Co-movement dynamics between global sukuk and bond markets

New insights from a wavelet analysis

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Abstract

Purpose – Market links (and price discovery) between financial assets and lead–lag relationships are topics of interest for financial economists, financial managers and analysts. The lead–lag relationship analysis should consider both short and long-term investors. From a portfolio diversification perspective, the first type of investor is generally more interested in determining the co-movement of financial assets at higher frequencies, which are short-run fluctuations, while the latter concentrates on the relationship at lower frequencies, or long-run fluctuations. The paper aims to discuss these issues.

Design/methodology/approach – For this study, a technique was employed known as the wavelet approach, which has recently been imported to finance from engineering sciences to study the co-movement dynamics between global sukuk and bond markets. Data cover the period from January 2010 to December 2015.

Findings – The results indicate that: there is no unidirectional causality from developed market bond indices to Malaysia and Dow Jones indices, which is promising for fixed-income investors of a developed market; and in relation to emerging markets, the Malaysian sukuk market has a bidirectional causality with Indonesia, Malaysia, India and South Korea bond indices but not China bond indices, while in terms of the Dow Jones sukuk index, there is no unidirectional causality between the listed emerging markets and the sukuk index except Indonesia's market during the sample period.

Research limitations/implications – This analysis provides evidence regarding the timely and appropriate measure of correlation changes and the behaviour of sukuk and bond indices globally, which is beneficial to the management of sukuk and bond portfolios.

Originality/value – The evidence hitherto unexplored, which was produced by the application of a wavelet cross-correlation amongst the selected sukuk and bond indices, provides robust and useful information for international financial analysts as well as long and short-term investors.

Keywords Sukuk, Islamic finance, Bond

Paper type Research paper

1. Introduction

The lead–lag causal relationship between financial assets reflects how fast each financial asset reacts to information as well as the effectiveness of its co-movement. If one financial asset reacts faster to market information than another financial asset, a lead–lag relationship is expected to be observed in the data. In other words, the lead–lag relationship between financial assets demonstrates how well two markets are connected and how fast one market reacts to current information from the other (Floros and Vougas, 2007). Thus, the information flow between the two financial assets and their causal directions should be determined.

In recent years, researchers have attempted to explore bond markets and to analyse the time-varying properties of bond market correlations. Many recent empirical studies have shown that there is no constant relation between global bond markets; rather, it changes

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over time (e.g. Longin and Solnik, 1995; Yang, 2005; Dacjman *et al.*, 2012). In the context of global bond markets, Cappiello *et al.* (2006) analysed the correlation between major bond markets and concluded that it was not static and changed over time. Integrating the dynamics between several bond markets will help improve the prediction accurateness of statistical models (Barassi *et al.*, 2001). The benefits of international diversification depend on the co-movement of international bond markets. If co-movements exist, then the benefits of diversification might not be achieved long-term.

More importantly, the lead–lag relationships between several financial markets have been analysed in previous studies in terms of methodology, and these studies applied multivariate statistical approaches, such as vector autoregressive (Lee, 1992; Gjerde and Saettem, 1999; Rapach, 2001) and vector error correction (Cheung and Ng, 1998; Nasseh and Strauss, 2000, Masih and Masih, 1997a, b, 1999, 2001) models. These studies only examined the interactions between the stock market and aggregate economic activity and explored either their short-term or long-term relationships because the time series methodologies employed (usually a cointegration analysis with an acknowledgement of the non-stationary property of stock prices) may only separate two-time periods in an economic time series, i.e. the short-term and the long-term (Gallegati, 2012); however, the precise definitions of "short-term" and "long-term" are unknown. In addition, the stock market is an example of a market in which diverse investors make decisions in different time periods, such as from minutes to years, and operate at each moment during different time intervals (from hedging to investment activities).

The lead–lag relationship among bond markets is an essential issue to investigate because it can illustrate how efficiently the bond markets are associated and how fast one market transmits the latest information to another (Floros and Vougas, 2007). If markets are linked and responsive to one another, investors and analysts can use historical data to predict returns (A'Hearn and Woitek, 2001; Pakko, 2004). Although the sukuk market climbed to US$269.4bn at the end of 2013, which is a remarkable growth, surprisingly, there are no studies on the lead–lag relationships among sukuk, developed and emerging market bond indices. Furthermore, as contagion is rapidly increasing among financial markets, it is crucial to examine the causal effects among these markets. Some researchers examined the contagion effect among the financial markets such as Shabri Abd Majid and Hj Kassim (2009), Kiymaz (2013), Saiti *et al.* (2016), Vortelinos (2016), Al Refai *et al.* (2017) among others. In the case of comparing the performance in developed and developing countries, Ruiz *et al.* (2017) tested the development of the institutional context contributes to the creation of hypercompetitive conditions by using data from both developing and developed countries. And their findings support the proposition that there is a significant difference in superior economic performance and persistent superior economic performance sustainability between firms in developed and developing countries.

Sukuk issuance in the global market increased sharply in terms of foreign currency, specifically in USD, while Malaysia increased issuances from other regional markets, such as Singapore and Turkey. Sukuk listings also increased cross-border activities, and sukuk is listed on many key stock exchanges specifically in Europe, such as the London Stock Exchange, Irish Stock Exchange and Luxembourg Stock Exchange[1]. A remarkable initiative was taken to facilitate Islamic financial institutions' compliance with Basel III and capital obligations in 2013 and 2014[2]. Indeed, the sukuk market reached a new level over the past couple of years with a broader issue base, increased cross-border operations and increased innovative issuance. In addition, several first-time sovereign obligors included sukuk issuances, such as the UK, Senegal, the Emirate of Sharjah, Hong Kong, South Africa, Luxembourg and Pakistan.

Globalisation and technological advancements enhance cross-class correlations, complicating diversification opportunities. To obtain global portfolio diversification benefits, individual and institutional investors are more interested in co-movements and causality between indices. A large portion of international asset markets is represented by bond markets, and it is also important to understand the associations between them. In this context, this study investigated the sukuk and bond causality among the developed and emerging economies by applying a wavelet analysis. This analysis is useful because it represents a refinement in terms of time and frequency domains (Rua and Nunes, 2009).

Conventional bonds differ significantly from sukuk in such a way that the returns to bondholders or investors signify the right to claim indebtedness for borrowed money whereas the return to sukuk holders signifies the right to avail payments from a trade transaction, claim ownership of business venture or a specific asset. Moreover stated that sukuk is an innovative financial instrument having a flexible structure based on Islamic financial contracts, unlike a bond which is based on the ancient structure of a loan imposed with interest. Basically, sukuk is not an interest-based financial instrument but rather, one that promotes real economic activities and generates a return based on sharing or leasing acceptable assets.

2. Literature review

Intensive research has been carried out on portfolio diversification models for the stock market. This covers literature on global stock market integration (e.g. Eun and Shim, 1989; Arshanapalli and Doukas, 1993; Francis and Leachman, 1998; Bessler and Yang, 2003) and global money market integration (e.g. Fung and Isberg, 1992; Fung and Lo, 1995); however, few studies have been conducted on bond market links (Yang, 2005). According to Burger and Warnock (2003), the unavailability of data is an obstacle to research on global bond portfolios, especially when comparing bond yields among different markets. The availability of historical data on bond returns is limited, and emerging bond market indices did not appear until the mid-1990s. As such, Hansson *et al.* (2009) noted that most studies that focussed on bond diversification analyses were limited to certain developed markets, such as the UK, USA, Germany and Japan. Moreover, the focus included only government bond markets.

For example, Kim *et al.* (2006) examined the correlations between European government markets to analyse the time-varying levels of global bond market integration, and they found that the Eurozone bond market has a dynamic link with Germany's bond market. Another study conducted on Asian bond markets was conducted by Johansson (2008). The study analysed the relationships between four major Asian bond markets and showed that there were long-term independencies between them. In a related study, Christiansen (2010) examined the volatility spillover from the USA and aggregate European asset markets into European national asset markets. This study found significant volatility-spillover effects, and the national bond (stock) volatilities were influenced by bond (stock) effects. The European markets were more integrated after the introduction of the euro, and bond markets were even more integrated than stock markets.

In terms of international bond markets, there are few research studies on the lead–lag relationships among bond markets. Hunter and Simon (2005) investigated the lead–lag relations and the conditional correlations between US government bond returns with Japan, the UK and Germany. The authors found that mean and volatility spillover existed between the international bond indices and that the correlation between the USA and other bond market returns were time-varying and were driven by changing market conditions and macroeconomics. Ciner (2007) investigated the dynamic links among the international government bond markets of developed countries as well as the cointegration and causality between bond indices. The outcome showed that in terms of causality tests, lead–lag relationships were significant among the bond markets.

Dewandaru *et al.* (2013) examined the co-movement and transmission channels of the Gulf Cooperation Council (GCC) Islamic equity index with other Islamic equity indices and they also included the global sukuk index. The study revealed that short-term and long-term shocks were created by the US subprime crisis, which affected the volatility of all Islamic indices. Moreover, the authors also highlighted that Islamic and conventional indices behaved in the same way when co-movement and volatility transmissions were considered. Naifar (2016) investigated the co-movement and the dependence structure between DJIMI returns and influential global financial market conditions, and the results demonstrated that conventional stock market returns, stock market implied volatility and the slope of the yield curve are significant for all quantiles, which indicated asymmetric tail dependence.

Alam *et al.* (2013) examined the impact of conventional bonds and sukuk announcements on shareholder wealth and their determinants using 79 sukuks and 87 conventional bonds. It was revealed that the market reaction was negative for the announcements of sukuk before and during the 2007 global financial crisis. Reboredo and Naifar (2017) studied the relationship between Islamic bond (sukuk) prices and financial and policy uncertainty conditions using a quantile regression approach. Their empirical results showed that US bond prices had a negative impact and causality effects on sukuk prices, whereas European Monetary Union bond prices only co-moved with sukuk prices. Aloui, Hkiri, Lau and Yarovaya (2018), Aloui, Jammazi and Hamida (2018) investigated the relationship between the *Shariah* stock index and three Islamic bond yields within a global perspective of the GCC Islamic financial markets by applying a wavelet multiple correlation, a wavelet multiple cross-correlation and wavelet cohesion. They found a significant changing pattern in the dynamic links between *Shariah* stocks and Islamic bond yields in the time-frequency domain.

In a recent study, Maghyereh and Awartani (2016) stated that the core distinctive characteristics of the sukuk market are the weaker transmission of information from the sukuk market to other markets and the higher transmission of information from equities. This study revealed the importance of sukuk as a hedging instrument for global investors as well as its importance in strategic asset allocation. More recently, Bhuiyan *et al.* (2018) examined the volatilities and correlations of the bond indices of emerging countries by applying wavelet coherence and Multivariate GARCH analyses. They concluded that the sukuk market offers effective portfolio diversification opportunities for fixed-income investors of the sample countries under investigation. Hassan *et al.* (2018) examine the conditional correlations and volatility linkages between sukuk (Islamic bonds) and conventional bond markets in Europe, the USA, and emerging markets by application of the multivariate GARCH framework. They find that sukuk and conventional investment-grade bonds have a lower reaction of conditional volatility to market shocks and higher persistence. The similar approach is employed by Saiti and Noordin (2018) to investigate the diversification benefits of Islamic investment to conventional investors.

There is limited literature on sukuk market interdependence and integration, so there is no clear indication of diversification benefits. Although several studies were found on conventional bond market interdependence and integration, it is important to examine this relation critically due to the inconsistent results reported. Therefore, first, this study examined the co-movement between sukuk, developed and emerging market bond indices. Second, the way lead–lag relationships are developed among sukuk, developed and emerging market bond indices was analysed. Finally, this study attempted to answer the following questions:

RQ1. What is the relationship in terms of co-movement between sukuk, developed and emerging market bond indices in short and long runs?

RQ2. Is there a lead–lag relationship between sukuk, developed and emerging market bond indices during the sample period in short and long runs?

3. Methodology

This study examined the co-movement and lead–lag relationships between the Islamic bond (sukuk) market and the conventional bond market. Thus, Johansen co-integration and Wavelet cross-correlation were applied to investigate the relationship between conventional bonds and Islamic bonds (sukuk). Since the co-integration test is a well-known technique, its details are not discussed here due to space constrains, for more details the readers can refer to Johansen (1988), Johansen and Juselius (1990), Masih and Masih (1997a, b) and among others.

