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Research Article

Dynamic Connectedness, Spillovers, and Delayed Contagion between Islamic and Conventional Bond Markets: Time- and Frequency-Domain Approach in COVID-19 Era

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Using the Baruník and Křehlík spillover index, the study examines the dynamic connectedness and spillovers between Islamic and conventional (G6) bond markets to reveal the time- and frequency-domain dynamics of the two asset classes under different market conditions. From August 22, 2012, through September 17, 2021, the daily bond yield indices for Islamic and G6 markets were employed. The findings reveal that volatility spillovers between and within Islamic and/or G6 bond markets are time- and frequency-dependent, although conventional bonds are more volatile than Islamic bonds during Black Swan periods. Across all time horizons, USA, UK, and Canada are the biggest producers of shocks to the Islamic and G6 markets, with Pakistan being the lowest shocks transmitter. During the European debt crisis, Brexit, and COVID-19 periods, the results underscore delayed contagious spillovers emanating from USA, Canada, and UK. With both the Islamic and G6 bond markets, short-term spillovers are more important than long-term spillovers. Investors should use their understanding of market trends and volatility to hedge their holdings against poorer asset returns when volatility spillover is more severe during market turmoil. Spillovers should be closely monitored by policymakers, since they jeopardise cross-market linkages.

1. Introduction

The recent coronavirus disease (COVID-19) pandemic, according to Giles et al. [1] and Baldwin and Di Mauro [2], is a global health catastrophe that has morphed into a severe economic crisis, culminating in unprecedented global economic and financial instability. Volatility spikes, repricing issues, liquidity difficulties, capital outflows, and currency devaluation have all been major financial market consequences of the COVID-19 epidemic [3, 4]. As a result, experts have predicted that COVID-19 would send the globe into a global recession. Shareholders become fearful and panicked as a consequence of the COVID-19 pandemic, and they detach their assets from the financial markets, causing share values to plummet. Similarly, owing to COVID-19, the debt market was disrupted, and bond buyers incurred losses that would be difficult to recoup [5]. Yarovaya et al. [6] noted that nearly all of the G7 countries lost between 30% and 42% of their stock market values, while global stocks, such as the S&P Dow Jones Indices and the S&P500 in the United States, lost approximately $6 trillion and $5 trillion, respectively, in market capitalisation [7]. Similarly, in line with the 2020 International Islamic Financial Market (IIFM) Report, Naeem, Billah, Marei, and Balli (2021) submitted that the growth rate in the Middle East and Central Asia areas dropped sharply from 1.2% to 2.8% between 2019 and 2020, which was worse than the GFC of 2008. It is not surprising that fresh Islamic bonds issuance is presently very slow as economies in major countries progressively open up [8].

These occurrences across global financial markets present shreds of evidence that suggests that the prices of assets in the uncertain times of the COVID-19 pandemic are reflective of the market conditions. This evidence partially supports the efficient market hypothesis (EMH), which assumes that most asset prices are fairly priced based on the information available [9, 10]. In an efficient market, current asset prices materialise all available relevant information about a financial asset, such that the ideal projected return equates to the equilibrium return on the market. Future economic activity information inferred from current financial asset prices is a major conditioning factor that affects current financial asset prices. As a result, the broad uncertainties triggered by COVID-19 may drive global financial markets and rational investors to react and this follows two main hypotheses: the adaptive markets hypothesis (AMH) engineered by [11] and the heterogeneous markets hypothesis (HMH) developed by Müller et al. [12].

Thus, consequential to the COVID-19 pandemic and its associated information flows in existing markets, new markets may be created where economic agents (investors) are led to switch to or include several asset classes in their portfolios for hedging and diversifying risks. The switch from or inclusion of new assets to investment portfolios in Black Swan (Introduced by Taleb (2007) and describes events that occur randomly but are a part of human lives. Such events are characterised by (1) an outlier, deviating from usual expectations; (2) being accompanied by extreme impacts; and (3) being reasonable and foreseeable because reasons for its occurrence are imaginary after the fact. Black Swan events are shocks that occur on a large scale and have severe consequences on economic activity, social cohesion, and political stability.) periods requires that investors undergo some searches for safe havens (Baur and Lucey [13] define safe haven as any asset that has no correlation or is inversely correlated with another asset or portfolio during unusual (Black Swan) market conditions.) [13]. In brief, investors would be competing for lucrative returns on substitute assets to satisfy their investment needs. Corollary, the intensity of information flows and spillover across markets of the same and other asset classes is increased by rational investors. Also, irrational investors' have a never-ending quest for competing rewards and risks to meet portfolio objectives, which corroborates the competitive market hypothesis (CMH) propounded by Owusu Junior et al. [14]. The question now is, which asset class(es) is(are) predominantly available to investors during market crises and in which market type (Islamic or conventional)?

