International Review of Business Research Papers
Vol. 9. No. 5. September 2013 Issue. Pp. 12 – 27

The Volatility Spillover Effects in Islam Financial Market[1]

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This paper empirically investigates the price discovery and volatility spillover effects between the stock and bond markets in Malaysia. The transmission mechanisms of volatility between the stock and bond markets have drawn the attention of numerous academics and practitioners because they both play crucial roles in portfolio and risk management. However, there has been no consensus on the evidence of volatility spillover between the stock and bond markets in previous studies of this topic. In light of this gap in the literature, we examine the volatility linkages between the stock and Sukuk markets in Malaysia using a VAR-bivariate-GARCH model during the recent financial crisis and a VECM-bivariate GARCH model after the crisis. The estimation results of the GARCH-BEKK model suggest that there was a unidirectional volatility spillover from the Sukuk GII market to the Sharia stock market during the financial crisis, implying that the Sukuk market has a strong influence on the stock market, but not vice versa. However, we find no volatility spillover effect between the MGS Bond market and the Sharia stock market after the financial crisis.

JEL Codes: G12, G14, C32 and C58

1. Introduction

Bursa Malaysia is one of the largest stock markets in Asia with approximately 1,000 listed companies dedicated to the development of Sharia-compliant capital market products and trading platforms. As for the value of the bond market, it had reached RM 763.4 billion, approximately 97% of GDP, by the end of December 2010. The FTSE-Bursa Malaysia EMAS Sharia'h index (hereafter Sharia) in the Malaysian stock market is a market capitalization-weighted index that incorporates the large and mid cap stocks of the 100 index as well as the small cap index.

This study has two objectives. First, if credit risk occurs, certain financial variables play the most important role in delivering information on the global financial market. Price discovery is measured using the information share model developed by Hasbrouck (1995) and Gonzalo and Granger (1995). This is based on a VECM (Vector Error Correction Model) that consists of permanent and transitory components. Second, the transmission mechanisms of price volatility between the stock and bond markets have drawn the attention of numerous academics and practitioners because they both play crucial roles in portfolio and risk management (Fleming, Kirby and Ostdiek 1998; Campbell and Taksler 2003; Connolly, Stivers and Sun 2005). Risk-averse investors tend to shift funds from stocks and bonds depending on the volatility linkages between both markets. If volatility is highly correlated across both markets, portfolio and risk managers do not view bonds as alternative or safe assets, referring to a flight to quality. The existence of this volatility

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spillover effect implies that a large shock increases the volatilities not only in its own assets or market but also in other assets or markets. If we consider the information transmission between the equity and bond markets, common information, such as systematic risks, affects both markets at the same time (Ederington and Lee 1995; Harvey and Huang 1991; Fleming, Kirby and Ostdiek 1998).

The influences of such common information stimulate trading activity in more than one market by changing investors' sentiments or speculative demands, which results in the transmission of volatilities between the equity and bond markets. In this context, the present paper examines the volatility linkages between the Sharia stock market, Islam Sukuk, and the Malaysian government securities (MGS) bond market in Malaysia, the representative of Islamic finance. In particular, it investigates the volatility spillover effects between the stock and Sukuk markets using a VAR-bivariate GARCH model during the recent global financial crisis and a VECM-bivariate GARCH model between the stock and MGS bond markets thereafter. This study found a unidirectional relation between the permanent volatility of the Sharia and Sukuk markets. Thus, we found a unidirectional volatility spillover from the Sukuk market to the stock market in Malaysia during the recent financial crisis for providing liquidity to market via banks, but that Sharia stock market volatility did not clearly spill over into MGS bond market volatility during periods of stability.

This study makes two original findings. First, we investigated an emerging market during the financial crisis with a particular focus on the Islamic financial market. We provide information on the complex volatility transmission, portfolio diversification, and asset allocation in this sample period. Second, previous empirical studies have utilized a univariate GARCH model, which is unable to capture the covariance effect in residuals because of bias in the estimated results. Even though some studies have considered a multivariate technique, they do not explain the causality (or direction) of the volatility spillover effect. To improve this problem, we considered cross-market causality using a bivariate-GARCH model within the BEKK framework.

The remainder of this paper is organized as follows. Section 2 discusses a brief overview of previous studies of this topic. Section 3 presents the econometric methodology. Section 4 provides the descriptive statistics of the sample data. Section 5 discusses the empirical results. Section 6 concludes.

