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An Application of GARCH Modeling on the Malaysian Sukuk Spreads

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Abstract

This study explores the influencing factors of the Islamic bond (sukuk) spreads, by employing the generalised auto-regressive conditional heteroscedasticity (GARCH) method. Apart from the general GARCH (1,1) model, a higher order of lags for both ARCH and GARCH terms are also considered which is applied onto both the investment and non-investment grade sukuk. This study is among the first few to document the empirical evidence on sukuk spreads and its volatility which is expected to further enrich the empirical literature of the financial markets especially in the Islamic finance. This is in line with the pressing demand for more in-depth information on various dimensions of the sukuk market given the importance of the sukuk in the global capital market. This study contributes significantly to the benefit of the investors, portfolio managers as well as regulators to better understand the underlying factors influencing the pricing and risk management of sukuk instruments. In addition, the assessment on the impact of the recent global financial crisis allows for a thorough understanding on the behavior of sukuk spreads so as to pre-empt the impact of future financial shocks to the sukuk market.

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Keywords: GARCH modelling, sukuk spreads, conditional variance, credit spreads, crisis.

1. Introduction

Sukuk spreads are relatively a new area of research covering on the technical aspects of sukuk by analysing the difference in yields between the corporate sukuk and government sukuk. A number of recent studies present interesting findings on the trend and behaviour of sukuk spreads covering the Gulf Corporation Council (GCC) sukuk market (Naifar and Mseddi, 2012; Rahman and Omar, 2012) and Malaysian sukuk market (Rahman, 2008). These studies are undertaken based on bond credit spread analysis that have been primarily developed from the theoretical theory of the Merton model (1974) and the infamous two-factor framework of Longstaff and Schwartz (1995) focusing on the well developed bond market such as in the United States of America (US), United Kingdom (UK) and Japan[1].

Apart from possessing a critical role in reflecting the risk premium of the corporate bonds and provide a measure of the bond default risk (Elton, Gruber, Agrawal and Mann, 2001), credit spreads are also used to examine the investors' behaviour on bond investment during the different cycles of the economy. RAM Rating Services Berhad (2010) shows that by comparing the year of 2008 and 2009, the credit spreads for 5-year AAA and AA tightened by at least 100 bps and 90 bps respectively, indicating a recovery in investors' confidence along with the rejuvenated Malaysian economy from the 2007/2008 global financial crisis. This finding is consistent with the previous empirical analysis, where credit spreads tend to increase

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[1] These countries possess large amount of domestic debt issued compared to other countries in the world (*BIS Quarterly Review*, June 2011)

during recessions and narrow during expansions (Demchuk and Gibson, 2006; Krainer, 2004 and Tang and Yan, 2010).

In consideration that the movement of prevailing interest rates and stock market mainly influences the variation of bond spreads, it will be interesting to unveil whether these factors possessa similar impact on sukuk spreads. Hence, with the increasing importance of sukuk in the Islamic capital market, it is imperative to study on the influencing factors of sukuk spreads. Unlike the previous studies that are based on a self-constructed index (Naifar and Mseddi, 2012) or individual sukuk (Rahman, 2008; Rahman and Omar, 2012), this study utilises the consolidated yield to maturity maintained by the Bond Pricing Agency Malaysia (BPAM), which provides a more reliable, accurate and comprehensive basis for the calculation of the sukuk spreads.

2. Literature Review

Given the importance of credit spreads in the valuation of risky debt, a research undertaken by Longstaff and Schwartz (1995) examines the properties of credit spreads and argues that credit spreads are driven by two factors, the interest rate risk factor and the asset factor. Fundamentally, it is argued that variation of credit spreads should be influenced mainly by the movement of the prevailing interest rates, as well as by the changes in the asset value of the firms. Hence, in order to empirically support this two-factor framework, Longstaff and Schwartz (1995) introduce a regression equation (1) and regress the changes in credit spreads (ΔS) on 30-year Treasury yield representing the interest rate risk factor (ΔY) while the Standard and Poor's stock index become the proxy for the changes in the underlying asset of the firm (I) or the asset factor;

$$\Delta S = \alpha + b\Delta Y + cI + \varepsilon \quad (1)$$

One of the important implications of this study is the inverse relationship between the spreads and interest rate factor, where from the perspective of demand and supply, an increase in interest rates may cause the supply of corporate bonds to reduce, which reducing the bond yields and hence reduces the spreads (Manzoni, 2002; Rahman, 2003). From the economic point of view, an increase in interest rates will likely increase the yields of Treasury bonds and as this increase will not be proportionately similar to the increase in the yields of corporate bonds, spreads will decrease.