3.1 Lead–lag relationship analysis

It is crucial to determine whether an index is considered the leader or the follower in the industry. Previous research on financial indices has been done in which temporal interrelations in time were studied. Rua and Nunes (2012) argue that these interrelations can be studied in more detail by applying wavelet methods. Hence, this paper analyses the lead–lag relationships between the sukuk and 12 other bond indices from developed and emerging markets by applying a wavelet cross-correlation. Although similar methodologies have been applied in the case of Islamic stock indices, such as Najeeb *et al.* (2015, 2016), Saiti *et al.* (2016), Abdullah *et al.* (2016), Buriev *et al.* (2018), Jaffar *et al.* (2018), Aloui *et al.* (2016), Aloui, Hkiri, Lau and Yarovaya (2018), Aloui, Jammazi and Hamida (2018), Rizvi and Arshad (2018) and Rizvi *et al.* there are almost no studies that have addressed the lead–lag relationships among fixed-income securities by applying a wavelet analysis.

3.1.1 Wavelet cross-correlation. Wavelet methods can provide an alternative representation of the variability and relationship structure of a specific stochastic process on a scale-by-scale basis in addition to the benefits of a multi-resolution decomposition analysis (Percival, 1995; Gençay *et al.*, 2001a, b; Gallegati, 2012). Based on the prerequisites that the stationary stochastic process $\{X\}$ with the variance σ_X^2 and the wavelet variance definition at scale j as $\sigma_{X,j}^2$, the following relationship holds:

$$\sum_{j=1}^{\infty} \sigma_{X,j}^2 = \sigma_X^2. \tag{1}$$

Thus, the contribution of the changes at scale j to the overall variability of the process is reflected by $\sigma_{X,j}^2$, and this association states that the wavelet variance delivers an exact decomposition of the variance of a time series into components that are related to different time scales. The wavelet variance decomposes the variance of a stationary process with respect to the scale at the jth level, just as the spectral density decomposes the variance of the original series with respect to frequency f:

$$\sum_{j=1}^{\infty} \sigma_{x,j}^2 = \sigma_x^2 = \int_{-1/2}^{1/2} S_x(f) df, \tag{2}$$

where S(.) is the spectral density function.

By definition, the (time-independent) wavelet variance at scale j, $\sigma_{X,j}^2$, is given by the variance of the j-level wavelet coefficient:

$$\sigma_{X,j}^2 = var\{\varpi_{j,t}\}. \tag{3}$$

A time-independent wavelet variance defined for stationary processes as well as non-stationary processes but also with stationary dth order differences and for non-stationary processes but with local stationary (see Percival and Walden, 2000). Thus, the difference between two generalised averages is reflected by the wavelet filter $\{h_l\}$ and is also associated with a difference operator (Whitcher *et al.*, 2000). Wavelet variance is also time-independent in the case of non-stationary processes but has stationary dth order differences, meaning that the length L of the wavelet filter is sufficiently large. Percival and Walden (2000) found that $L \geqslant \mathrm{d}$ is an appropriate condition to create the wavelet coefficients $\varpi_{j,t}$ of a stochastic process whose dth order backward difference is stationary as a sample of stationary wavelet coefficients.

As the Maximum Overlap Discrete Wavelet Transform (MODWT) applies circular convolution, both beginning and ending data generate coefficients that could be spurious. Hence, there are (2^{j-1}) $(L-1)$ coefficients affected for a 2^{j-1} scale wavelet and scaling coefficients considering the length of the filter L (Percival and Walden, 2000). As mentioned in Percival (1995), given that $N-L_j \geqslant 0$, an unbiased estimator of the wavelet variance based on the MODWT may be acquired after eliminating all coefficients affected by the periodic boundary conditions:

$$\sigma_{X,j}^2 = \frac{1}{N_j}\sum_{t=Lj}^{N} \varpi_{j,\,t}^2, \tag{4}$$

where $N_j = N-L_j+1$ is the number of maximal overlap coefficients at scale j, and $L_j = (2_j-1)$ $(L-1)+1$ is the length of the wavelet filter for level j. Hence, the jth scale wavelet variance is simply the variance of the non-boundary or interior wavelet coefficients at that level (Percival, 1995; Serroukh *et al.*, 2000). The sample variance of a time series can be decomposed by both DWT and MODWT on a scale-by-scale basis via its squared wavelet coefficients; however, the MODWT-based estimator is superior if compared with the DWT-based estimator (Percival, 1995).

The concept of wavelet variance for the MODWT was explored by Whitcher *et al.* (1999, 2000), who introduced the definition of wavelet covariance and wavelet correlation between the two processes, including their estimators as well as approximate confidence intervals. The concept of wavelet covariance is used to determine the magnitude of the relationship between two series of observations X and Y on a scale-by-scale basis. According to Gençay *et al.* (2001a, b) and Gallegati (2008), the covariance between scale j wavelet coefficients of X and Y, which is $\gamma_{XY,j} = Cov\,[\varpi_{j,t}^X \varpi_{j,t}^Y]$, is defined by the wavelet covariance at wavelet scale j. For an unbiased estimator of the wavelet covariance using MODWT after eliminating all wavelet coefficients affected by boundary conditions, the equation is:

$$\breve{\gamma}_{XY,j} = \frac{1}{N_j} N-1 \sum_{t=L_{j-1}}^{N-1} \varpi_{j,t}^X \varpi_{j,t}^Y. \tag{5}$$

Then, using wavelet cross-covariance, $\breve{\gamma}_{XY,j}$, the MODWT estimator of the wavelet cross-correlation coefficient for scale j and lag τ can be obtained, and the square root of their wavelet variances, $\sigma_{X,j}$ and $\sigma_{Y,j}$, are as follows:

$$\rho_{\tau,XY,j} = \frac{\breve{\gamma}_{\tau,XY,j}}{\sigma_{X,j}\sigma_{Y,j}}. \tag{6}$$

Finally, the lead–lag relationships between the two processes on a scale-by-scale basis can be derived from the wavelet cross-correlation coefficients $\rho_{\tau,XY,j}$, which behave similar to the unconditional cross-correlation coefficients between 0 and 1.

It is possible to determine the asymptotic variance V_j of the MODWT-based estimator of the wavelet variance initiated from the spectrum $S\omega_{X,j}$ of scale j wavelet coefficients and to create a random interval that generates a 100(1−2p) per cent confidence interval. Gençay *et al.* (2002) provided the formulas for an imprecise 100(1−2p) per cent confidence interval MODWT estimator robust to non-Gaussianity for $\upsilon^2_{X,j}$. It is suggested by empirical evidence that the wavelet variance should be $N_j = 128$, which is a large enough number of wavelet coefficients for the large sample theory to be a good approximation (Whitcher *et al.*, 2000).

4. Data and empirical results

4.1 Data

Data were collected from the Bloomberg and Data Stream databases covering the period from January 2010 to December 2015. These bond and sukuk indices are transformed into compounded stock market returns by calculating the natural logarithmic differences of the daily prices: return $= \ln(p_t/p_{t-1})$, where P_t and P_{t-1} represent the bond or sukuk price index at time t and $t-1$, consecutively. The list of the indices and the respective symbols are provided in Table I.

The primary rationale for selecting emerging market countries in the Asian region was to investigate regional effects. Malaysian bond and sukuk market indices were selected to examine the domestic diversification opportunities for Malaysian bond markets investors. The selected emerging market countries have sharp growth in their economies, and especially in China and India, there is a high savings rate compared to other countries. Moreover, the selected emerging market countries have established an efficient bond market in their region that represents the region effectively. Developed bond market countries were selected based on their well-established position in terms of market capitalisation. Investors from developed countries are more interested in investing in emerging markets due to higher expected returns. In addition, according to the literature, there is a high demand for sukuk certificates among the investors of Western countries.

No.	Indices	Symbol
Developed market		
1.	Bloomberg US Government Bond Index	BUSG
2.	Bloomberg Canada Sovereign Bond Index	BCAN
3.	Bloomberg Germany Sovereign Bond Index	BGER
4.	Bloomberg UK Sovereign Bond Index	BRIT
5.	Bloomberg Australia Sovereign Bond Index	BAUS
6.	Bloomberg Japan Sovereign Bond Index	BJPN
Emerging market		
1.	Bloomberg Singapore Sovereign Bond Index	BSIN
2.	Bloomberg Indonesia Local Sovereign Index	BINDO
3.	Bloomberg Malaysia Local Sovereign Index	BMYR
4.	Bloomberg S Korea Local Sovereign Index	BKRW
5.	Bloomberg China Local Sovereign Index	BCGB
6.	Bloomberg India Local Sovereign Index	BINDI
7.	Dow Jones Sukuk Index	DJSUKUK
8.	Thomson Reuters BPA Malaysia Sukuk Index	TRBPAMGOVI

Table I. List of indices

Data availability is also another important reason for selecting the countries. Moreover, few of the sampled countries have already issued sovereign sukuk, which shows their familiarity with and interest in the sukuk market.

4.2 Bivariate Johansen cointegration test between bonds and the sukuk index

Based on the Johansen cointegrations tests, it can be determined that all series are $I(1)$. To identify common long-term trends, cointegration tests can be performed on these series. Tables II–V illustrate the bivariate Johansen test between the two sukuk bond markets and the other 12 bond markets. In the tables, the first column includes the paired indices that consist of bonds and sukuk, while the second and third columns define the H_0 and H_1, respectively. The fourth column represents the final decision based on the trace and max-Eigen statistics.

In terms of the developed market bonds, after analysing the indices, the trace and max-eigen statistics illustrate that the Malaysia sukuk market has no cointegration with the USA, the UK, German or Canadian bond markets; however, it has a cointegration with

Table II. Bivariate Johansen cointegration test between developed market bonds and malaysian sukuk index

	H_0	H_1	Trace statistic	5% critical value	Max-Eigen statistic	5% critical value	Decision
BUSG- TRBPAMGOVI	$r=0$	$r>0$	11.14	15.49	7.84	14.26	$r=0$
BCAN- TRBPAMGOVI	$r=0$	$r>0$	12.56	15.49	10.56	14.26	$r=0$
BAUS- TRBPAMGOVI	$r=0$	$r>0$	17.79	15.49	16.19	14.26	$r=0$**
BGER- TRBPAMGOVI	$r=0$	$r>0$	15.38	15.49	12.90	14.26	$r=0$
BRIT- TRBPAMGOVI	$r=0$	$r>0$	11.63	15.49	9.30	14.26	$r=0$
BJPN- TRBPAMGOVI	$r=0$	$r>0$	17.91	15.49	17.49	14.26	$r=0$**

Note: **Significant at 99 per cent level

Table III. Bivariate Johansen cointegration test between developed market bonds and Dow jones sukuk index

	H_0	H_1	Trace statistic	5% critical value	Max-Eigen statistic	5% critical value	Decision
BUSG- DJSUKUK	$r=0$	$r>0$	12.96	15.49	9.61	14.26	$r=0$
BCAN- DJSUKUK	$r=0$	$r>0$	10.22	15.49	8.97	14.26	$r=0$
BAUS- DJSUKUK	$r=0$	$r>0$	11.08	15.49	8.95	14.26	$r=0$
BGER- DJSUKUK	$r=0$	$r>0$	11.09	15.49	9.04	14.26	$r=0$
BRIT- DJSUKUK	$r=0$	$r>0$	12.94	15.49	10.66	14.26	$r=0$
BJPN- DJSUKUK	$r=0$	$r>0$	9.48	15.49	9.47	14.26	$r=0$

Table IV. Bivariate Johansen cointegration test between emerging market bond and Malaysian sukuk index

	H_0	H_1	Trace statistic	5% critical value	Max-Eigen statistic	5% critical value	Decision
BSIN- TRBPAMGOVI	$r=0$	$r>0$	10.70	15.49	8.37	14.26	$r=0$
BINDO- TRBPAMGOVI	$r=0$	$r>0$	8.68	15.49	6.91	14.26	$r=0$
BINDI- TRBPAMGOVI	$r=0$	$r>0$	7.99	15.49	7.91	14.26	$r=0$
BMYR- TRBPAMGOVI	$r=0$	$r>0$	21.13	15.49	19.53	14.26	$r=0$**
BCGB- TRBPAMGOVI	$r=0$	$r>0$	4.94	15.49	4.92	14.26	$r=0$
BKRW- TRBPAMGOVI	$r=0$	$r>0$	16.11	15.49	15.00	14.26	$r=0$**

Note: **Significant at 99 per cent level

Australian and Japanese bond markets during the sample period. On the other hand, in terms of the emerging market, there is no cointegration between the Malaysian sukuk market and the bond markets of India, Indonesia, China or Singapore, whereas the South Korean and Malaysian bond markets are cointegrated with the sukuk market. It is also worth noting that the Dow Jones sukuk index strongly rejected any cointegrating relationship with the developed and emerging bond markets during the sample period.