2. Literature Review

2.1 Sharia-Compliant Capital Markets

According to the Sharia Advisory Council (SAC), 839 companies had Sharia-compliant securities on the capital market, with 89% of these securities listed on the Bursa Malaysia in November 2011. To be listed, companies that have activities comprising both permissible and non-permissible elements must also fulfill two additional criteria: (a) the public perception or image of the company must be good and (b) the core activities of the company must be important and considered beneficial to the Muslim community and the country, while the non-permissible element must be very small and involve matters such as common plight, difficult-to-avoid customs, and the rights of the non-Muslim community that are accepted by Islam. To determine the tolerable level of mixed contributions from permissible and non-permissible activities towards the turnover and profit before tax of a company, the SAC has established several benchmarks that have been suggested by qualified Sharia scholars. If the contributions from non-permissible activities exceed these benchmarks, the securities of the company are classified into one of four levels of Sharia non-compliance. These benchmarks are 5% (interest-based companies such as conventional banks, gambling, liquor, and pork), 10% (interest income from fixed deposits in conventional banks and tobacco-related activities), 20% (rental payments from premises that involve gambling or the sale of liquor), and 25% (hotel and resort operations, share trading, stockbroking, and others).

Further, the Islamic Sukuk and bond market have a balanced mix of both public sector and private sector bonds, each contributing a 45% and 55% share of total outstanding bonds, respectively. Bond issuers include the Government of Malaysia, Bank Negara Malaysia, quasi-government institutions, corporations, and multilateral development banks. More importantly, of the key Islamic financial centers, Malaysia offers a wide variety of Islamic bonds that are Sharia-compliant. At the end of December 2010, Islamic bonds accounted for 39% of the total bonds outstanding. Further, 89% of the securities listed on Bursa Malaysia are Sharia-compliant and represent approximately two-thirds of Malaysia's market capitalization. The local and international listed and non-listed entities on Bursa Malaysia can issue Sukuk denominated in Malaysian Ringgit and foreign currencies. The governing laws of Malaysia, the UK, or the US may be used for bond documentation for both Malaysian and non-Malaysian Ringgit-denominated Sukuk. Government Investment Issues (hereafter GII) and Malaysian Islamic Treasury Bills (MITB) - long-term and short-term non interest-bearing Government securities, which are issued based on Islamic principles by the Government of Malaysia. MGII and MITB were issued to allow Islamic banks to hold liquid papers that meet their statutory liquidity requirements. The issuance of these papers also enabled them to invest their liquid funds in instruments that are issued based on *Shariah* principles as they are unable to purchase or trade in Malaysian Government Securities (hereafter MGS), Malaysian Treasury Bill (MTB) or other interest-bearing instruments. By contrast, the Sharia index has been designed to provide Malaysian investors with a broad benchmark for Sharia-compliant investments. This index is reviewed biannually in June and December. In addition, the Hijrah Sharia index has been designed to be used as the basis of Sharia-compliant investment products that meet the screening requirements of international Islamic investors. The companies in the index are screened by the Malaysian Securities Commission’s SAC and the leading global Sharia consultancy, Yasaar.

2.2 Volatility Spillover Effect

A considerable number of studies have explored the volatility spillover between the equity and bond markets. However, there has been no consensus on the evidence of volatility spillover between these markets. Table 1 summarizes the findings of previous studies of this topic. The research evidence on the volatility spillover effect in previous studies can be classified into three groups. The first group of studies reports a unidirectional volatility spillover effect from the stock market to the bond market. Fang, Lin, and Lee (2007) investigated the volatility transmission of the stock and bond markets between the US and other major financial markets, namely the UK, Japan, and Germany. They suggested that stock volatility shocks have a strong influence on the volatility of the bond market in domestic markets.

Table 1: Summary of Literature Review

Author(s)	Data (period)	Method	Findings
Fleming, Kirby, and Ostdiek (1998)	S&P 500, T-bond, T-bill (1983.1–1995. 8)	GMM	Common information leads to comovement in the volatility of stock, bond, and money markets.
Kim, In, and Viney (2001)	Australian stock, bond, and money markets (1988.1–1999.12)	Multivariate-EGARCH	Strong volatility interactions across the three markets.
Andersen et al. (2005)	Major stock exchange rates and bond markets (intraday data)	OLS; Multivariate GARCH	Contemporaneous cross-market and cross-country linkages.
Cappiello, Engle, and Sheppard (2006)	21 European stocks, 13 European bonds (1987.1–2002.2)	AG-DCC-multivariate GARCH	Strong asymmetric volatility spillover.
Kim, Moshirian, and Wu (2006)	Euro zone; non-Euro zone markets (1994.2–2003.9)	EGARCH	Bond market volatility spills over into the equity market in European countries, Japan, and the US.
Steeley (2006)	FTSE100, GILT (1984.6–2004.6)	Multivariate GARCH	No spillover effect.
Fang, Lin, and Lee (2007)	Major stock indices and bond indices (1988.1–2004.2)	Bivariate GARCH	Unidirectional relationship from the stock market to the bond market.
Chuliá and Torró (2008)	European stock and bond markets (1991.1–2006.1)	VAR-multivariate ADC	Bidirectional volatility spillover effect takes place.
Dean, Faff, and Loudon (2010)	Australian stock and bond markets (1992.6–2006.11)	Multivariate-asymmetric GARCH	Bond market volatility spills over into the equity market but the reverse is not true.