Credit spreads are also found to be negatively related to the returns on a firm's assets or equity (asset factor), which means that an increase in the value of a firm's asset or equity, will increase the ability of the firms in servicing the debt, hence decreases the probability of default and reducing the spreads. While the negative relation between the spreads and these two factors are more pronounced for firms with higher default probabilities i.e. lower grade bonds, the investment grade bonds are more susceptible to changes in the interest rates rather than changes in the value of the assets of the firm. Though based on different kind of methods, subsequent studies appeared to support this finding that includesAvramov et al., (2007), Ahmad, Muhammad and Masron (2009), Batten, Fetherston and Hoontrakul (2006), Boss and Scheicher (2002), Demchuk and Gibson (2003), Collin-Dufresne, Goldstein and Martin (2001), Giesecke et al., (2011), Rahman (2003), Rahman (2008) and Yap and Gannon (2007).

2.1. Factors influencing the variation in sukuk spreads

The simple linear regression analysis is also employed by Rahman (2003) and Rahman (2008) in finding the factors influencing bond spreads and sukuk spreads respectively, for the Malaysian bond market. Based on weekly data for the period of October 1999 to November 2002, the finding of a negative relation between the spreads and interest rate factor as measured by Kuala Lumpur interbank offer rate (KLIBOR) by Rahman (2003) is consistent with previous studies. In addition to that, Rahman (2003) also finds a significant negative relation between the spreads and asset, as represented by the returns of the Kuala Lumpur Composite Index (KLCI). However, Rahman (2008) who studies on the weekly spreads of individual sukuk from November 2003 to June 2006 failed to establish a significant relation between the sukuk spreads and interest rate factor, in contrary to the previous literature, especially in the two-factor theoretical framework of Longstaff and Schwartz (1995). By conjecture, Rahman (2008) argued that in meeting the mandate of Islamic fund portfolios, institutional and pension fund managers tend to disregard the movement of interest rate in purchasing sukuk, hence causing the sukuk spreads to chart independently to interest rate factor. The limited number of sukuk in the secondary market appeared to be a plausible explanation for such moves by the portfolio managers. Nevertheless, other variables such as the equity market return, lag of the spreads and the slope are significant in explaining the variation in sukuk risk premium which is in line with studies by Batten et al. (2006), Hattori et al., (2000), Manzoni (2002).

Another study undertaken by Ahmad et al. (2009) on the Malaysian bond market reveals the significance of interest rate factor as a proxy by the three month Bank Negara Malaysia treasury bills and the equity market return represented by the FTSE Kuala Lumpur Composite Index (KLCI) to the movement of bond spreads. By employing the cointegration and Granger causality methods on the spreads of investment grade bonds and Malaysian government bonds during January 2001 to December 2008, Ahmad et. al (2009) also shows that the inflation variable as represented by the Consumer Price Index (CPI) is another significant factor in explaining the movements of both the corporate and government bonds. The growth variable of the Industrial Production Index (IPI) on the other hand shows no significance. It is important to highlight however that the spreads calculated in this analysis are somehow different than the previous studies in such a way that the spreads is calculated by taking the difference of the corporate/government bond yield against the three month treasury bills.

Yap and Gannon (2007) provides a different perspective in studying the spreads, by analysing the USD denominated bonds issued by the Malaysian companies and examine whether the changes in the US treasury rate, exchange rate, emerging market equity index return, Malaysian equity market return and crude oil prices could influence the movement of the USD denominated bond spreads. Similar to the methodology employed Morris, Neal and Rolph (1998), Yap and Gannon (2007) finds that the changes in credit spreads are negatively correlated with the interest rate factor as represented by the US Treasury rate. The possible explanation put forward by Yap and Gannon (2007) on the insignificant of the asset factor is due to the restriction on free trading outside the Malaysian market and the capital control. Other points highlighted are that credit spreads for bonds with shorter term to maturity are insensitive to changes in interest rates and that the domestic factors are almost irrelevant in explaining the sovereign spreads denominated in the USD.

In view that spreads analysis is relatively a new research approach to the sukuk market in the Gulf Corporation Council (GCC), only a few studies are included in this review. Among the recent ones based on the cointegration approach, is the study by Rahman and Omar (2012) that examines the spreads of the USD denominated corporate sukuk issued by the corporations in the GCC, against the movement in the US capital market. With the daily data span of 22 June 2007 to 31 December 2011, this study unveils the relation of the US treasury and equity market against the spreads of the sukuk, during the recent global financial crisis. Interestingly, interdependence appears to exist between the spreads of GCC sukuk even though the relations are not consistent with the empirical findings in the previous literature. In addition to that, the dummy variable representing the crisis in the analysis is only significant to the longest tenure, albeit weak. As such, Rahman and Omar (2012) argue that due to the nature of the sukuk, in terms of its structure and the source of income as well as its importance in the portfolios of Islamic fund, the relation of spreads against the changes to the US treasury rate and the stock market are found to be different than theoretically implied. Apart from that, it is also put forward that the relatively smaller size of the sukuk market as compared to the conventional bond market is the main reason why spreads of the GCC sukuk is not really affected by the 2007/2008 global financial crisis.