The summarised results of the Multivariate Johansen procedure are highlighted in Table VI, which shows the cointegration between the sukuk and the bond markets. The null hypothesis of $r = 0$ defined as there is no cointegration vector; as per the trace and maximum eigenvalue statistics, the findings showed that there is no cointegration vector between developed bond and sukuk market indices. Hence, due to no cointegration among the indices, it was unnecessary to extend the analysis to construct a VECM model. The outcome of the cointegration test indicates that there is no long-term association between developed bond and sukuk markets.

4.3 VECM results of sukuk and emerging market bond indices

The first model consists of Malaysian sukuk (TRBPAMGOVI) and emerging market bond indices, and the second consists of the Dow Jones global sukuk (DJSUKUK) and emerging market bond indices. According to the results provided in Table VII, no long-term relationship between Malaysian sukuk and selected emerging market bond indices was found. In terms of the Dow Jones sukuk index, Table VIII shows similar results to the first model, which implies that there is no long-term association between the Dow Jones sukuk and emerging bond market indices. The findings support the study conducted by Yang (2005), who found no long-term association among developed bond markets during the sample period. Moreover, Ciner (2007) examined the cointegration between international sovereign bond markets and found no evidence of dynamic links between the indices during the sample period; however, another recent study revealed that Asian bond markets were

	H_0	H_1	Trace statistic	5% critical value	Max-Eigen statistic	5% critical value	Decision
BSIN- DJSUKUK	$r=0$	$r>0$	14.41	15.49	10.25	14.26	$r=0$
BINDO- DJSUKUK	$r=0$	$r>0$	14.31	15.49	9.19	14.26	$r=0$
BINDI- DJSUKUK	$r=0$	$r>0$	12.97	15.49	12.23	14.26	$r=0$
BMYR- DJSUKUK	$r=0$	$r>0$	9.70	15.49	9.20	14.26	$r=0$
BCGB- DJSUKUK	$r=0$	$r>0$	9.53	15.49	9.43	14.26	$r=0$
BKRW- DJSUKUK	$r=0$	$r>0$	9.23	15.49	9.23	14.26	$r=0$

Table V. Bivariate Johansen cointegration test between emerging market bond and Dow Jones sukuk market

	H_0	H_1	Trace statistic	5% critical value	Max-Eigen statistic	5% critical value	Decision
Developed Market Indices –	$r=0$	$r>0$	118.56	125.62	38.36	46.23	$r=0$
TRBPAMGOVI	$r=1$	$r>1$	80.20	95.75	29.39	40.08	
Emerging Market indices –	$r=0$	$r>0$	138.94	125.62	48.86	46.23	$r>0$*
TRBPAMGOVI	$r=1$	$r>1$	90.08	95.75	29.97	40.07	$r=1$
Developed Market Indices –	$r=0$	$r>0$	109.93	125.62	40.31	46.23	$r=0$
DJSUKUK	$r=1$	$r>1$	69.62	95.75	24.45	40.07	
Developed Market Indices –	$r=0$	$r>0$	127.16	125.62	46.26	46.23	$r>0$*
DJSUKUK	$r=1$	$r>1$	80.90	95.75	30.30	40.07	$r=1$

Notes: *,**,***Significant at 95, 99 and 99.9 per cent levels, respectively

Table VI. Multivariate cointegration test results between sukuk and different bond indices

highly cointegrated in the long-term and that these relationships were highly significant during the sample period (Johansson, 2008). The findings of this study also support the results of studies conducted by DeGennaro *et al.* (1994) and Clare *et al.* (1995), though the current findings contradict other recent study findings, such as those by Smith and Barassi *et al.* (2001).

There are many implications of the analysis in this section. For instance, the results may help improve the understanding of the integration shared by global, regional and local bond markets with the presence of the sukuk market. These issues are important in terms of the growth and potential expansion of sukuk markets.

4.4 The wavelet cross-correlations between developed market bond and sukuk indices

The individual cross-correlation functions correspond to – from bottom to top wavelet scales, such as$\lambda_1, \ldots, \lambda_5$, which are associated with changes of 1–2, 2–4, 4–8, 8–16 and 16–32 days and are represented as level 1, level 2, level 3, level 4 and level 5 in the figures. The red line bound approximately a 95% confidence interval for the wavelet cross-correlation. If the wavelet cross-correlation is skewed to the left, it indicates that the bond index leads the sukuk index, whereas if it is skewed to the right, the opposite is true. Another important principle is that a positive wavelet cross-correlation is significant if both 95% confidence intervals are above the horizontal axis, while a significant negative wavelet cross-correlation is significant if both 95 per cent levels are below the horizontal line.

4.4.1 Wavelet cross-correlation between BUSG, TRBPAMGOVI and DJSUKUK. Figures 1 and 2 present the wavelet cross-correlations of the Bloomberg US government bond index with the Thomson Reuters Malaysian government bond index and Dow Jones global sukuk index, respectively. The outcome of the analysis is discussed in this section.

At the first and second wavelet levels, the results illustrate that similar findings exist between the two pairs of bond and sukuk indices. Neither pair has a significant correlation

Table VII. VECM equation results: Malaysia sukuk with emerging market bond indices

	T–1		*T*–2	
	Coeff.	*t*-value sign	Coeff.	*t*-value sign
TRBPAMGOVI	0.035	1.050	−0.028	−0.843
BSIN	0.021	1.911	0.010	0.867
BINDO	0.009	1.858	0.007	1.486
BINDI	0.033	3.765**	0.007	0.796
BMYR	0.133	2.609**	−0.006	−0.136
BCGB	0.012	1.955	−0.010	−1.654
BKRW	0.002	0.210	0.010	0.872

Note: **Significant at 95 per cent level

Table VIII. VECM equation results: Dow Jones global sukuk with emerging market bond indices

	T–1		*T*–2	
	Coeff.	*t*-value sign	Coeff.	*t*-value sign
DJSUKUK	0.078	2.882**	−0.009	−0.342
BSIN	−0.011	−0.580	0.035	1.867
BINDO	0.029	3.440**	0.005	0.563
BINDI	0.004	0.245	−0.002	−0.147
BMYR	0.109	1.631	0.083	1.265
BCGB	−0.011	−1.080	−0.020	−1.894
BKRW	0.032	1.652	−0.003	−0.144

Note: **Significant at 95 per cent level

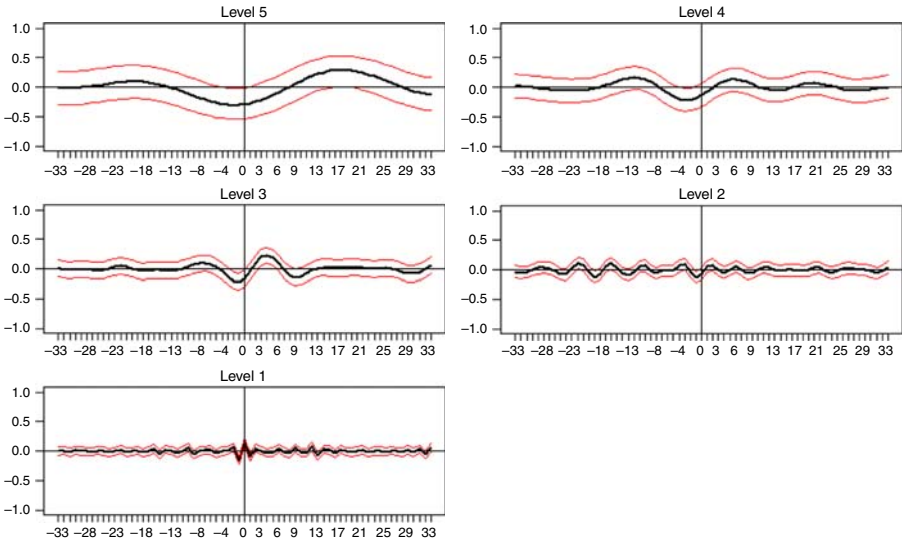

Figure 1.
Wavelet cross-correlation between BUSG and TRBPAMGOVI

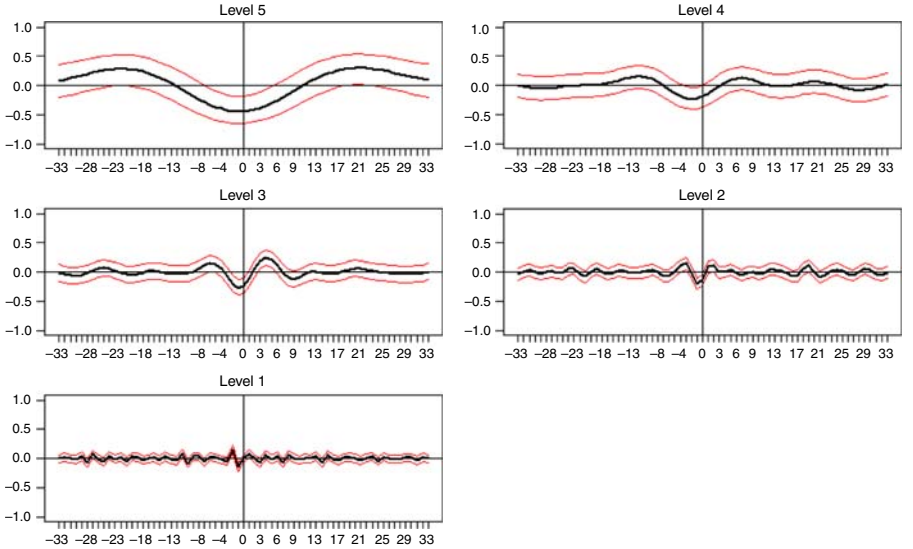

Figure 2.
Wavelet cross-correlation between BUSG and DJSUKUK

in Figures 1 and 2. The findings indicate that there is no influence of the US bond index on the Malaysian and Dow Jones sukuk indices.

At the third wavelet level, the lead–lag relationships between these two pairs are clear. The wavelet cross-correlation skewed to the right implies that the Malaysian and Dow Jones indices lead the US bond index. This outcome should be further investigated in future studies as this paper only discusses the potential explanations for the relations.

For the fourth and fifth wavelet levels, no significant event was found on either side of the Figures 1 and 2 because the wavelet cross-correlation did not shift towards the right or left, which implies that the indices do not influence each other.

4.4.2 Wavelet cross-correlation between BCAN, TRBPAMGOVI and DJSUKUK. Figures 3 and 4 illustrate the wavelet cross-correlations of the Bloomberg Canada government bond index with the Thomson Reuters Malaysian government sukuk index and Dow Jones Global sukuk index, respectively. The results of the analyses indicate the following.

At the first and second wavelet levels, the results illustrate that the same findings exist between the two pairs of bond and sukuk, which have no significant correlation on either side of the graphs. The findings indicate that the Canada bond index has no influence on the Malaysian or Dow Jones sukuk.