The second group supports unidirectional volatility spillovers from the bond market to the stock market. Kim, In, and Viney (2001) found the existence of volatility spillover effects in the Australian stock, bond, and money markets. This result means that a large shock in the bond market decreases the volatility of other markets. Kim, Moshirian, and Wu (2006) found a unidirectional volatility spillover from the bond market to the stock market in European countries, indicating that bond volatility shocks increase stock market volatility, but not vice versa. Dean, Faff, and Loudon (2010) described the volatility spillover between the stock and bond markets in Australia and showed that bond market volatility has a strong influence on the volatility of the stock market, but that the reverse is not true. The final group shows the bidirectional volatility spillovers between the stock market and the bond market. Fleming, Kirby, and Ostdiek (1998) investigated the nature of volatility spillovers between the stock, bond, and money markets in the US. They found strong evidence of volatility linkages between these three markets because of common inter-market information. Andersen et al. (2005) used high-frequency futures data to document contemporaneous cross-market and cross-country linkages. Cappiello, Engle, and Sheppard (2006) examined the asymmetric volatility spillover effect between the stock and bond markets and found a strong asymmetric volatility spillover between both markets. Chuliá and Torró (2008) showed strong evidence of a bidirectional volatility spillover between the stock and bond markets in European futures contracts.

3. Methodology

3.1 Price Discovery

There are two models that indicate the role of price discovery in financial markets. This paper explains them following Baba and Inada (2009). First, the permanent-transitory model proposed by Gonzalo and Granger (1995) is based on the idea that asset prices consist of permanent and transitory components. It decomposes the permanent component itself, while the permanent component is not necessarily assumed to be a random walk process. It means that if the price of efficiency and martingale is primarily founded in one market, the price in the other market tends to converge to the price in the primary market. Thus, the adjustment speed of the primary market price is slower than that of the other market price, and the intensities of price adjustments are measured by the error correction coefficients in VECM. Second, the information share model proposed by Hasbrouck (1995) notably consider the variance of the permanent component in a market price, permanent shocks occurred in both its own and the other markets develops the variance of the permanent component. This model measures each market's contribution to the variance of common factor (random walk efficient price) innovations, or the new information. The primary market for price discovery contributes most to the covariance matrix of innovation ε_{1t} and ε_{2t}. There are several literatures for price discovery between CDS and Bond spread using two models(Blanco, et al. 2005; Chan-Lau and Kim 2004; Coudert and. Gex 2008; Forte and Pena 2009; Norden and Weber 2009; Wit 2006; Zhu 2005). However, this study apply both models for investigating price discovery o stock and bond markets of Malaysia. Both models are calculated from a VECM of market prices in the following form:

$$\Delta \mathrm{Stock}_t = \lambda_1(\mathrm{Stock}_{t-1}\text{-}\alpha_1 \mathrm{Bond}_{t-1} - \mathrm{C}) + \sum_{j=1}^{p} \beta_{1j} \Delta \mathrm{Stock}_{t-j} + \sum_{j=1}^{p} \gamma_{1j} \Delta \mathrm{Bond}_{t-1} + \varepsilon_{1t} \quad (1)$$

$$\Delta \mathrm{Bond}_t = \lambda_2 (\mathrm{Stock}_{t-1}\text{-}\alpha_1 \mathrm{Bond}_{t-1} - \mathrm{C}) + \sum_{j=1}^{p} \beta_{2j} \Delta \mathrm{Stock}_{t-j} + \sum_{j=1}^{p} \gamma_{2j} \Delta \mathrm{Bond}_{t-1} + \varepsilon_{2t} \quad (2)$$

where ε_{1t} and ε_{2t} are i.i.d. shocks. As mentioned above, the underlying assumptions are that an unobservable permanent component or an efficient price of credit risk in the case of the information share model follows a random walk and that observable prices contain transitory noise. If the equity (bond) market contributes to price discovery in the sense of the Gonzalo and Granger model, then λ_2 (λ_1) is significantly positive (negative). As stated by Engel and Granger (1987), the existence of cointegration ensures that at least one market has to adjust. Specifically, the price discovery measure in the Gonzalo and Granger model can be given by