Another study that examines spreads from the sukuk issued in the GCC is by Naifar and Mseddi (2012). With the spreads calculated based on a self-constructed sukuk index yield from 11 sukuk originated in United Arab Emirates (UAE) from October 2009 to July 2011, Naifar and Mseddi (2012) shows that the slope of the yield curve and the changes in the stock market are the main influencing factors to the variation in sukuk spreads. Apart from that, they also show that the rate of inflation and the volatility of the stock market are not significant to the changes in sukuk spreads. From this study, Naifar and Mseddi (2012) shows the significance of the slope of the interest rates consistent with previous studies. However, the sukuk spreads appear to react positively to the changes in the stock market, indicating that an increase in the stock market is followed by an increase in the sukuk spreads. Nevertheless, the exclusion of the general interest rate factor as one of the influencing variables in the analysis is questionable and is not consistent with the initial two-factor framework of Longstaff and Schwartz (1995).

It is important to highlight that the above studies on sukuk are based on the spreads of individual sukuk samples, which may not be able to represent the sukuk market as a whole. As such, it is essential to re-examine this factor based on a much larger and reliable sample of sukuk spreads.

3. Data and methodology

The initial empirical model introduced by Longstaff and Schwartz (1995) adopts the simple regression analysis of the ordinary least squares (OLS) and shows that changes in spreads is mainly influenced by the movement of the interest rate and firm value (asset) factors. Over time, many other researchers have employed a different kind of econometric approaches in the effort to meet their research objectives that include the cointegration, error correction, Markov switching as well as GARCH models.

Nonetheless, it is important to emphasize that for a linear regression model to be classified as best, linear, unbiased and efficient (BLUE), one of the standard assumptions is that the variance of all squared error terms is the same, which is referred to as homoskedasticity (constant variance)2. In consideration that many time series data exhibit heteroskedasticity (variances of the error terms are not equal), an alternative method is required to accommodate heteroskedasticity as a variance to be modelled.

One of the main assumptions under the classical linear regression model (CLRM) is that the variance of the error is constant, var(ut) = σ 2< ∞ - the assumption known as homoskedasticity. Data in which the variances of the error terms are not equal, where the error terms are expected to be larger for some points or ranges of the data, is said to be suffering from heteroskedasticity. Instead of treating heteroskedastic as a problem to be corrected, Engle (1985) introduced the autoregressive conditionally heteroskedastic (ARCH) models and the extension of GARCH models was later introduced by Bollerslev (1986) to treat heteroskedasticity as a variance to be modelled. The key concept of this model is the conditional variance, that is, the variance conditional in the past and is expressed as a linear function of the squared past values of the series. According to Engle (2001), by applying the ARCH and GARCH models on financial time series, not only are the deficiencies of least squares are corrected, but a prediction is computed for the variance of the error term that allows an insight into the behaviour of the variance. This is important for forecasting and pricing analysis on financial instruments with high data frequency (Rachev, Mittnik, Fabozzi, Focardo, Jasic, 2007).

Francq and Zakoian (2010) further emphasize that the complexity of modelling financial time series lies not only on the variety of the series in use (interest rates, exchange rates, stocks, etc), or to the importance of frequency of distribution (day, hour, minute, second etc) or to the availability of large data sets, but mainly due to the existence of statistical regularities or stylised facts referring to, among others, the time-varying volatility and fat tails (leptokurtic), that is common to a large number of financial time series data.

3.1 Data selection

The data for sukuk spreads are computed from the YTM and government yields from the database of BPAM. The rating-specific indices rather than data on individual issues are used to analyse spreads for three main reasons. First, the market for fixed income, be it conventional bonds or sukuk, is often illiquid and the consistency of the spread component of corporate yields is strongly affected by liquidity constraints. Two, the consolidated YTM based on rating and maturity reflects changes recorded from both the trading of sukuk (or bond), or from the movement in value of that particular group of sukuk (or bond),

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[2] A comprehensive discussion on the classical regression assumptions can be accessed from Gujarati, Damodar N. (2004) *Basic Econometrics, Fourth Edition.* New York: McGraw-Hill, pp 335-441.

arising from mark-to-market (MtM)3 system (Meor, Interview by Author, Mid Valley City, Kuala Lumpur, 25 March 2012)4. Three, not only that BPAM is the sole pricing agency appointed by the Malaysian government via the Securities Commission to enhance the transparency and consistency for bond pricing, it is also the world's first agency to specialise in Ringgit-denominated bond (or sukuk)5 . As such, it has become the official source for references the data on consolidated sukuk or bond is maintained with high accuracy and integrity.