At the third wavelet level, the findings are significant at the right side of the graph, and both pairs consist of bonds with sukuk. The wavelet cross-correlations that are clearly

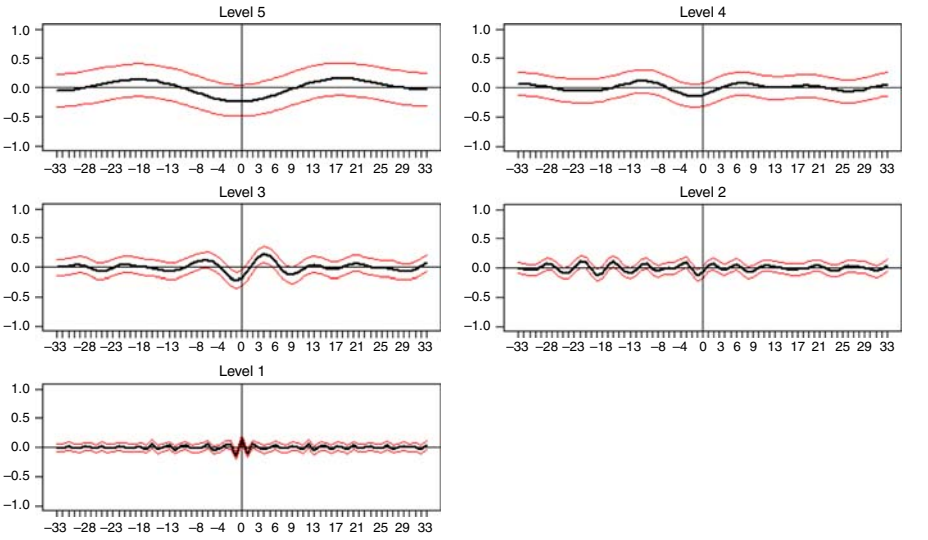

Figure 3.
Wavelet cross-correlation between BCAN and TRBPAMGOVI

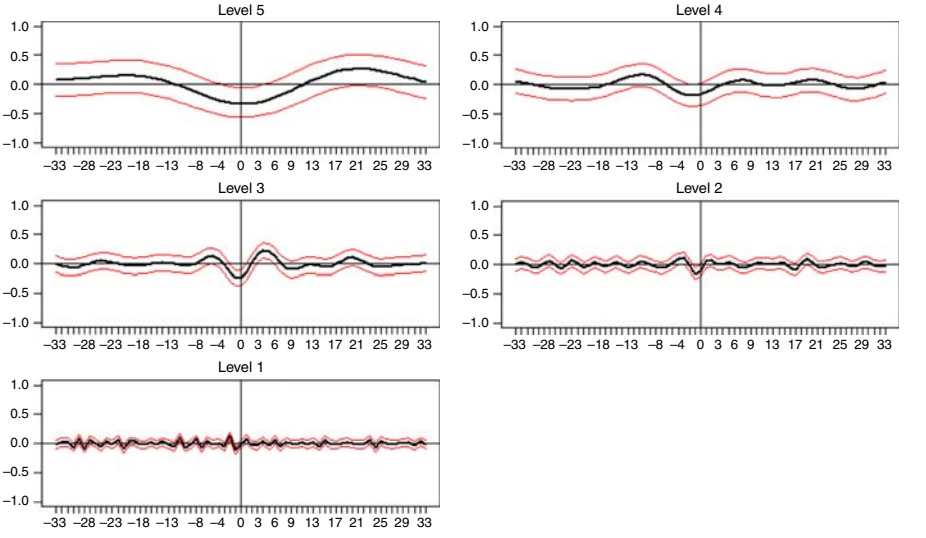

Figure 4.
Wavelet cross-correlation between BCAN and DJSUKUK

skewed to the right side indicate that the Malaysian and Dow Jones global sukuk lead the Canada bond index, similar to findings related to the US market.

Finally, at the fourth and fifth wavelet levels, the wavelet cross-correlation is slightly skewed to the right but insignificant because the confidence intervals are not above the horizontal line in either figure, which means there is no evidence of a lead–lag relationship between these bonds and sukuk indices at these two levels.

4.4.3 Wavelet cross-correlation between BGER, TRBPAMGOVI and DJSUKUK. Figures 5 and 6 illustrate the wavelet cross-correlations of the Bloomberg German government bond index with the Thomson Reuters Malaysian government sukuk index and Dow Jones Global sukuk index, respectively. The results of the analyses indicate the following.

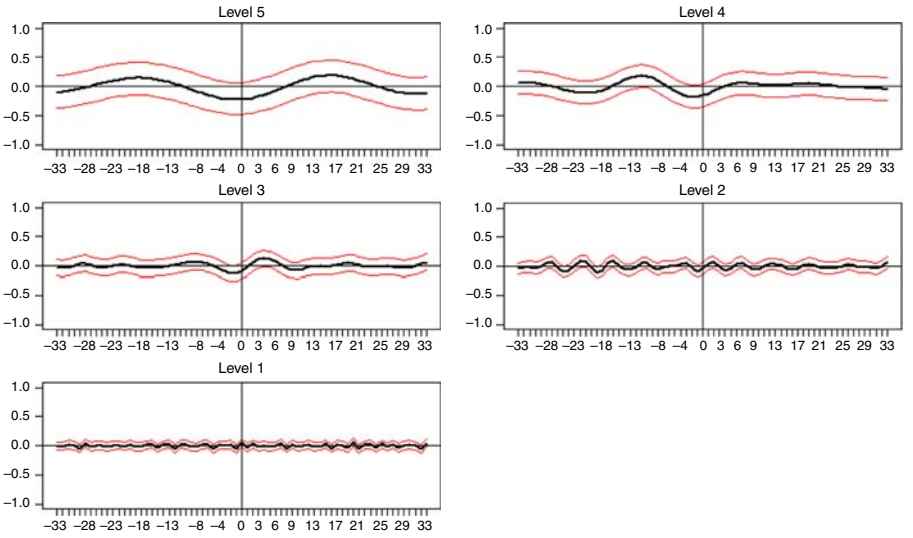

Figure 5.
Wavelet cross-correlation between BGER and TRBPAMGOVI

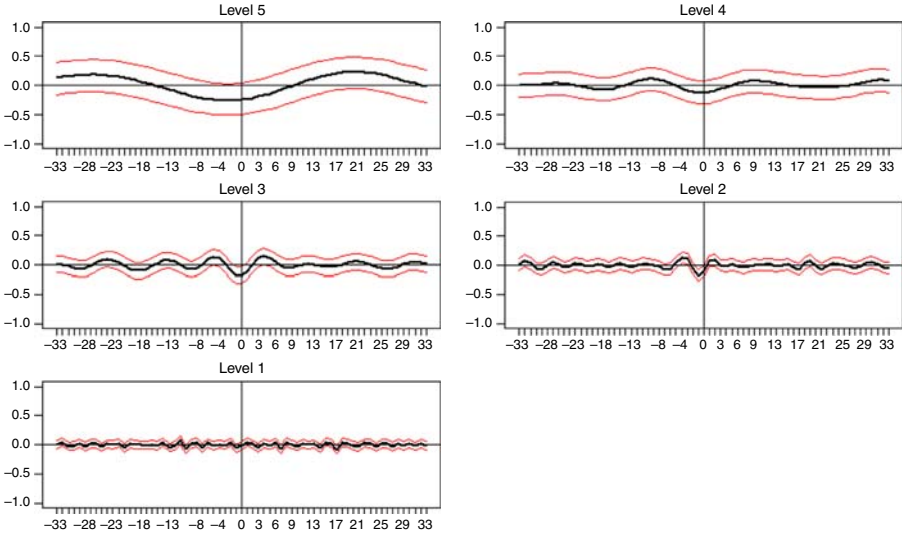

Figure 6.
Wavelet cross correlation between BGER and DJSUKUK

At the first wavelet level, there are similar findings between bonds and both sukuk indices because there is no significant correlation in the figure, and the lines are not skewed to the right or left. This implies that the German bond index does not lead the Malaysian or Dow Jones sukuk indices.

At the second level, the lead–lag relationship between bonds and sukuk indices is different. Figures 5 and 6 show no lead–lag relationship between German bonds and Malaysian or global sukuk markets because there is no significant event on the right or left side.

At the third wavelet level, the wavelet cross-correlation is slightly skewed to the right in Figure 5 but not significant because only one of the confidence intervals is below the horizontal line, whereas in Figure 6, the lines are also skewed to the right but not significant, which implies that there is no lead–lag relationship between the bonds and the sukuk indices.

Finally, at the fourth and fifth levels, there is no clear evidence of a positive or negative correlation on the right or left side in Figures 5 and 6, which implies that no significant events were found on either side. Hence, because there is no leading index, there is no lead–lag relationship between these indices.

4.4.4 Wavelet cross-correlation between BRIT, TRBPAMGOVI and DJSUKUK. Figures 7 and 8 illustrate the wavelet cross-correlations of the Bloomberg UK government bond index with the Thomson Reuters Malaysia government sukuk index and Dow Jones global sukuk index, respectively. Based on the figures, the results indicate the following.

At the first and second wavelet levels, the outcome of the analysis shows no significant positive or negative correlation on the left or right side of the figures, which implies there is no significant event on either side.

For the third wavelet level, the results are different between the two pairs. In terms of the Malaysian sukuk index, there is no significant positive or negative correlation with the German bond index; however, the Global sukuk index shows a significant event on the right side of the graph because the wavelet cross-correlation is skewed to the right, which implies that the global sukuk index leads the UK bond index.

Finally, at the fourth and fifth wavelet levels, the wavelet cross-correlation is slightly skewed to the right but not significant because the confidence intervals are not above the

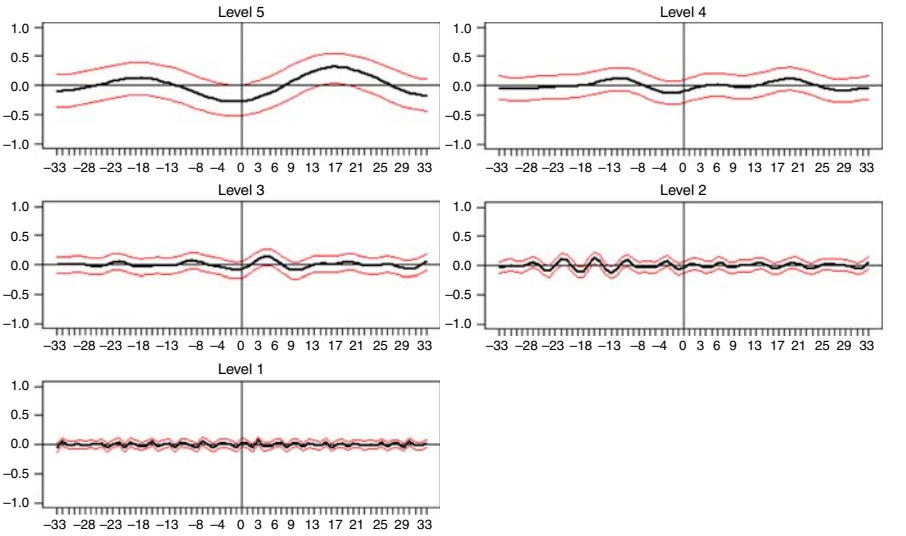

Figure 7.
Wavelet cross-correlation between BRIT and TRBPAMGOVI

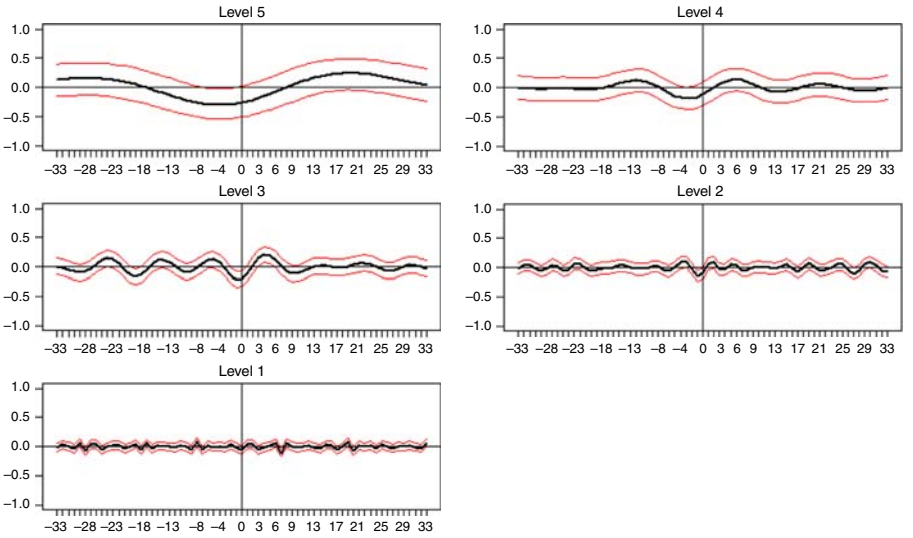

Figure 8.
Wavelet cross-correlation between BRIT and DJSUKUK

horizontal line in either figure, which means there is no evidence of a lead–lag relationship between the above bond and the sukuk indices at these two levels.