GG = $\frac{\lambda_2}{\lambda 2 - \lambda_1}$

Following previous studies, we judge that market 1 (equity) has a more dominant role in price discovery than market 2 (bond) when this GG measure for market 1 is larger than 0.5. The measure, however, has a shortcoming in that its absolute value does not necessarily represent the intensity of the price adjustment because the variances on the right-hand sides of Eqs. (1) and (2) might vary in size owing to differences in the variances of the shock terms in these equations.Next, Hasbrouck's measure is given by

$$\mathrm{Has}_1 = \frac{\lambda_2^2(\sigma_1^2 - (\sigma_{12}^2/\sigma_2^2))}{\lambda_2^2\sigma_1^2 - 2\lambda_1\lambda_2\sigma_{12} + \lambda_1^2\sigma_2^2} \quad , \quad \mathrm{Has}_2 = \frac{(\lambda_2\sigma_1 - \lambda_1(\sigma_{12}/\sigma_1))^2}{\lambda_2^2\sigma_1^2 - 2\lambda_1\lambda_2\sigma_{12} + \lambda_1^2\sigma_2^2}$$

where σ_1^2, σ_2^2 , and σ_{12} are factors in the covariance matrix of ε_{1t} and ε_{2t}. We also judge that market 1 (equity) has a more dominant role in price discovery than market 2 (bond) when this Hasbrouck measure for market 1 is larger than 0.5. Note here that the Hasbrouck measure is given by the lower bound of Has1 and the upper bound of Has2 because it uses a Cholesky factorization for the covariance matrix of ε_{1t} and ε_{2t} . Yan and Zivot (2007) rigorously analyzed the determinants of these two price discovery measures under structural models in which both permanent (fundamental) and transitory shocks are identified. In this regard, these authors argued that combining information from the two price discovery measures enables us to remove the ambiguity associated with the Hasbrouck measure. More specifically, a high Hasbrouck measure together with a low GG measure for market 1 is likely to indicate that market 1 has a more significant response to fundamental shocks. In other words, it has a more dominant role in price discovery.

3.2 Volatility Spillover Effects

Much attention has focused on how news from one market affects the volatility process of another. In this study, we analyze the mean and volatility spillover effects between the stock market and the bond market using a bivariate framework of the BEKK parameterization (Engle and Kroner, 1995). In this model, the variance-covariance matrix of equations depends on the squares and cross products of innovation ε_t, which is derived from the following mean equation:

$$R_t = \mu_t + \varepsilon_t, \quad \varepsilon_t \mid \Omega_{t-1} \sim N(0, H_t), \tag{3}$$

where R_t is the 2×1 vector of returns at time t for each market. The $n \times 1$ vector of random errors, ε_t represents the innovation for each market at time t with its corresponding 2×2 conditional variance-covariance matrix H_t The market information available at time $t-1$ is represented by Ω_{t-1}. Thus, we investigate the volatility spillover effect using two methods that consider the cointegration test and market conditions. First, we use VAR-GARCH during the crisis period. Second, after the crisis period, this article adopts the VECM-GARCH model following a two-step estimation strategy: 1) estimate the conditional mean equation using the VECM and 2) apply the bivariate GARCH model to the residuals obtained from the VECM. This bivariate structure thus facilitates the measurement of the effects of innovations in the mean returns of one market on its own lagged returns and those of the lagged returns of the other market. The standard BEKK parameterization for the bivariate GARCH model is written as

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B, \tag{4}$$

where H_t is a 2×2 matrix of conditional variance-covariance at time t and C is a 2×2 lower triangular matrix with three parameters. A is a 2×2 square matrix of coefficients that measures the extent to which conditional variances are correlated with past squared errors. B is a 2×2 squared matrix of coefficients that shows the extent to which current levels of conditional variances are related to past conditional variances. Thus,

$$\begin{bmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{bmatrix} = \begin{bmatrix} c_{11} & \\ c_{21} & c_{22} \end{bmatrix}' \begin{bmatrix} c_{11} & \\ c_{21} & c_{22} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon^2_{1,t-1} & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1} & \varepsilon^2_{2,t-1} \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}' \begin{bmatrix} h_{11,t-1} & h_{12,t-1} \\ h_{21,t-1} & h_{22,t-1} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}, \tag{5}$$