Gold, bonds, crude oil, bitcoins, and so forth are traditionally preferred by portfolio managers because they are predominantly inversely related to stock returns, making them capable of offsetting stock market losses in Black Swan events [15, 16]. Given the relative intense nature of the COVID-19 pandemic, information flow in these safe markets is a key element in deciding investor reaction, which would mainly impact the financial sector. Thus, with the COVID-19 pandemic's unparalleled constraints on global financial markets, empirical investigations of these commodities' potential to provide favourable returns to meet portfolio objectives are warranted. A plethora of literature have examined the potentials of safe assets such as gold [13, 17–21], crude oil [22–24], and bitcoin [19, 20, 25, 26]. A similar observation could be made in respect of bonds [27–40]; however, a significant distinction must be noted.

Unlike other safe assets which have a common market, bonds are traded separately in conventional and Islamic markets. So far, studies on bonds have largely focused on the conventional markets with little attention [41–44] on Islamic bonds, a section of the Islamic financial markets (IFMs). Thus, having selected the right asset class is not enough. Another important decision is to choose between conventional and Islamic markets to operate. Islamic assets, which are considered virtue assets, have been introduced and expanded on global financial markets during the past decade. Sharia-compliant assets have grown in popularity not just in Islamic developing countries but also in traditional financial markets. Because they function differently from their conventional equivalents, Sharia-compliant equities and Islamic bonds (Sukuk) are considered innovations in the international financial system. Portfolio risk diversification using Islamic assets would be attractive to investors because of its size, continuous development, and steady performance during and after previous financial crises [45–48].

However, with the daunting nature of the COVID-19 pandemic, which caused a substantial loss (between 30% and 42% of their stock market values) to nearly all of the G7 economies [6], the connectedness of the conventional and Islamic bond markets, which are two distinct asset classes, merits to be revisited in by employing somewhat a novel approach.

As a result, the Baruník and Křehlík [49] (BK-18) methodology is employed to comparatively analyse volatility spillovers between Islamic and conventional bond markets and to assess the dynamism and asymmetries in the connectedness of these markets, contributing to the growing literature on the COVID-19 pandemic and resilience of Islamic markets. In the context of Islamic finance, the study's contribution to the literature on volatility spillover is fourfold. First, the study tackles the disadvantage of analysing composite volatility spillovers across markets, which may conceal important information for fund allocation and risk management. This study accounts for investor heterogeneity (in terms of investment choice and risk appetite) in examining volatility spillovers and the connection network between Islamic and conventional bond markets across the short-, medium-, and long-term periods.

Second, the emotions, expectations, and risk preferences of market participants change over time. Short-term investments appeal to speculators and hedgers, whereas medium-term investments appeal to institutional investors and market regulators. As a consequence, the periodicity-investment component is important for making investment decisions and carrying out long-term objectives. To accomplish so, the study examines how the intricate linkages between Islamic and conventional bond markets have developed over time and at varying frequencies (high, medium, and low). Third, the BK-18 approach, which is based on the Diebold and Yilmaz [50] (DY-12) spillover index's construction, is employed. The DY-12 spillover index, on the other hand, suggests that investors act similarly in markets and that spillover is unaffected by investment horizons, indicating that it is the same in the short-, medium-, and long-term horizons. The study utilises the BK-18 spillover index, which is based on heterogeneous shock frequency responses, to get past this limitation of the DY-12 approach.

Relative to other approaches (e.g., the GARCH-based methods, transfer entropy, and static and time-domain connectedness approaches), the BK-18 index provides useful information on the magnitudes and directions of spillovers in the time-frequency domain, which is important for identifying the source and magnitude of contagions, as well as the market recipient of shocks. It also examines the volatility connection between markets over time and across various frequencies at the same time. Transfer entropies, GARCH-based models, and spillover approaches that focus on static and time domain only fail to reveal this important information that provides practical insights for market participants. The decomposition into frequencies under the BK-18 approach benefits market participants significantly by separating frequency-domain spillover effects from aggregate risk spillover effects. By differentiating the frequencies, investors may optimise their funding allocation and hedge their position against significant price declines.

Using the BK-18 spillover index, the study finds little evidence of intermittent volatilities for Islamic bonds during the COVID-19 period at high frequencies only, compared to G6 bonds, which showed traces of volatility clusters at all frequencies during the COVID-19 period studied. This finding is suggestive of the relative resilience of Islamic bonds over their conventional counterparts, the G6 bond markets, in the intermediate-to-long-term horizon. More importantly, the findings indicate delayed contagion occurrences based on higher spillovers in 2013, 2016/17, and 2020/21, respectively, owing to the European debt crisis (EDC), the Brexit impact, and the COVID-19 pandemic. USA, Canada, and UK bond markets are the sources of the inferred contagion across all time horizons due to the magnitude of shocks they contribute/transmit across all the bond markets examined. The findings divulge that short-term dynamics play a significant role in spillovers across Islamic bond markets during volatile trading periods, allowing institutional investors to profit from Islamic bonds during market shocks. When G6 bonds are included in a portfolio, speculators and hedgers may concentrate on Islamic bonds only in the medium-to-long term to meet their competitive portfolio objectives.