4.4.5 Wavelet cross-correlation between BAUS, TRBPAMGOVI and DJSUKUK. Figures 9 and 10 illustrate the wavelet cross-correlations of Bloomberg Australia government bond index returns with the Thomson Reuters Malaysian government sukuk index returns and Dow Jones global sukuk index returns, respectively. The findings of the analysis are discussed in this section.

According to the outcomes of the analysis between Malaysia sukuk and Australia bond indices, the wavelet cross-correlation has no significant correlation on either side of the

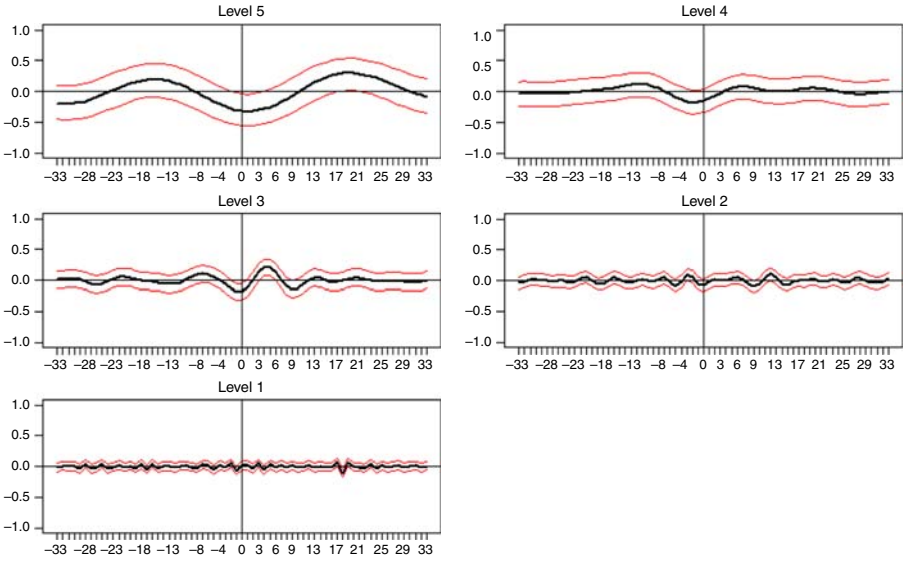

Figure 9.
Wavelet cross-correlation between BAUS and TRBPAMGOVI

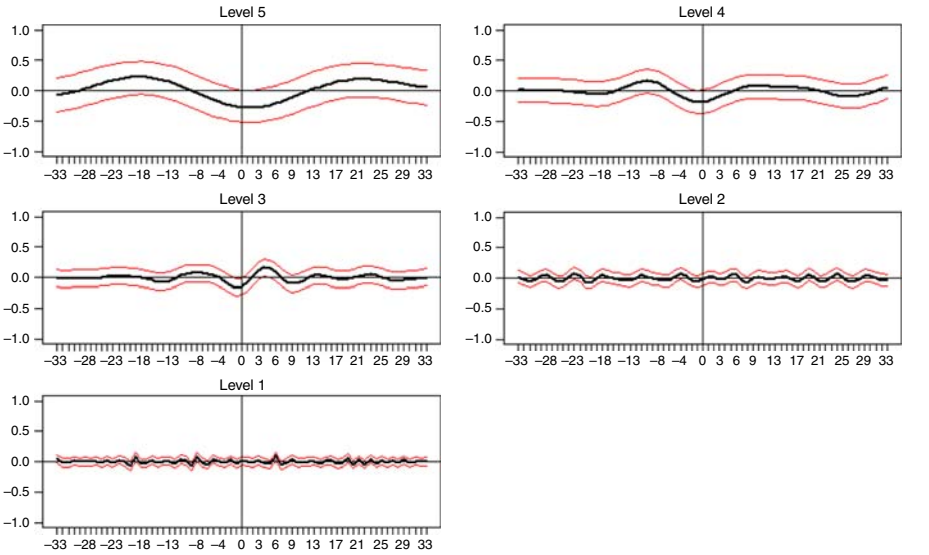

Figure 10.
Wavelet cross-correlation between BAUS and DJSUKUK

graph at the first and second wavelet levels, while it is skewed to the right at the third wavelet level, which is clearly observed in Figure 9. For wavelet levels four and five, there is no clear lead–lag relationship because the correlation is symmetric with a zero lag. In terms of global sukuk, there is no significant correlation between the Australian bond and Dow Jones sukuk at any wavelet level except level three, and these findings are similar to Malaysia sukuk index.

4.4.6 Wavelet cross-correlation between BJPN, TRBPAMGOVI and DJSUKUK. Figures 11 and 12 illustrate the wavelet cross-correlations of Bloomberg Japan Government bond index returns with the Thomson Reuters Malaysian government sukuk index returns and

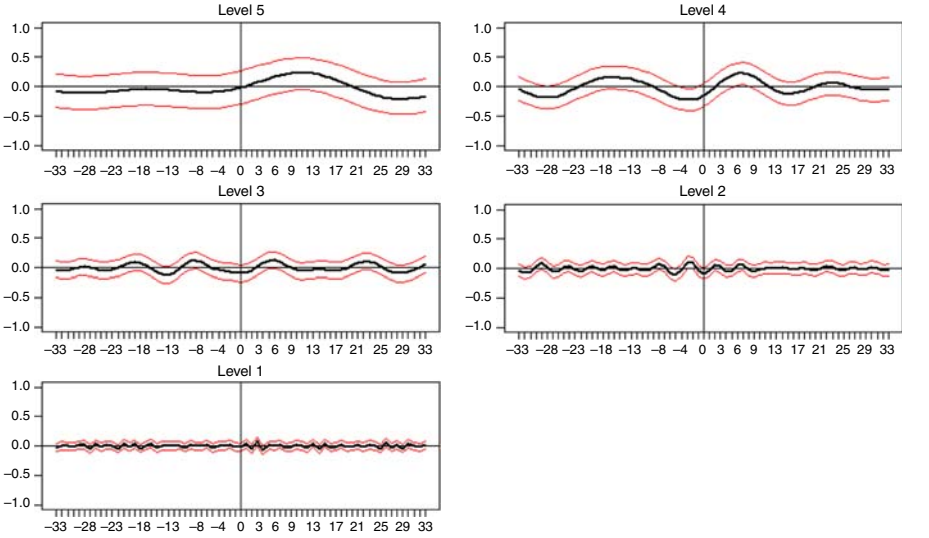

Figure 11.
Wavelet cross-correlation between BJPN and TRBPAMGOVI

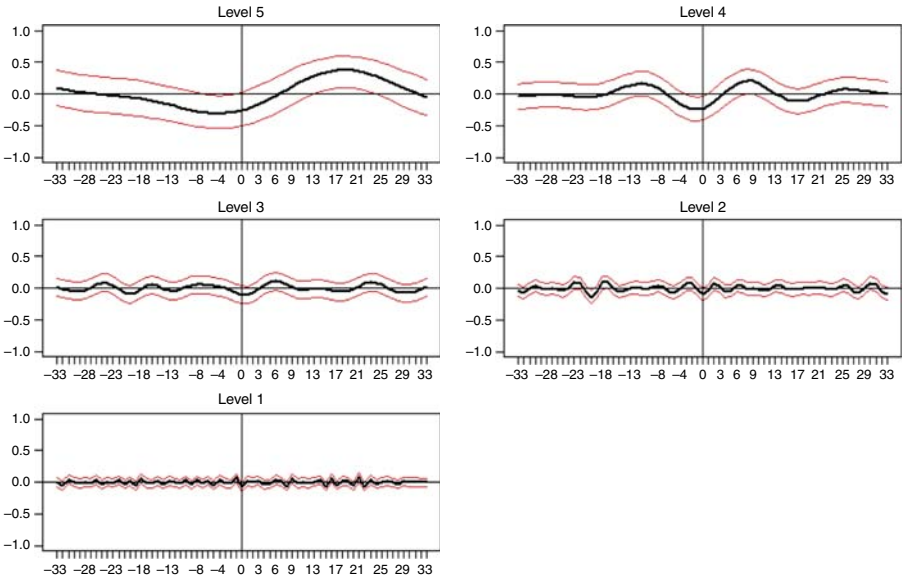

Figure 12.
Wavelet cross correlation between BJPN and DJSUKUK

Dow Jones global sukuk index returns, respectively. The findings of the analysis are discussed in this section.

Based on the wavelet cross-correlation, the outcome of the analysis suggested that there is no significant correlation at any wavelet level except level four between Malaysia sukuk and Japan bonds because there is no evidence of any skewness towards the right or left in either figure. In the case of wavelet level four, the wavelet cross-correlation is skewed to the right, and the confidence interval is above the horizontal line, as shown in Figure 11, which indicates that the TR Malaysian government sukuk index leads the Japan bond index; however, the leading role of sukuk indices disappears at wavelet level five, and no significant relationship is found between bonds and sukuk. The findings are similar in terms of the Dow Jones sukuk index with a slight difference. In the case of level five, the wavelet cross-correlation is skewed towards the right, meaning that there is an influence of the Dow Jones sukuk on the Japanese bond index, whereas in terms of the other wavelet levels, no relationship was found between them.

4.5 The wavelet cross-correlations between emerging market bond and sukuk indices

4.5.1 Wavelet cross-correlation between BSIN, TRBPAMGOVI and DJSUKUK. Figures 13 and 14 demonstrate the wavelet cross-correlation of the Bloomberg Singapore government bond index with the Thomson Reuters Malaysian government sukuk index and Dow Jones global sukuk index, respectively. The outcome of the analysis highlights the following.

In Figure 13, the wavelet cross-correlation is skewed to the right for the first four wavelet levels, which highlights that the Malaysian sukuk market leads the Singapore bond market and that the relation is positively correlated at all levels. This is because Singapore is a neighbouring country of Malaysia and a trading partner, and thus there is a direct influence of the Singapore market. At wavelet level five, the meaningful relation shifted to a neutral state, which implies there is no lead–lag relationship between them.