where $h_{11,t}$ denotes the variance in stock market returns, $h_{12,t}$ the covariance in stock market returns and bond market returns, and $h_{22,t}$ the variance in bond market returns. The significance of the diagonal coefficients $a_{11,t}$ ($a_{22,t}$) suggests that the current conditional variance of $h_{11,t}$ ($h_{22,t}$) is correlated with its own past squared errors, while the significance of the lagged variance $b_{11,t}$ (($b_{22,t}$)) indicates that the current conditional variance of $h_{11,t}$ ($h_{22,t}$) is affected by its own past conditional variance. In addition, the significance of the off-diagonal coefficients $a_{12,t}$ and b_{12} indicates evidence of a volatility spillover effect from the bond market to the stock market, whereas the significance of the off-diagonal coefficients a_{21} and b_{21} suggests evidence of a volatility spillover effect from the stock market to the bond market. The standard BEKK model implies that only the magnitude of past return innovations is important in determining current conditional variances and covariances. The parameters of the bivariate GARCH model can be estimated using the maximum likelihood estimation method optimized with the Berndt, Hall, Hall, and Hausman algorithm. The conditional log likelihood function $L(\theta)$ is expressed as

$$L(\theta) = -T\log 2\pi - 0.5\sum_{t=1}^{T}\log\left| H_t(\theta)\right| - 0.5\sum_{t=1}^{T}\varepsilon_t(\theta)' H_t^{-1}\varepsilon_t(\theta), \tag{6}$$

where T is the number of observations and θ denotes the vector of all unknown parameters.

4. Data and Descriptive Statistics

We consider two daily indices, namely the Sharia index and the five-year Sukuk GII(MGIY5y) yield, over the period from January 2, 2007, to January 30, 2009, and Sharia index and the five-year MGS from January 2, 2009, to December 30, 2011, respectively. All sample data were obtained from Bloomberg. Excluding days when either market was closed yields a sample size of 531 and 861 observations, respectively. The return series of the stock index are computed from $R_{i,t} = \ln(P_{i,t} / P_{i,t-1}) * 100$, where $R_{i,t}$ denotes the continuously compounded returns for index i at time t and $P_{i,t}$ denotes the closing price of index i at time t. The return series of bond yields are computed from $R_t = \ln(1+r_t) - \ln(1+r_{t-1}) \cong r_t - r_{t-1}$, where $R_{i,t}$ denotes the continuously compounded returns for index i at time t and r_t denotes the yield to maturity of bond i at time t.

Table 2 presents the descriptive statistics for the two return series during the crisis period. Both the Sharia and MGIY5y returns show a negative mean. Further, both return series have negative skewness and the excess kurtosis shows that both are leptokurtic. This evidence implies that the distributions of both return series are not normally distributed, which is also supported by the results of the Jarque–Bera normality test.

Table 2: Descriptive statistics of the sample returns during the crisis period

Statistics	Sharia	MGIY5y
Mean	-0.0373	-0.0268
Std. dev.	1.2874	1.2593
Skewness	-1.568	-0.7447
Kurtosis	12.033	12.859
Jarque–Bera	3415.057***	3701.0316***
$LB^2(32)$	44.856***	91.820***

Notes: Jarque–Bera corresponds to the test statistic for the null hypothesis of normality in the sample returns distribution. The Ljung–Box statistic, $LB^2(32)$, checks for the serial correlation of the squared returns up to the 32nd order. *** indicates the rejection of the null hypothesis at the 1% significance level.

Table 3 illustrates that both the Sharia and MGS returns show a positive mean after the crisis period. Further, both return series have negative skewness and the excess kurtosis shows that both are leptokurtic. The distributions of both return series are not normally distributed, which is also supported by the results of the Jarque–Bera normality test.

Table 3: Descriptive statistics of the sample returns after the crisis period

Statistics	Sharia	MGS
Mean	0.0221	0.0001
Std. dev.	0.5368	0.1343
Skewness	-0.6093	-0.5632
Kurtosis	7.6162	129.840
Jarque–Bera	738.948***	521577.5***
$LB^2(32)$	21463.1***	1568.9***

Notes: Jarque–Bera corresponds to the test statistic for the null hypothesis of normality in the sample returns distribution. The Ljung–Box statistic, $LB^2(32)$, checks for the serial correlation of the squared returns up to the 32nd order. *** indicates the rejection of the null hypothesis at the 1% significance level.

