship between bonds and stocks in emerging countries. *Journal of Portfolio Management*, *24*, 110–122.

Kim, H. B., & Kang, S. H. (2012). Volatility transmission between the Shariah stock and sukuk GII markets in Malaysia. http://search.yahoo.com/search;_ylt=AuynaOiNRkSG9bf6F4qvcFebvZx4?p=volatility%2C+causality

Kim, S. J., Moshirian, F., & Wu, E. (2006). Evolution of international stock and bond market integration: Influence of the European Monetary Union. *Journal of Banking & Finance*, *30*, 1507–1534.

Kwan, S. H. (1996). Firm-specific information and the correlation between individual stocks and bonds. *Journal of Financial Economics*, *40*, 63–80.

Li, L. (2004). Macroeconomic factors and the correlation of stock and bond returns. *Proceeding of the 2004 American Finance Association Meeting.*

Majid, M., Meera, A. K. M., Omar, M. A., & Aziz, H. A. (2009). Dinamic linkages among ASEAN-5 emerging stock markets. *International Journal of Emerging Markets*, *4*, 160–184.

Majid, M., Yusof, R. M., & Razal, A. N. (2007). Dynamic financial linkages among selected OIC countries. *Journal of Economic Cooperation Among Islamic Countries*, 28.

Marashdeh, H. (2005). Stock market integration in the MENA region: An application of the ARDL bounds testing approach. *Working paper: University of Wollongong.*

Markowitz, H. (1952). Portfolio selection. *Journal of Finance*, *7*, 77–91.

Markowitz, H. (1959). Portfolio selection: Efficient Diversification of Investments. *Cowles Foundation Monograph: Wiley.*

Moody's (2014). Sovereign sukuk: Issuance rises as new governments enter islamic capital markets. *Moody's report.*

Mosaid, F., & Boutti, R. (2014). Sukuk and bond performance in Malaysia. *International Journal of Economics and Finance*, *6*, 226–234.

MSCI (2012). *Index calculation methodology for the MSCI equity indices.*

Najeeb, S. F., Bacha, O., & Masih, M. (2014). Does a held-to-maturity strategy impede effective portfolio diversification for Islamic bond (sukuk) portfolios? *A multi-scale continuous wavelet correlation analysis. Working paper: MPRA, 56956.*

Nelson, D. B. (1991). Conditional heteroskedasticity in asset returns: A new approach. *Econometrica*, *59*, 347–370.

Rahman, A. A., & Sidek, N. Z. M. (2011). Spillover effect of US subprime crisis on ASEAN-5 stock markets. *In Business and Social Science Research Conference Dubai.* Australia: World Business Institute.

Rusgianto, S., & Ahmad, N. (2013). Volatility behavior of sukuk market: An empirical analysis of the Dow Jones Citigroup Sukuk Index. *Middle-East Journal of Scientific Research*, *13*, 93–97.

Shiller, R., & Beltratti, A. (1992). Stock prices and bond yields. *Journal of Monetary Economics*, *30*, 25–46.

Tariq, A., Dar, A., & Dar, H. (2007). Risks of sukuk structures: Implications for resource mobilization. *Thunderbird International Business Review*, *49*, 203–223.

Vishwanath, S. R., & Sabahuddin, A. (2009). An overview of Islamic sukuk bonds. *The Journal of Structured Finance*, 58–67.

Yang, J., Zhou, Y., & Wang, Z. (2009). The stock–bond correlation and macroeconomic conditions: One and a half centuries of evidence. *Journal of Banking & Finance*, *33*, 670–680.

Zin, M. Z. M., Sakat, A. A., Ahmad, N. A., Roslan, M., Nor, M., Bhari, A., ... Jamain, M. S. (2011). The effectiveness of sukuk in Islamic finance market. *Australian Journal of Basic and Applied Sciences*, *5*, 472–478.