Figure 14 indicates that there is no significant relationship between the Singapore bond and Dow Jones sukuk markets at the first and second wavelet levels; however, the wavelet

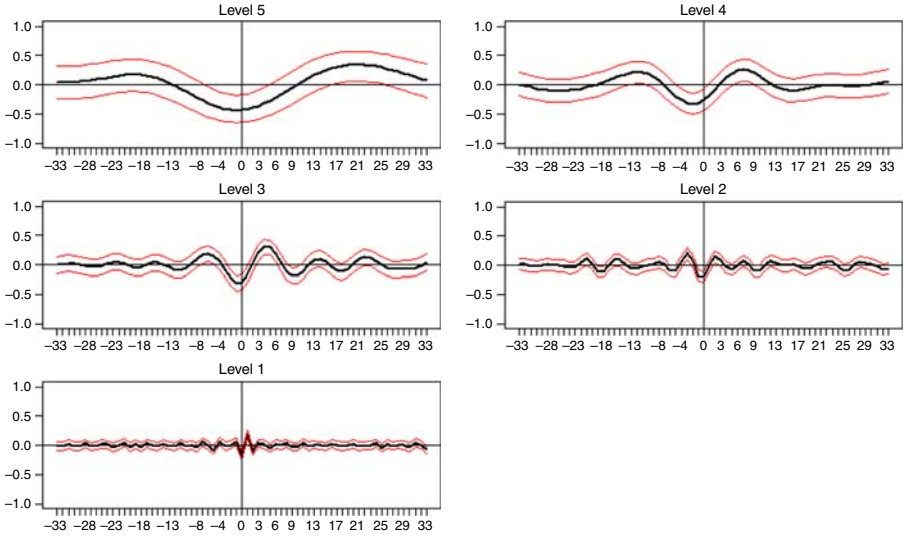

Figure 13.
Wavelet cross-correlation between BSIN and TRBPAMGOVI

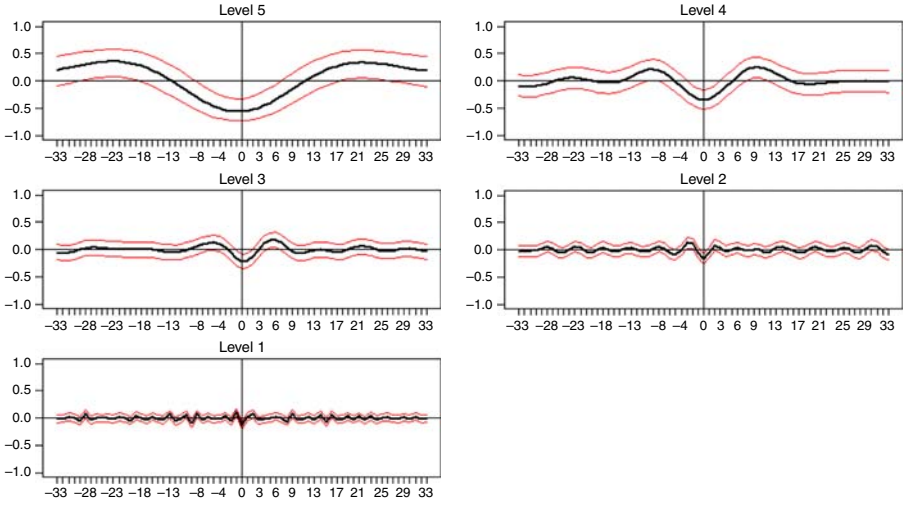

Figure 14.
Wavelet cross-correlation between BSIN and DJSUKUK

cross-correlation is skewed to the right, and both confidence intervals are also above the horizontal line in Figure 14, which implies a significant correlation on the right side at the third and fourth wavelet levels. Thus, the Dow Jones sukuk leads the Singapore bond index. At the fifth level, the correlation disappears, which indicates there is no lead–lag relationship between the Singapore bond and Dow Jones global sukuk indices.

4.5.2 Wavelet cross-correlation between BINDO, TRBPAMGOVI and DJSUKUK. Figures 15 and 16 demonstrate the wavelet cross-correlation of the Bloomberg Indonesian government bond index with the Thomson Reuters Malaysian government sukuk index and Dow Jones global sukuk index, respectively. The outcome of the analysis highlights the following.

Based on the wavelet cross-correlation, there is no considerable evidence of a correlation between Indonesian bond and Malaysian sukuk markets at wavelet level one or two, as

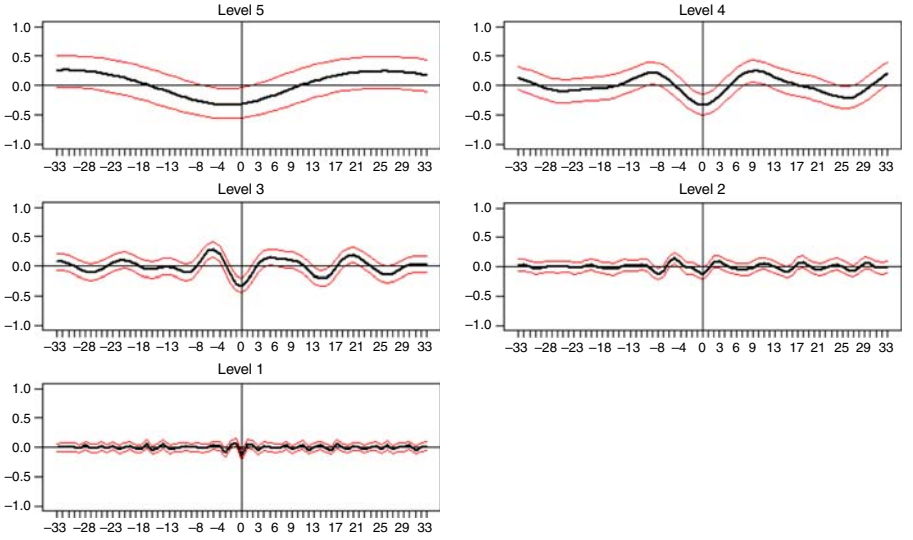

Figure 15.
Wavelet cross-correlation between BINDO and TRBPAMGOVI

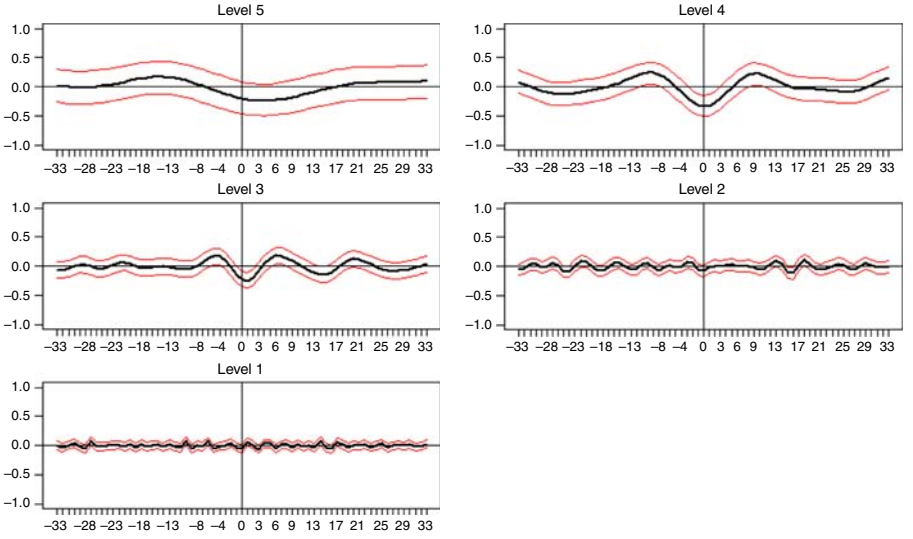

Figure 16.
Wavelet cross-correlation between BINDO and DJSUKUK

shown in Figure 15, and thus there is no lead–lag relationship. For level three, interesting results were found that indicate significant correlations on the left side of the graph, which implies that the Indonesian bond market leads the Malaysian sukuk market; however, for wavelet level four, the situation is the opposite because the wavelet cross-correlation is skewed to the right, which implies that the Malaysian sukuk leads the bond market. Finally, the lead–lag relationship between the bond and sukuk disappears at the fifth level.

The Dow Jones global sukuk index has no significant correlation with the Indonesian bond index, as shown in Figure 16 in which the wavelet cross-correlation does not shift

towards the left or right and the confidence interval lines are below the horizontal line at all levels expect wavelet level three. Because the wavelet cross-correlation is skewed to the right, the Dow Jones sukuk market leads the Indonesian bond market at wavelet level three, which is dissimilar to all other levels.

4.5.3 Wavelet cross-correlation between BMYR, TRBPAMGOVI and DJSUKUK. Figures 17 and 18 demonstrate the wavelet cross-correlation of the Bloomberg Malaysia government bond index with the Thomson Reuters Malaysia government sukuk index and Dow Jones global sukuk index, respectively. The outcome of the analysis highlights the following.

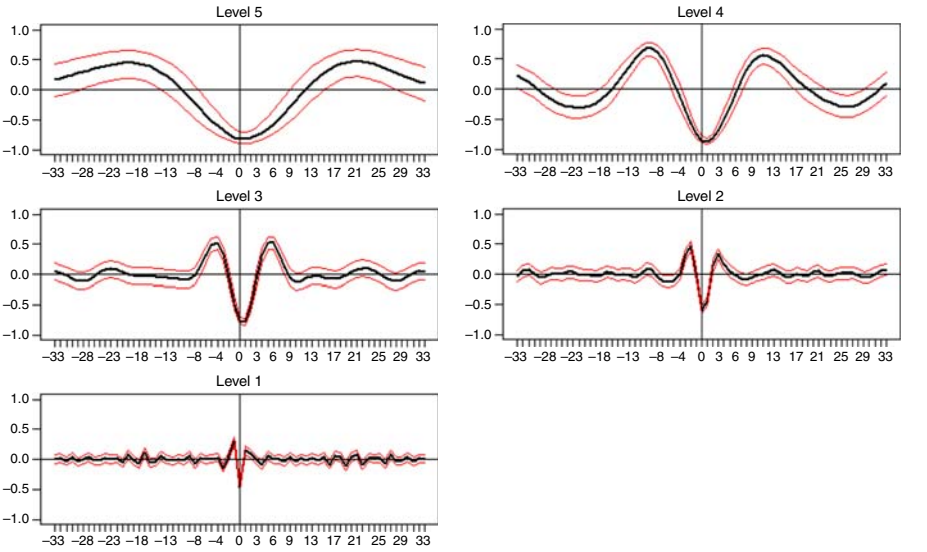

Figure 17.
Wavelet cross-correlation between BMYR and TRBPAMGOVI

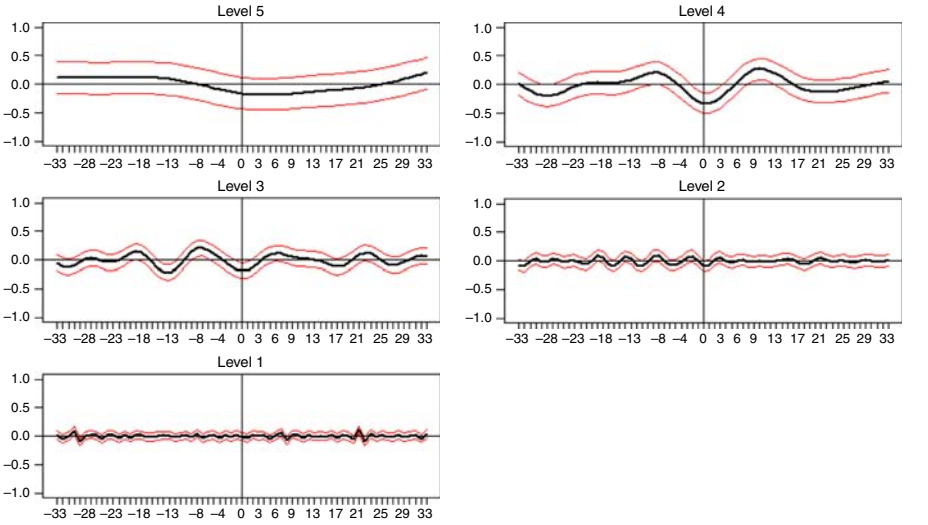

Figure 18.
Wavelet cross-correlation between BMYR and DJSUKUK

As both indices are under the same domestic market, there are some influences between them. At the first wavelet level, there is a clear indication of a lead–lag relationship between these two indices, and thus the Malaysian bond market leads the Malaysian sukuk market, as shown in Figure 17; however, for the second, third and fourth wavelet levels, the wavelet cross-correlation is skewed to the left and to the right at the same level based on different lags, which indicates lead–lag relationship changes based on lags. At wavelet level two, bond leads sukuk if −4 lags are selected, while sukuk leads bond if four lags are selected, so the lead–lag changes with lags at the same level. The same outcome was found for the next two levels; the wavelet cross-correlation is skewed to the left if five lags are selected, whereas the wavelet cross-correlation is skewed to the right if six lags are selected at wavelet level three. Moreover, at wavelet level 4, the wavelet cross-correlation is skewed to the left if −10 lags are selected, whereas the wavelet cross-correlation is skewed to the right if 11 lags are selected, which implies that the markets influence one another. The Malaysian bond market is already an established market domestically, while the sukuk market is still in its growing stage; therefore, there must be an impact of the Malaysian bond market on the sukuk market. The sukuk market also influences the bond market because these financial markets are interrelated and substitute one another. At the fifth level, the correlation disappears, which indicates there is no lead–lag relationship between the Malaysian bond market and the sukuk index.