In addition, the null hypothesis of no serial correlation is statistically rejected at the 1% significance level by the Ljung–Box test statistic, $LB^2(32)$, with a lag of 32 for the squared return series. This implies that the squared returns display significant signs of serial correlation. These results are in favor of a model that incorporates ARCH/GARCH features. Table 4 provides the results of ADF and PP unit root tests for the level series and the return series. The null hypothesis of the ADF and PP tests is that a time series contains a unit root. As shown in Table 4, the calculated values of both the ADF and the PP test statistics indicate that the level series contain a single unit root at the 1% significance level, implying that the level series are non-stationary. However, in the case of the return series, both these statistics reject the null hypothesis of a unit root at the 1% significance level, implying that the return series are stationary in all samples.

Table 4: Unit root test for log price and returns during the crisis period

	Sharia		MGIY5y	
	Index level	Returns	Yield level	Returns
ADF	-0.433	-20.131	-1.821	-17.899
[prob.]	[0.900]	[0.000]	[0.370]	[0.000]
PP	-0.455	-20.131	-1.658	-17.886
[prob.]	[0.896]	[0.000]	[0.452]	[0.000]

Note: Mackinnon's (1991) 1% critical value is –3.435 for the ADF and PP tests.

As shown in Table 5, the statistics indicate that the bond yield series do not contain a single unit root at the 1% significance level, indicating that they are stationary. Likewise, both the return series are stationary in all samples.

Table 5: Unit root test for level and returns after the crisis period

	Sharia		MGS	
	Index level	Returns	Yield level	Returns
ADF	-0.511	-26.691	-8.314	-15.666
[prob.]	[0.886]	[0.000]	[0.000]	[0.000]
PP	-0.695	-26.555	-9.723	-80.163
[prob.]	[0.845]	[0.000]	[0.000]	[0.000]

Note: Mackinnon's (1991) 1% critical value is –3.435 for the ADF and PP tests.

5. Empirical Results

5.1 Cointegration and Causality Tests

If both series are suspected not to be stationary, it makes the regression potentially spurious. Formal testing for unit roots should thus be carried out, followed by the appropriate cointegration analysis.Table 6 shows the results of the Johansen (1991) cointegration test for the Sharia equity and Sukuk GII return series during the crisis period. The null hypothesis that the two series are not cointegrated $(r = 0)$ against the alternative of one cointegrating vector $(r > 0)$ is not rejected because the $\lambda_{trace}(r = 0)$ and $\lambda_{\max}(r = 0)$ statistics do not exceed their critical values at the 5% significance level. Thus, we conclude that there is no evidence of a cointegration relationship between the Sharia equity and Sukuk MGIY5y series. In other words, there is no long-run relationship between the stock market and the bond market.

Table 6: Johansen cointegration test

Null hypothesis	Trace statistic	0.05 Critical value	Max-Eigen statistic	0.05 Critical value
$r = 0$	8.313	15.494	6.823	14.264
$r \leq 0$	1.490	3.841	1.490	3.841

Notes: A one-sided test of the null hypothesis showed that the variables are not cointegrated. The reported critical values are Osterwald-Lenum’s (1992) critical values.

Furthermore, we examine the causality relationship of returns between the stock market and the Sukuk market. Table 7 reports the results of the Granger (1969) causality test between the Sharia and MGIY5y returns. The optimal lag length is chosen by the Akaike information criterion. The causality test results of the Sharia and MGIY5y returns clearly reject the null hypothesis that the Sharia returns do not Granger-cause the MGIY5y returns. This means that there is a unidirectional returns transmission between the Sharia equity and Sukuk MGIY5y markets.

Table 7: Pairwise Granger causality tests

Null hypothesis	Lags	Test values	
		F-value	P-value
Sharia vs. MGI			
$(SHARIA) \neq> (MGI)$	1	3.9631**	0.0470
$(MGI) \neq> (SHARIA)$		2.5997	0.1075

Notes: The symbol “$\neq>$” means “does not Granger-cause.” ** indicates the rejection of the null hypothesis at the 5% significance level.

Table 8 shows the results of the Johansen cointegration test for the Sharia equity and the MGS bond return series after the crisis period. The null hypothesis is rejected because the $\lambda_{trace}(r = 0)$ and $\lambda_{\max}(r = 0)$ statistics exceed their critical values. Thus, there is evidence of a cointegration relationship between the Sharia equity and MGS series, indicating a long-run relationship between the stock market and the bond market after the crisis period.