The data used in this research is the daily data which is believed to provide a more timely and accurate proxy for conditional risk and reflects the practicality approach in the management of bond portfolio which is subject to daily monitoring. The use of daily data is also similar to the previous studies (Batten et al. 2006; Batten and Hogan, 2003; Manzoni, 2002; Miloudi and Mouraux, 2009; Nakashima and Saito, 2009; Pedrosa and Roll, 1998 and Yap and Gannon, 2007)

The daily data set extends from August 1, 2005 to December 31, 2011 for a number of 1675 observations and includes the extreme event such as the 2007/2008 global financial crisis. Apart from identifying the factors influencing the variation in spreads, this data set also allows investigation on the impact of the crisis and stock market volatility to the volatility of the sukuk spreads to be undertaken.

3.2 Computation of spreads - the dependent variable

The computation of spreads is based on the last traded yield of the consolidated rating and maturity of corporate sukuk, against the respective Government Investment Issues (GII)[6];

$$Sukuk\ spreads\ (SS)_{i,t} = Yield_{i,t} - Yield_{GII,t} \qquad (2)$$

where $Yield_{i,t}$ is the consolidated yield of sukuk with i rating at t-period (where i = AAA3, AAA10, AA3, AA10.... B10) and $Yield_{GII,t}$ is the consolidated yield of GII at t-period.

3.3 Selection of influencing variables

Studies on factors influencing credit spreads changes were inspired by the structural default-risk model by Merton (1974) which was later empirically tested by Longstaff and Schwartz (1995) showing the significance of the interest rate and asset factors to the variation in spreads. Over time, subsequent studies show that the slope of the term-structure of interest rates and the autoregressive term or lag of the spreads are also significant in influencing the movement of spreads.

Apart from that, the variable of volatility of the spreads represented by the conditional variance term of the spreads is also being taken into consideration by a number of researchers (Batten and Hogan, 2003; Batten et al., 2006; Manzoni, 2002; Yap and Gannon, 2007). As highlighted by Engle (2001) and supported by Rachevet. al (2007), researchers are given an insights into the behaviour of the volatility of any financial instruments by examining its conditional variance term. In this analysis, the volatility of the spreads is examined to empirically show whether the dummy variable representing the global financial crisis 2007/2008 and the volatility of the stock market could influence the movement of the spreads volatility, apart from the ARCH term and GARCH term which represents the past news or shock and the squared changes of the dependent variable (forecast variance) respectively.

3.4 The application of GARCH modelling

In consideration that financial time-series data normally displays evidence of non-normality and volatility clustering (Pagan, 1996), Pedrosa and Roll (1998) is one of the initial studies that highlights on

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[3]Mark-to-market is an act of providing a price that is market relevance and may be done via fair valuation or taking the market price (Meor, 2012)

[4]MeorAmriMeorAyob, Chief Executive Officer, Bond Pricing Agency Malaysia SdnBhd (BPAM)

[5] www.bpam.com.my/services.asp

[6] GII are government securities issued based on Islamic principles and are placed on competitive tender (Ariff, Cheng and Neoh, 2009,64)

the issue of volatility clustering of the changes in spreads. As highlighted in the previous section, volatility clustering refers to the situation where the amplitude of returns varies over time, for example large changes in returns are likely to be followed by further large changes, and small returns by more small returns, suggesting that returns are serially correlated (Perrelli, 2001). In Econometrics, this situation is termed as heteroskedasticity, where the variance of the error term is not constant and varies over time (Engle, 2001). In finance, it is important for researchers to model this variance as it contains additional information on the behaviour of the dependent variable.

After performing the inspection of data and relevant statistical testing on the sukuk spreads data, it is found to exhibit persistent volatility clustering nature of time series data as highlighted by Engle (2001) and Pedrosa and Roll (1998), hence become a strong reason to embark the analysis on the relation between the sukuk spreads and the influencing factors by employing the non-linear GARCH model as introduced by Bollerslev (1986). According to Engle (2001), in financial Econometrics application where the dependent variable is the return on an asset or portfolio, heteroskedasticity is likely to be an issue where the data in which the variances of the error term are not equal or constant. Even though running a regression analysis in the presence of heteroskedasticity provides an unbiased result, the standard errors and confident intervals estimated will be too narrow, resulting in misleading inferences.

As highlighted by Rachev et al. (2007), the introduction of GARCH modeling is to accommodate heteroskedasticity so that valid coefficient estimates and models are obtained for the variance of the error terms. In addition to that, Duasa (2004) in studying the efficiency of the Malaysian economy during the Asian financial crisis concurred that the GARCH model allows for the conditional variance of an economic time series to change over time and is appropriate to model its behaviour when the series displays periods of high volatility. In our case, the periods of high volatility refers to the 2007/2008 global financial crisis.

Previous studies on bond spreads that have employed the non-linear GARCH modelling include Batten and Hogan (2003), Batten et al. (2006), Manzoni (2002) and Yap and Gannon (2007).Hence, the application of GARCH modelling is the most suitable for the sukuk spreads analysis in order to meet the objectives of this study mainly;

i. To explore the significant factors influencing the variation in spreads from the mean equation; and
ii. To explore the significance of the 2007/2008 global financial crisis and stock market volatility to the volatility of the spreads from the variance equation.