Figure 18 illustrates that there is no meaningful relationship between the Malaysian bond and Dow Jones sukuk markets at the first and second wavelet levels; however, the wavelet cross-correlation is skewed to the left, and both confidence intervals are above the horizontal line in Figure 18, which shows a significant correlation on the left side at the third level and implies that the Malaysia bond market leads the Dow Jones sukuk index. Moreover, for wavelet level four, the situation is the opposite. The wavelet cross-correlation is skewed to the right, which implies that the Dow Jones sukuk leads the Malaysian bond market. At the fifth level, the correlation disappears, which indicates there is no lead–lag relationship between the Malaysian bond market and the Dow Jones global sukuk index.

4.5.4 Wavelet cross-correlation between BCGB, TRBPAMGOVI and DJSUKUK. Figures 19 and 20 illustrate the wavelet cross-correlation of the Bloomberg China government bond index

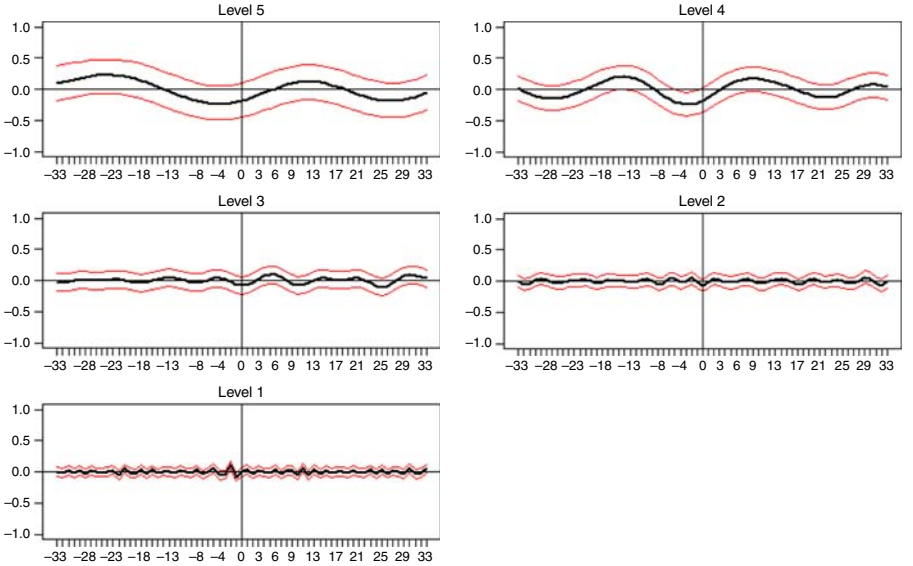

Figure 19.
Wavelet cross-correlation between BCGB and TRBPAMGOVI

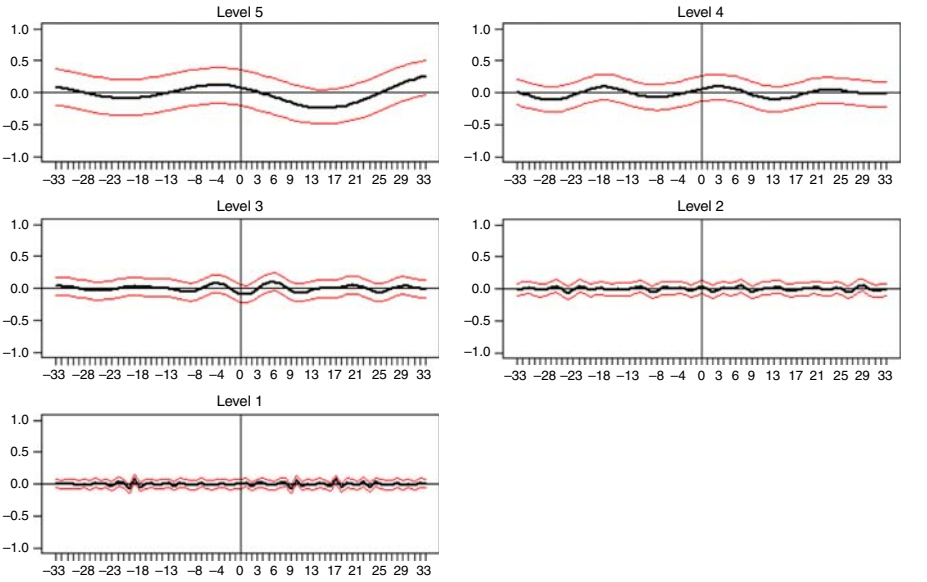

Figure 20.
Wavelet cross-correlation between BCGB and DJSUKUK

with the Thomson Reuters Malaysia government sukuk index and Dow Jones global sukuk index, respectively. The outcome of the analysis highlights the following.

The findings for China are similar to those of the Bloomberg Japan government bond market as they belong to the same region. Based on the wavelet cross-correlation, there was no considerable evidence of a correlation between the China bond market and the Malaysian sukuk market, as shown in Figure 19, and thus neither market leads the other.

Like the Malaysian sukuk index, the Dow Jones global sukuk index had no significant correlation with the China bond index. As shown in Figure 20, the wavelet cross-correlation does not shift towards the left or right, and the confidence interval lines are below the horizontal line.

4.5.5 Wavelet cross-correlation between BINDI, TRBPAMGOVI and DJSUKUK. Figures 21 and 22 illustrate the wavelet cross-correlations of the Bloomberg India government bond index with the Thomson Reuters Malaysian government sukuk and Dow Jones Global sukuk indices, respectively. The results indicate the following.

Based on the wavelet cross-correlation, the outcome of the analysis suggests that there is a significant correlation at the first wavelet level as there is evidence of skewness towards the right. For the second and third wavelet levels, the wavelet cross-correlation is skewed to the left, and the confidence interval is above the horizontal line, as shown in Figure 21, which indicates that the India bond index leads the Malaysian government sukuk index; however, the leading role of the sukuk indices disappears at wavelet levels four and five, indicating that there is no meaningful relationship between bond and sukuk.

On the other hand, based on the wavelet cross-correlation, there is no significant correlation between the Dow Jones global sukuk and India bond indices at any wavelet level, as shown in Figure 22, and the findings are similar to the findings of the Chinese government index.

4.5.6 Wavelet cross-correlation between BKRW, TRBPAMGOVI and DJSUKUK. Figures 23 and 24 show the wavelet cross-correlation of the Bloomberg South Korea government bond index with the Thomson Reuters Malaysian government sukuk index and Dow Jones global sukuk index, respectively. The outcomes indicate the following.

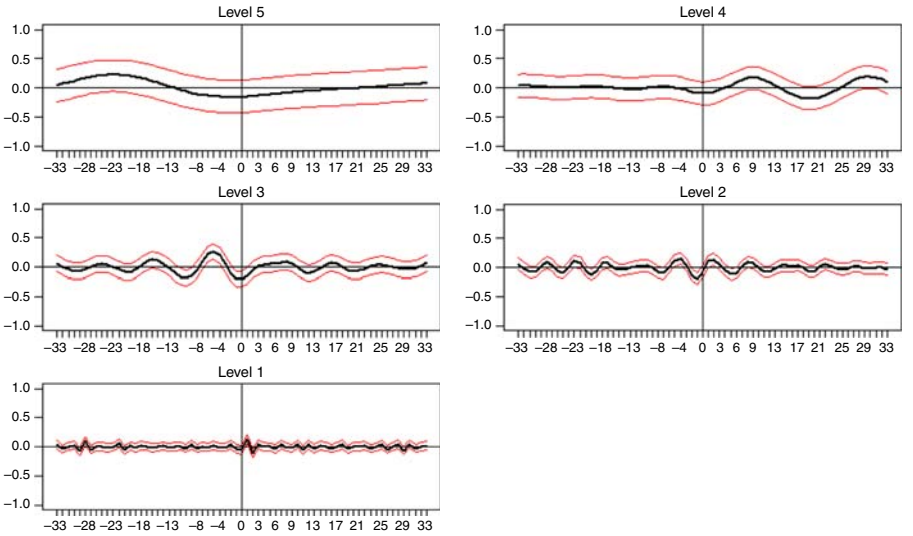

Figure 21.
Wavelet cross-correlation between BINDI and TRBPAMGOVI

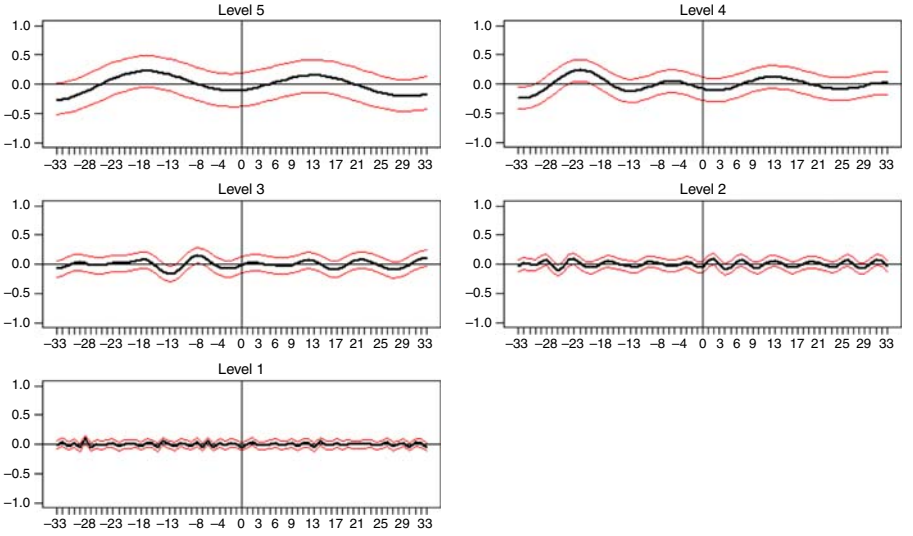

Figure 22.
Wavelet cross-correlation between BINDI and DJSUKUK

Based on the wavelet cross-correlation, there is no considerable evidence of a correlation between South Korea bond and Malaysian sukuk markets, as shown in Figure 23, at wavelet levels one and two; however, the wavelet cross-correlation is skewed to the right, and both confidence intervals are above from the horizontal line, as shown in Figure 24, which implies a significant correlation on the right side at the third level and indicates that Malaysia sukuk leads the South Korea index. Moreover, for wavelet level four, the situation is the opposite. The wavelet cross-correlation is skewed to the left, which implies that the South Korea bond market leads the Malaysia sukuk market. Finally, the wavelet cross-correlation is skewed to the right, which indicates that the sukuk leads the bond at wavelet level five.