Table 8: Johansen cointegration test

Null hypothesis	Trace statistic	0.05 Critical value	Max-Eigen statistic	0.05 Critical value
$r = 0$	74.973	15.494	74.628	16.264
$r \leq 0$	0.345	3.841	0.345	3.841

Notes: A one-sided test of the null hypothesis showed that the variables are cointegrated. The reported critical values are Osterwald-Lenum's (1992) critical values.

Table 9 shows the results of the VECM for the stock and MGS bond markets.

Table 9: Estimation results of the VECM

	D(Stock(-1))	D(Bond(-1))
Error correction term	-0.00079*** (-0.0005)	-0.000011*** (-0.0000)
D(Stock(-1))	0.0466*** (0.0358)	-0.00019*** (-0.000089)
D(Bond(-1))	9.2949** (14.436)	-0.0964*** (0.0357)
Constant	-1.800 (1.8256)	-0.0005 (0.0452)

Notes: Standard errors in parentheses, *** indicates the rejection of the null hypothesis at the 1% significance level.

Table 10 shows the results of the price discovery measures for the stock and bond markets.The bond market contributes to price discovery in the sense of the Gonzalo and Granger model; thus, λ_1 is significantly negative. We judge that market 2 (bond) has a more dominant role in price discovery than market 1 (stock) when this GG measure for market 1 is smaller than 0.5. We also judge that market 2 (bond) has a more dominant role in price discovery than market 1 (stock) when this Hasbrouck measure for market 1 is smaller than 0.5. Note here that the Hasbrouck average measure is given by the lower bound of Has1 and the upper bound of Has2.

Table 10: Price discovery (GG and Hasbrouck)

Measure	λ1	λ2	GG	Has1	Has2	Average
Value	-0.00079***	-0.000011***	-0.0141	0.0010	0.2154	0.1082

Notes: Standard errors in parentheses, *** indicates the rejection of the null hypothesis at the 1% significance level.

5.2 Volatility Spillover between the Sharia Equity and Sukuk (bond) Markets

In order to examine the volatility spillover effect, we employ the GARCH (1,1) model based on the BEKK approach. As mentioned earlier, the diagonal elements in matrix A capture own past shock effect, while the diagonal elements in matrix B measure own past volatility effect. From Table 11, the diagonal parameters ($b_{11}$and b_{22}) in matrix B are statistically significant, indicating the presence of strong GARCH effects, namely own past volatility affects the conditional variance of both markets. Furthermore, the diagonal parameters ($a_{11}$and a_{22}) are significant, implying an ARCH effect in both markets. The off-diagonal elements (a_{12} and a_{21}) of matrices A and B capture cross-market effects, such as the shock spillover and volatility spillover effects between the stock and bond markets.

The estimation results of the VAR-GARCH-BEKK model during the crisis are reported in Table 11. We find no evidence of the shock spillover effect between the Sharia stock and Sukuk GII markets because the coefficients a_{12} and a_{21} are not significant at the 1% level. This implies that past shocks have no significant effect on the present volatility between both markets and that the increase in the innovation of one market does not change the volatility of another market.

Table 11: Estimation results of the GARCH-BEKK model

Variable	Coefficient	
c_{11}	0.3990***	(0.0581)
c_{21}	-0.0569**	(0.0286)
c_{22}	0.0883**	(0.0351)
a_{11}	0.4711***	(0.0471)
a_{12}	-0.0401	(0. 0257)
a_{21}	0.0196	(0.0392)
a_{22}	0.3430***	(0.0306)
b_{11}	0.8436***	(0.0295)
b_{12}	0.0284**	(0.0124)
b_{21}	-0.1154	(0.0123)
b_{22}	0.9537***	(0.0060)
Panel B: Diagnostic tests		
$LB_1^2(20)$	5.065 [0.999]	
$LB_2^2(20)$	25.565 [0.1806]	
log-likelihood	-1579.09	

Notes: P-values are in brackets and standard errors are in parentheses. The $LB_i^2(20)$ test statistic checks for the serial correlation of squared standardized residuals. ** and *** indicate significance at the 5% and 1% levels, respectively.