With the above discussion, the proposed model of GARCH (1,1) is developed in order to explore the significant factors influencing the variation in spreads from the mean equation and whether the volatility of sukuk spreads can be influenced by the presence the 2007/2008 global financial crisis and stock market volatility.

This proposed model which includes the conditional variance term (h_t) is also similar to the model used by Batten and Hogan (2003), Batten et al. (2006) and Manzoni (2002) in order to capture the persistence volatility in the conditional variance of credit spreads;

$$SS_t = \alpha + \beta_1 risk\text{-}free + \beta_2 asset + \beta_3\ slope + \beta_4 SS_{t-1} + \varepsilon_t, \quad (3)$$

$$\varepsilon_t = \sqrt{h_t}\eta_t, \eta_t \sim N\ (0,1)$$

$$h_t = \alpha + \gamma_1 \varepsilon^2{}_{t-1} + \gamma_2 \sigma^2_{t-1} + \gamma_3 crisis + \gamma_4 market\ volatility \quad (4)$$

where the SS_t is the change in the relative sukuk spreads (for the consolidated sukuk rated AAA, AA, A, BBB, BB, and B with short-term maturity 3 years and long-term maturity 10 years (a total of 20 rating and maturity combinations) at time *t*, *risk-free* is the treasury bill of Bank Negara Malaysia, *asset* is the change in the logarithm of the stock market index, *slope* is the change in the slope of the yield curve, SS_{t-1} is the autoregressive term or the lag of spreads and *crisis* is the dummy variable tagging the 2007/2008 global financial crisis, and *market volatility* refers to the volatility of the stock market[7].

The conditional variance term $(h_t)$is modelled by the past shock or news measured as the lag of the squared residual from the mean equation which is known as the ARCH term $(\gamma_1 \varepsilon^2{}_{t-1})$ and its own lagged value known as the GARCH term $(\gamma_2 \sigma_{t-1}^2)$ representing the last period's forecast variance. For equation (4) to be well defined and to ensure that the conditional variance of the error term $(h_t)$is stationary, $\gamma_1 + \gamma_2$ must be close to 1. As highlighted by Batten and Hogan (2003), this model specifies that this period's variance is formed by a weighted average of long-term average (the constant), the information about volatility observed in the previous period arising from some shock or news (ARCH term) and the forecast variance from the last period (GARCH term).

In order to ensure that the statistical significance of the results was not affected by the conditionally non-normally distributed residuals, the methods described by Bollerslev and Wooldridge (1992) was applied when calculating the standard errors. This method is proposed by Engle (2001) and is also used by Manzoni (2002) and Batten et. al (2006).

3.4.1 GARCH model with different lags for ARCH and GARCH terms

In financial Econometrics, the GARCH (1,1) model is simply the most popular for modelling the asset-return volatility (Rachev et. al, 2007). Nevertheless, a higher order of lags for both ARCH and GARCH terms are also considered for the purpose of undertaking a more robust analysis. Specific to the studies undertaken on bond spreads, Manzoni (2002) considers only the GARCH (1,1) model whereas Batten et. al (2006) considers the specification of the GARCH model up to GARCH (3,3), in consideration that the first differenced time series data demonstrate statistically significant auto and partial correlation of up to lag 3.

In this research, apart from examining the time series data for auto and partial correlation in order to determine the appropriate lags to be used, the information criterion is also used for consistent lag order selection in vector auto regression (VAR) models (Lütekepohl, 1991). It is important to highlight that the best lag order selection will be indicated by the different types of information criterion namely; Akaike information criterion (AIC), Schwartz information criterion (SIC) and Hannan-Quinn information criterion (HQ) of which the most minimum value of the criterion is chosen to be most appropriate lag length. For this study, the lag length is chosen by taking into consideration the one that is mostly selected by these information criterions, which is the lag of one.

Despite knowing the appropriate lag length to be used in this analysis, a sensitivity analysis of a higher lags GARCH models is still applied, in order to find the best model, by running the GARCH (1,2) and GARCH (2,2) models. Subsequently, these models are compared and the best model between is decided based on the smallest information criterion, since the information criteria are often used as a guide in model selection (Grasa, 1989).

4. Empirical results and discussion

Confirming the stationarity of the time series data, Table 1 presents the results from ADF and P-P tests that include the 'trend and intercept' and 'no trend and intercept'. The optimal lag length selection is automatically chosen by Eviews software from maximum number of lag that minimises Schwartz Information Criteria (SIC) while for the P-P test, the number of lag as suggested by Newey-West is used. The ADF and P-P tests show that the null hypothesis that the time series are non-stationary cannot be rejected for all variables at levels, and running the test on first difference gives the results for rejecting the null, suggesting stationary in the first difference of the variables. Hence, these variables are integrated of order 1, or I(1).