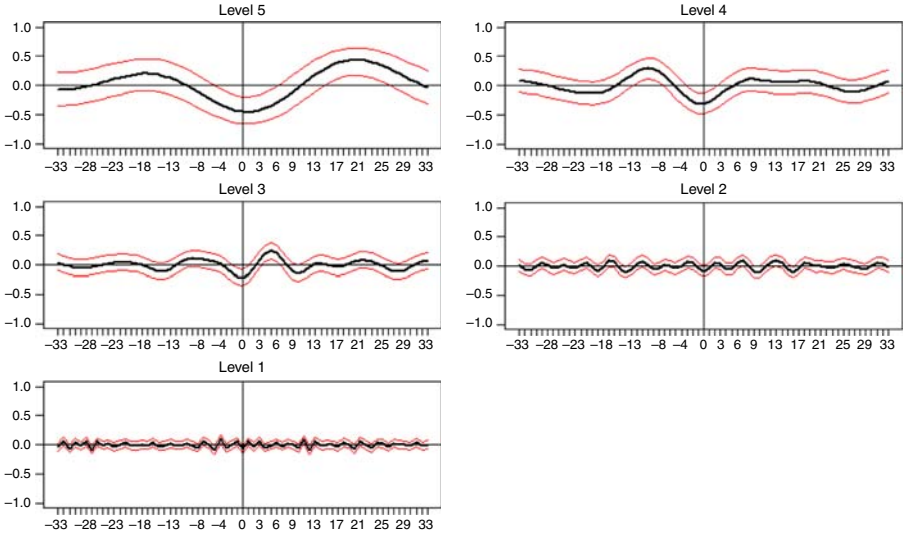

Figure 23.
Wavelet cross-correlation between BKRW and TRBPAMGOVI

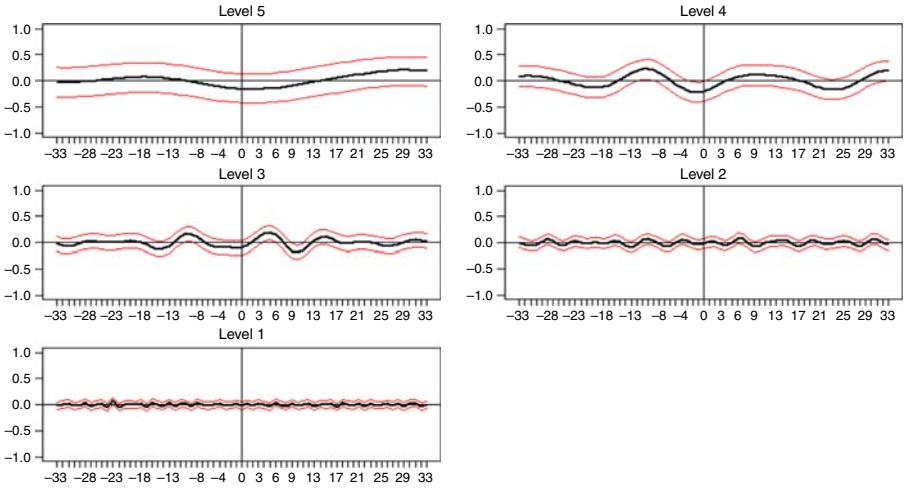

Figure 24.
Wavelet cross-correlation between BKRW and DJSUKUK

At the first and second wavelet levels, the results of the analysis did not show any significant correlation between Dow Jones sukuk and South Korea bond indices on either side of the graph, as shown in Figure 23. Thus, there is no lead–lag relationship between these indices until level two. At the third wavelet level, the wavelet cross-correlation is skewed to the right, which indicates a significant positive correlation between the Dow Jones sukuk and South Korea bond market and that the sukuk market leads the bond index market; however, the leading role of the sukuk index disappears at levels four and five. Thus, there is no significant correlation between the Dow Jones global sukuk and South Korea bond indices at the last two levels, as shown in Figure 24.

5. Summary of findings

Tables IX–XII provide a summary of the lead–lag relationships between the sukuk and bond market indices. As shown in Tables IX and X, in most cases, there is no lead–lag relationship between the sukuk and developed market bond indices. Hence, the developed markets have no influence on Malaysia or on the global sukuk markets. Moreover, as a global market leader, the USA has no dominance on the sukuk market, which implies that if there is any shock generated from the US market, the sukuk markets are unlikely to be affected. There were notable exceptions for wavelet level 3 where both sukuk indices dominated some bond indices, such as that of Canada, the UK and Australia. In the case of Japan, the outcome of the analysis was different because the Malaysian sukuk index leads the Japanese bond index at wavelet level three, and the Dow Jones sukuk index also leads the Japanese bond index at wavelet level five. The analysis of this study was primarily empirical in nature and requires additional economic clarifications regarding the reason that no lead–lag relationship was found between the sukuk and developed market bond indices. One probable reason could be that the sukuk index is considered a young and growing asset class with information asymmetries and is structurally less sensitive to volatility and interest rates in other markets. The outcome of the analysis is intriguing, and further research is suggested. Yang (2005) found that international bond markets are not fully segmented. Instead, they are partially segmented in the short-term, and there is no distinctive leadership role. Another study highlighted that the US bond market has a strong influence on developed bond markets in terms of the information transmission process, which implies that there was causality from the USA to other sample countries during the sample period. This outcome seems to indicate that US monetary policy innovations are transmitted globally (Ciner, 2007). Nonetheless, in this study, no influence of the US bond market was found on Malaysia or on the global sukuk market.

Lead–lag relationship	BUSG vs TRBPAMGOVI	BCAN vs TRBPAMGOVI	BGER vs TRBPAMGOVI	BRIT vs TRBPAMGOVI	BAUS vs TRBPAMGOVI	BJPN vs TRBPAMGOVI
Wavelet level 1	≠	≠	≠	≠	≠	≠
Wavelet level 2	≠	≠	≠	≠	≠	≠
Wavelet level 3	→ (+)	→ (+)	≠	≠	→ (+)	≠
Wavelet level 4	≠	≠	≠	≠	≠	→ (+)
Wavelet level 5	≠	≠	≠	≠	≠	≠

Notes: Definition of the symbols used in Tables IX-XII;→Sukuk market leads the bond market;←Bond market leads the sukuk market;↔Bond and sukuk markets lead each other at the same level using different lags; ≠No lead–lag relationship between the bond and sukuk markets; (+) Positively correlated; (−) Negatively correlated; (±)Positive as well as negative at the same level using different lags

Table IX. Summary of the lead–lag relationship between Malaysia sukuk and developed market bond indices

Lead–lag relationship	BUSG vs DJSUKUK	BCAN vs DJSUKUK	BGER vs DJSUKUK	BRIT vs DJSUKUK	BAUS vs DJSUKUK	BJPN vs DJSUKUK
Wavelet level 1	≠	≠	≠	≠	≠	≠
Wavelet level 2	≠	≠	≠	≠	≠	≠
Wavelet level 3	→ (+)	→ (+)	≠	→ (+)	→ (+)	≠
Wavelet level 4	≠	≠	≠	≠	≠	≠
Wavelet level 5	≠	≠	≠	≠	≠	→ (+)

Table X. Summary of the lead–lag relationship between Dow Jones sukuk and developed market bond indices

Furthermore, no significant causal relationship was found from the developed market bond indices on sukuk indices.

The findings in Table XI indicate that the Malaysia sukuk market leads the Singapore bond market beginning from wavelet level one until level four, which implies a strong dominance over the Singapore bond market. They are neighbouring countries and trading partners, which may be a probable reason for a strong unidirectional causal relationship that may be reflected in their financial markets. The lead–lag relationship between the Malaysia sukuk and Indonesian bond markets was neutral in most cases; however, a unidirectional causal relationship was found for wavelet levels three and four, which could be because they are close neighbouring countries and the Indonesian government is trying to incorporate Islamic finance and also launched sukuk in their financial market. Malaysian bonds and sukuk bonds are a close substitute for each other and operate under the same financial market platform. Thus, there was a strong bidirectional causality for most wavelet levels. China's bond market had no lead–lag relationship with the Malaysian sukuk market at any level. On the other hand, the Malaysian sukuk markets leads the India bond market at the first level, whereas the India bond market leads the sukuk market at the second and third wavelet levels; however, no solid evidence could define this causality. Finally, the South Korea bond and Malaysia sukuk markets both lead each other in the long-term at different wavelet levels. Similar to this study, Johansen (2008) analysed the dynamic links of Asian bond markets, and the results clearly indicated a causality in both directions between most market pairs. Another recent study illustrated that the monetary policies of emerging markets have an impact on bond and sukuk market returns in a similar manner (Paltrinieri *et al.*, 2015).

The findings in Table XII illustrate that there is no lead–lag relation between the Dow Jones global sukuk and emerging market bond indices in most cases; however, at the third

Table XI.
Summary of the lead–lag relationship between Malaysia sukuk and emerging market bond indices

Lead–lag relationship	BSIN vs TRBPAMG	BINDO vs TRBPAMG	BMYR vs TRBPAMG	BCGB vs TRBPAMG	BINDI vs TRBPAMG	KRW vs TRBPAMG
Wavelet level 1	→ (+)	≠	← (+)	≠	→ (+)	≠
Wavelet level 2	→ (+)	≠	↔ (±)	≠	← (+)	≠
Wavelet level 3	→ (+)	← (+)	↔ (±)	≠	← (+)	→ (+)
Wavelet level 4	→ (+)	→ (+)	↔ (±)	≠	≠	← (+)
Wavelet level 5	≠	≠	≠	≠	≠	→ (+)

Table XII.
Summary of the lead–lag relationship between Dow Jones sukuk and emerging market bond indices

Lead–lag relationship	BSIN vs DJSUKUK	BINDO vs DJSUKUK	BMYR vs DJSUKUK	BCGB vs DJSUKUK	BINDI vs DJSUKUK	BKRW vs DJSUKUK
Wavelet level 1	≠	≠	≠	≠	≠	≠
Wavelet level 2	≠	≠	≠	≠	≠	≠
Wavelet level 3	→ (+)	→ (+)	← (+)	≠	≠	→ (+)
Wavelet level 4	→ (+)	≠	→ (+)	≠	≠	≠
Wavelet level 5	≠	≠	≠	≠	≠	≠

wavelet level, the Dow Jones sukuk index leads the Singapore, Indonesian and South Korea indices. On the other hand, the Malaysian bond index leads the global sukuk index at the same wavelet level, which could be because more than 40 per cent of the sukuk bonds of the global sukuk market is issued by Malaysia. Moreover, a unidirectional causality was found from the Dow Jones sukuk index to the Malaysian and Singapore bond indices in the long-term. The global sukuk market is a suitable option for Malaysian fixed-income investors compared to the Malaysian sukuk market. Singapore fixed-income investors can predict future bond values since the Singapore bond index return followed the Malaysian sukuk index during the sample period. The outcomes of the analysis also apply to geographical diversification. Evidence showed that global and regional diversification is possible; however, domestic diversification is not supported.

6. Policy implications

The evidence of cointegration between sukuk and bond markets has many implications. First, it rules out spurious correlations, which implies theoretical associations among the indices that move towards equilibrium in the long-term. The outcomes of this research illustrate that the sukuk market has no cointegration with the bond markets in most cases, which implies that the bond and sukuk markets are independent and that there are opportunities to earn profit by constructing a diversified investment portfolio across these sample countries. Second, previous studies on financial indices mainly captured temporal interrelations in time. These interrelations can be analysed in more detail by applying the wavelet approach. In this study, the wavelet approach enriched the understanding of the dynamic behaviour of sukuk and bond indices. Another implication of the lead–lag relationship approach could be that financial turmoil seems to have a lower impact on the sukuk market than the conventional bond market. Furthermore, international investors usually excessively react to the information received from developed markets, and this study showed that developed markets have no causal relationship with sukuk markets. Therefore, investors can place less weight on the information from developed markets when investing in the sukuk market. Because integration amongst global financial markets has increased, it is essential to obtain knowledge of integrated financial markets, the pace with which international financial markets are moving and the propagation mechanism or the dynamics driving these relationships.

7. Conclusion

The findings of this study suggest that a cointegration analysis is needed for the optimisation process to incorporate only countries that do not have similar long-term equilibrium relationships. Therefore, for this study, a bivariate cointegration analysis was applied between sukuk and 12 foreign bond markets. A total of 24 pairs of portfolios were tested using the bivariate cointegration test, and in 20 cases, no cointegration was found between the pairs consisting of sukuk and bond indices. After applying the bivariate cointegration test for Malaysian sukuk and developed market bond indices, the results indicated that no cointegration exists between Malaysia's sukuk and the UK, the USA, German or Canadian bond indices, whereas Australia and Japan are cointegrated with the sukuk market. On the other hand, in terms of emerging markets, the Malaysian sukuk market had no cointegration with China, India, Indonesia or Singapore bond markets except Malaysia and South Korea bond markets during the sample period. It is also worth noting that the Dow Jones sukuk market strongly rejected any cointegrating relationship with the developed and emerging bond markets during the sample period.

The findings of the study highlight that lead–lag relationships developed among sukuk developed and emerging market bond indices. After critically analysing all outcomes, it can be concluded that first, there is no unidirectional causality from

developed market bond indices to the Malaysia or Dow Jones indices, which is a good sign for fixed-income investors of a developed market. Second, in relation to emerging markets, the Malaysian sukuk market has a bidirectional causality with Indonesia, Malaysia, India and South Korea bond indices except for China, while for the Dow Jones Sukuk index, there was no unidirectional causality from the listed emerging markets to the sukuk index except that of Indonesia during the sample period.

Information on cointegration and the lead–lag relationships among sukuk and bond indices may also be useful for regulators in terms of formulating macro stabilisation policies for the countries as well as for traders and fund managers in articulating their trading and investment objectives. This analysis provides evidence of the timely and appropriate measure of correlation changes and the behaviours of sukuk and bond indices globally, which is beneficial to the management of sukuk and bond portfolios.

Notes

1. IFIS.
2. ISRA.

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