As Lehman Brothers failed on September 15, 2008, the financial institutions suffered from funding dollars in the money market and global funding markets actually collapsed. As the turbulence in funding markets made market interest rate jump up and yield curve shift upward, there is no environment and incentive to issue and buy bonds globally during the crisis. Thus, the Malaysia government did not issue MGS after Lehaman failure, but repurchased GII to provide banks with liquidity requirements and stabilized economy based on Islamic principles. Therefore, we identify a unidirectional volatility spillover effect from the Sukuk GII market to the stock market to fund lower yield owing to the significance of coefficient b_{12}, there is no significant volatility spillover effect from the stock market to the GII market. These results indicate that the Sukuk yield market seems to play a more important role in influencing the volatility of the stock market. Next, we employ the VECM-GARCH

(1,1) model based on the BEKK approach after the crisis period. The estimation results are reported in Table 12. We find no evidence of a unidirectional shock spillover effect from the Sharia market to the MGS market because the coefficient b_{21} is negatively significant at the 1% level. In fact, the past volatility in the Sharia stock market has a significant but negative effect on the present volatility in the bond market. In other words, the increase in the volatility of the stock market decreases the volatility of the bond market. However, there is no significant shock or volatility spillover effect from the stock market to the bond market. These results indicate that after the financial crisis the influence of past yield volatility is unclear, as it affects both the negative sign and small magnitude of current bond market volatility.

Table 12: Estimation results of the GARCH-BEKK model

Variable	Coefficient	Std. error
c_{11}	0.043**	(0.018)
c_{21}	0.534	(0.784)
c_{22}	2.633***	(0.249)
a_{11}	0.203***	(0.022)
a_{12}	0.708	(0.441)
a_{21}	0.002	(0.001)
a_{22}	0.364***	(0.055)
b_{11}	0.971***	(0.006)
b_{12}	0.088	(0.105)
b_{21}	-0.003***	(0.001)
b_{22}	0.831***	(0.021)
Panel B: Diagnostic tests		
$LB_1^2(32)$	24.604 [0.216]	
$LB_2^2(32)$	3.063 [0.999]	
log-likelihood	-3222.6	

Notes: Standard errors in parentheses, *** indicates the rejection of the null hypothesis at the 1% significance level.

To check the accuracy of the model specifications, we use two diagnostic tests and the Ljung–Box statistic, $LB_i^{\,2}(20)$, for squared standardized residuals. Note that the $LB_i^{\,2}(20)$ test statistic checks for the serial correlation of squared standardized residuals. The non-significance of the $LB_i^{\,2}(20)$ statistics confirms the suitability of the GARCH-BEKK model.

This study explored the impact of the 2008 global financial crisis and thereafter on volatility spillover effects. To summarize the two estimation results, although the bond market has a more dominant role in price discovery than the stock market after the crisis, our empirical results show a unidirectional volatility spillover from the stock market to the bond market during the crisis. Overall, this evidence is consistent with the findings presented by Fang, Lin, and Lee (2007), which found a unidirectional volatility spillover from the stock market to the bond market. This indicates that information on the stock market is transmitted to the bond market, thus providing efficient risk management, optimal asset allocation, and trading strategies for portfolio investors.

6. Conclusions

This paper investigated the volatility spillover effects between the Stock, Sukuk, and Bond markets in Malaysia using the VAR and VECM-bivariate GARCH models. In particular, we considered the volatility transmissions between the stock and bond markets during the global financial crisis and thereafter. We also find no evidence of returns transmissions between the Sharia stock, Sukuk and MGS markets.[2] By employing VAR-GARCH-BEKK models, we found unidirectional volatility transmissions between the Sukuk and Sharia markets during the crisis period, indicating that bond market volatility increases stock market volatility but not vice versa. Next, we considered the price discovery role and volatility transmissions between the stock and bond markets after the crisis period. By using price discovery measures, we found that the bond market contributes to price discovery in the sense of the models proposed by Gonzalo and Granger and by Hasbrouck, indicating that the bond market has a more dominant role in price discovery than the stock market. With regard to volatility transmission, we considered the VECM-bivariate GARCH-BEKK model. Our empirical results showed that a unidirectional volatility spillover from the Sharia stock market to the MGS bond market is unclear, indicating that stock shocks decrease bond market volatility. Thus, we found a unidirectional volatility spillover from the Sukuk GII market to the stock market in Malaysia to fund lower yield during the recent financial crisis. This study only compared the direction of volatility spillover before and after the global financial crisis. These findings have Sharia principles for Sukuk issue and have practical implication for portfolio selection between the stock and bond markets Malaysian financial markets.

Endnotes

1. This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2011-330-B00106) and Research Funded by Dongseo University in 2012.

2. Volatility responds asymmetrically to positive and negative innovations of equal magnitude. In other words, it tends to rise more in response to negative shocks (bad news) than it does to positive shocks (good news) (Engle and Ng, 1993; Glosten, Jagannathan and Runkle, 1993; Kroner and Ng, 1998). To check this problem, we tested Engle and Ng's (1993) test for asymmetry in volatility. However, we did not reject the null hypothesis of no asymmetry.

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