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[7]Stock market volatility is obtained from the conditional variance of regressing the stock market with its own lag by employing the GARCH method.

Table 1. Unit Root Summary ADF test

Variables	Levels		First Differences	
	No Trend	Trend	No Trend	Trend
Long Term				
AAA10	-2.4408	-2.5198	-40.8278*	-40.8172*
AA10	-1.6841	-1.4696	-39.7948*	-39.8038*
A10	-1.3504	-1.1763	-37.7002*	-37.7051*
BBB10	-2.2533	-1.6459	-35.3019*	-35.3564*
BB10	-2.6513	-2.5358	-13.0389*	-13.0792*
Short Term				
AAA3	-2.1193	-2.1083	-50.7459*	-50.7332*
AA3	-1.4481	-1.2481	-50.0264*	-50.0254*
A3	-1.0724	-0.8336	-48.5553*	-48.5529*
BBB3	-1.8640	-1.1779	-45.6739*	-45.7128*
BB3	-2.3373	-2.1507	-18.9678*	-19.0402*
Independent variables for mean equation				
	-1.8863	-2.3414	-36.1826*	-36.1844*
Rate	-1.0105	-1.3949	-36.2546*	-36.2436*
FBMKLCI	-2.2753	-2.6235	-15.6297*	-15.6308*
Slope				

Note: The critical values for the tests without a time trend and with the time trend at 1% level are -3.4340 and -3.9635 respectively. * denotes statistical significance.

It is important to highlight that the result summary presented in Table 2 is based on the best GARCH model, after running the variants of the GARCH models. This involves running the GARCH (1,2) and GARCH (2,2) models and assess whether the coefficient for higher lags are significant or not. If it is significant, and that the model possess the lowest information criterion as measured by the AIC and SIC as relatively compared to the general GARCH (1,1) model, the higher lags model will be chosen.8.

In order to check for robustness, further tests are conducted on the residuals generated through the GARCH model appeared to be the best model. The last column on the right hand side of Table 5 presents the Correlogram-Q statistics and the ARCH LM test. The Correlogram-Q statistics is used to test for remaining serial correlation in the mean equation and to check for the specification of the mean equation. When the mean equation is correctly specified, all Q-statistics should not be significant. On the other hand, the ARCH LM test carries out the Langrange multiplier tests to test whether the standardised residuals exhibit additional ARCH. When the variance equation is correctly specified, there should not be ARCH left in the standardised residuals.

In this analysis, the presence of serial correlation of the estimated residuals is tested by using the Ljung-Box Q-statistics for lags 2 which is applied to the squared standardised residuals. The Q-statistics shows that none of the lags considered reject the null hypothesis of no serial correlation at the 5% significant level. These results therefore imply that the mean equation is not misspecified. It is important to highlight that the portmanteau test statistics undertaken by Manzoni (2002) had considered the lag of 5 and 20, however in this analysis only the Q-statistics of up to lag 2 is presented even though it is observed that the null cannot be rejected up to lag 36 for all of the models. As for the ARCH LM specifications with all lags (up to lag 2), the observed R-squared (Obs*R-squared) statistics indicate that the ARCH effect is eliminated with the high value of the chi-square probability. Hence, the respective model for each rating used in this analysis is believed to be the best acceptable and robust model for hypothesis tests.

4.1 Factors influencing the variation in sukuk spreads

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[8] According to Gujarati (2003), the lower the value of the AIC and SIC, the better the model.

The mean equation presented on the left hand side of Table 2 shows the regression results of the variation in sukuk spreads with different rating and maturity against four independent variables namely the risk-free rate, asset factor, slope of the interest rate and the autoregression component or lag of the spreads based on the best GARCH model. Generally, the movement of the risk-free rates and the direction of the future short term rate (slope) are the most significant variables for both the investment grade and non-investment grade of long-term sukuk. On the other hand, the short term sukuk shows rather a different pattern, with the investment grades show no significant relation to the interest rate factor. Another variable, which represents the autoregressive terms (lag of spreads) is found to be not significant in all ratings and maturites.

4.2 The volatility of the sukuk spreads

Generally, the statistical significance of the variance equation of the GARCH (1,1) model is specified by the two terms (γ_1 and γ_2) in second column of Table 2 of the result summary. The volatility of sukuk spread changes is driven mainly by the observed squared changes in sukuk spread on the previous trading day (forecast variance) - as indicated by the size of the GARCH coefficient, for all ratings and maturities. This term, which also measure the long-term persistence in volatility is the only factor associated to an adjustment in the risk premium, or the spreads (Manzoni, 2002). On the ARCH term though significant, the size of the coefficient is much smaller, indicating that the volatility of spread is less affected by the past shock or news. In some cases, particularly referring to the short term sukuk spreads of the A3 and BBB3, the GARCH term of higher lags (up to lag 2) appeared to be significant, indicating that the persistent in volatility for a longer trading days.

According to Yap and Gannon (2007), the high value of the sum of GARCH estimates implies presence of persistence of volatility where the expected future volatility takes longer to decay to the unconditional variance. This suggests that any shocks will have a ripple type effect on the spreads of the Malaysian sukuk and will take some time before the spreads gradually return to equilibrium.

From this analysis, it is also evident that the coefficient of the crisis impact,(γ_3) is not statistically significant for all ratings and maturities except for AA3. The small size of the crisis coefficient for the volatility of AA3 spreads (0.0001) indicate that generally, the presence of the crisis gives almost no impact to the volatility of sukuk spread. One possible explanation for this is due to the confidence of the market players on sukuk as one of the essential asset classes in their investment portfolios. In addition to that, the concept of sukuk as a proof of ownership rather than debt may also contribute to the resilience of sukuk from the crisis (Rahman and Omar, 2012).

In addition to that, no significant relations can be established between the stock market uncertainty and the volatility of sukuk spreads for all ratings and maturity, except for BB3. This finding is in conformity with the findings of Longstaff and Schwartz (1995) and Davies (2007) that only lower grade bonds are more susceptible to changes in the asset factor.

5. Conclusion

Generally, changes in the sukuk spreads for both long term and short term sukuk appear to be negatively correlated with interest rate variable, and with the slope of the yield curve. The variable representing the asset factor though significant shows a different sign as compared to previous studies, which may indicate the investors' preference to hold both the sukuk and the equity market in a certain period of time. The autoregressive terms however (lag of spreads) is found to be not significant in all ratings and maturites. On the other hand, based on the variance equation, the volatility of sukuk is found to be driven mainly by the forecast variance (GARCH term) than the past shocks or news (ARCH term). The factor representing the presence of 2007/2008 crisis is found to be not significant in all cases whilst stock market volatility is onlysignificant on the lower grade ofsukuk spreads.

This study provides some empirical evidence that may be useful for industry players especially the traders, issuers and fund managers in articulating the strategies involving on the trading of sukuk, based on the spreads. By understanding how the important factors such as the risk-free rate and slope of the yield curve affect the movement of sukuk spread and hence the yield, this study may also assist the policy makers in designing the suitable monetary policy to influence the sukuk market. This study may be extended to include the sukuk market of other countries in order to validate the finding and further enrich the literature on spreads analysis.

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Sukuk Spreads	GARCH variants	Mean equation α	*β1risk-free*	*β2asset*	*β3 slope*	*β4SSt-1*	Variance equation α	ARCH (1)	ARCH (2)	GARCH (1)	GARCH (2)	*Crisis*	*Mkt Vol*	Diagnostic Tests Adj R^2	$Q^2(2)$	LM ARCH
AAA10	GARCH (1,1)	-0.0009**	-0.0287*	0.0521	-0.4118*	-0.0185	0.0000*	0.1554*		0.8421*		0.0000	0.0502	0.2020	2.3856	2.1869
		(-1.9543)	(-2.5688)	(0.6806)	(-13.8868)	(-0.6048)	(2.4078)	(4.8087)		(29.6243)		(1.0002)	(0.8189)			
		[0.0507]	[0.0102]	[0.4961]	[0.0000]	[0.5453]	[0.0160]	[0.0000]		[0.0000]		[0.3172]	[0.4128]		[0.303]	[0.1392]
AA10	GARCH (1,1)	-0.0009**	-0.0223*	0.0931	-0.3899*	-0.0168	0.0000*	0.1647*		0.8448*		0.0000	0.0166	0.1983	0.1930	0.1565
		(-1.8518)	(-2.1009)	(1.2081)	(-13.1683)	(-0.47651)	(2.2863)	(4.4843)		(26.3784)		(0.8411)	(0.2945)			
		[0.0641]	[0.0356]	[0.227]	[0.0000]	[0.6337]	[0.0222]	[0.0000]		[0.0000]		[0.4003]	[0.7683]		[0.908]	[0.6924]
A10	GARCH (1,1)	-0.0003	-0.0240*	0.0625	-0.4016*	0.0042	0.0000*	0.2066*		0.8038*		0.0001	0.0424	0.2067	2.4459	0.5316
		(-0.5808)	(-1.9599)	(0.8348)	(-14.2706)	(0.1141)	(2.4466)	(4.9132)		(22.3352)		(1.1827)	(0.5622)			
		[0.5613]	[0.0500]	[0.4038]	[0.0000]	[0.9092]	[0.0144]	[0.0000]		[0.0000]		[0.2369]	[0.574]		[0.294]	[0.4659]
BBB10	GARCH (1,2)	-0.0002	-0.0222**	0.1389**	-0.4503*	0.0106	0.0000*	0.2928*		0.2886**	0.4737*	0.0001	0.0083	0.1845	0.2384	0.0358
		(-0.4175)	(-1.7444)	(1.7593)	(-14.4974)	(0.2144)	(2.0449)	(4.9367)		(1.7630)	(3.3846)	(0.7345)	(0.1125)			
		[0.6763]	[0.0811]	[0.0785]	0.0000	[0.8302]	[0.0409]	[0.0000]		[0.0779]	[0.0007]	[0.4626]	[0.9104]		[0.888]	[0.8500]
BB10	GARCH (1,1)	-0.0002	-0.0273*	0.1645*	-0.4679*	0.0306	0.0000*	0.2751*		0.7922*		0.0001	-0.0059	0.1533	0.1092	0.0281
		(-0.3569)	(-2.1569)	(1.9908)	(-15.3544)	(0.7356)	(2.7070)	(2.5991)		(22.3270)		(0.8155)	(-0.0876)			
		[0.7211]	[0.031]	[0.0465]	[0.0000]	[0.4619]	[0.0068]	[0.0093]		[0.0000]		[0.4147]	[0.9302]		[0.947]	[0.8669]
AAA3	GARCH (1,2)	0.0002	-0.0085	0.1133**	0.3278*	-0.0510**	0.0000*	0.2364*		0.2802**	0.4597*	0.0001	0.0747	0.3285	0.3696	0.0362
		(0.4126)	(-0.9299)	(1.6462)	(13.0561)	(-1.6873)	(2.8217)	(4.1313)		(1.8187)	(3.4237)	(1.4741)	(0.9385)			
		[0.6799]	[0.3524]	[0.0997]	[0.0000]	[0.0915]	[0.0048]	[0.0000]		[0.0689]	[0.0006]	[0.1404]	[0.3480]		[0.831]	[0.8491]
AA3	GARCH (1,1)	-0.0004	-0.0067	0.1324**	0.2910*	-0.0110	0.0000*	0.2682*		0.7220*		0.0001**	0.0676	0.2985	1.1474	0.0446
		(-0.7496)	(-0.7754)	(1.8114)	(12.2597)	(-0.3506)	(3.2270)	(6.1081)		(20.2295)		(1.9226)	(0.9327)			
		[0.4535]	[0.4381]	[0.0701]	[0.0000]	[0.7258]	[0.0013]	[0.0000]		[0.0000]		[0.0545]	[0.3509]		[0.563]	[0.8327]
A3	GARCH (1,2)	0.0002	-0.0089	0.0806	0.2888*	-0.0441	0.0000*	0.3186*		0.2854*	0.4135*	0.0002	0.0830	0.2911	0.7468	0.1334
		(0.4703)	(-0.9421)	(1.2067)	(12.1018)	(-1.2451)	(2.6310)	(4.1158)		(2.2799)	(3.7957)	(1.3287)	(0.7138)			
		[0.6381]	[0.3461]	[0.2275]	[0.0000]	[0.2131]	[0.0085]	[0.0000]		[0.0226]	[0.0001]	[0.1839]	[0.4753]		[0.688]	[0.715]
BBB3	GARCH (1,2)	-0.0006	-0.0214**	0.1411**	0.3381*	-0.0657	0.0000**	0.3596*		0.2102*	0.4978*	0.0001	-0.0017	0.2598	0.3509	0.0598
		(-0.9904)	(-1.7260)	(1.6468)	(13.7997)	(-1.0098)	(1.7341)	(5.1151)		(2.0750)	(7.7762)	(0.8238)	(-0.0198)			
		[0.3219]	[0.0843]	[0.0996]	[0.0000]	[0.3126]	[0.0829]	[0.0000]		[0.0380]	[0.0000]	[0.4100]	[0.9842]		[0.839]	[0.8068]
BB3	GARCH (1,1)	-0.0032*	-0.0585*	0.2528*	0.3921*	-0.1017	0.0000*	0.2332*		0.7958*		0.0001	-0.1466*	0.2195	0.1109	0.0024
		(-3.0788)	(-3.4971)	(2.2849)	(10.0918)	(-1.6426)	(284.1666)	(5.1133)		(46.1514)		(0.6108)	(-9.0741)			
		[0.0021]	[0.0005]	[0.0223]	[0.0000]	[0.1004]	[0.0000]	[0.0000]		[0.0000]		[0.5413]	[0.0000]		[0.946]	[0.961]

*** The result shows the coefficient value, z-statistics in parenthesis and p-value in squared parenthesis with * and ** denote significance level at 5% and 10* respectively. This summary shows the best model after testing for different lags of ARCH and GARCH terms. Diagnostic tests takes into account the Ljung Box portmanteau test statistics, with 2 degrees of freedom applied to the squared standard residuals and the ARCH LM statistical test for the presence of remaining ARCH effects.