2. Literature Review

Greater portfolio variety requires a thorough understanding of the interdependencies or contagion (any substantial increase in cross-market connections after a shock in either one nation (market) or a group of nations may cause contagion (markets). The implication is that if there is comovement between two markets during average market conditions, there is interdependence (no contagion) if the comovement between them persists after one of them has experienced a shock; it is only contagion (or "shift-contagion") if a significant increase in an already existing cross-market relationship occurs (Forbes & Rigobon, 2001, 2002). See Forbes and Rigobon (2001, 2002), Ijasan, Owusu Junior, Tweneboah, and Adam (2021), Owusu Junior (2020), Owusu Junior et al. (2020), Owusu Junior, Tweneboah, and Adam (2019), and others for more on contagion.), spillovers, and comovements among the asset classes and markets under consideration.

The methods employed in the extant literature largely suffer from the inability to establish or infer contagion, if any, between these two asset classes. Roukiane and Marzouki [51] compared the dynamics of the volatility of the Sukuk index of various maturities, as well as their conventional counterparts, using a variety of tests, including the Jarque-Bera test, the Granger causality test, Student's t-test, and the Ljung-Box test. The authors modelled the behaviour of volatility using the unconditional volatility measured by the monthly standard deviation and the conditional volatility estimated by the generalised autoregressive conditional heteroscedasticity (GARCH) estimator. The study sample consisted of 10 Dow Jones indices of various maturities spanning from January 1, 2014, to April 25, 2017. Roukiane and Marzouki [51] concluded that Sukuks are less risky/volatile than conventional bonds. Akhtar et al. [52] estimated volatility connections, utilising a stochastic volatility model in a Generalised Methods of Moments framework, with additional volatility proxies. After adjusting for the country and asset-specific variables, Akhtar et al. [52] showed that adding at least one Islamic asset reduces volatility correlations by up to 7.17 percentage points and that, during financial crises, the results are better, with no influence from the oil industry. Ghaemi Asl and Rashidi [53] examined the spillover between the MENA stock index and various securities indices, such as Sukuk and conventional bonds, and compared the hedging efficacies of Sukuk and conventional bonds. The authors employed the VAR (1) and multivariate GARCH (1, 1) model to examine the volatility, shock, and asymmetric shock spillover between the Sukuk index and several bond indices in the MENA region.

Ghaemi Asl and Rashidi [53] showed that there is no shock, volatility, or asymmetric shock spillover between the Sukuk index and the MENA stock index, implying that Sukuk indices behave independently from MENA stock indices; however, shock and asymmetric shock spillover exists between MENA stock indices and security indices that include conventional bonds. They show that, throughout both normal and crisis times, the hedging efficacy of Sukuk exhibits consistent patterns. The authors failed to infer contagion from their study. Hkiri et al. [54] used the generalised vector autoregressive method to evaluate the decoupling and contagion hypotheses on the safe haven status of Islamic indices by looking at total, directional, and net volatility spillovers across nine regional Islamic stock indices and their conventional equivalents. The authors utilised daily data from 1999 to 2014, which covers a variety of financial crises, including those in Asia, Russia, Argentina, Brazil, and the United States. They revealed that GFCs have a significant impact on cross-market volatility. The authors further indicated that although the contagion theory holds for both Islamic and conventional indices, their results divulge that, during tumultuous times, Islamic indices decouple from their conventional counterparts. Although

Hkiri et al. [54] had assessed contagion, their study focused on Islamic equities other than bonds.

In the era of the COVID-19 pandemic, studies on financial markets have had diverse methodological paradigms, which either use the time domain (see [55] or the frequency domain only; see also, [46, 47]). Furthermore, the few works on Islamic financial markets also fail to employ methods that consider both time and frequency domains.

Naeem et al. [56] studied the return connectivity in the median, left, and right tails utilising the new quantile-based connectedness approach. Naeem et al. [56] employed daily data between January 2013 and October 2020, which covers several financial crises in the Gulf Cooperation Council, Indonesia, Malaysia, and Turkey. The authors reported that the COVID-19 pandemic has had a substantial impact on the Sukuk market and that the spillover structures in the higher and lower tails vary from those in the intermediate quantile. During the COVID-19 epidemic, Bahrain, Malaysia, Oman, and Qatar are reported by the authors to be higher transmitters of spillovers than they received.

Using the transfer entropy technique, Bossman [46] examined the impact of COVID-19 on Islamic and conventional financial markets, revealing that reported cases of COVID-19 pandemic affect market returns across diverse frequencies. With the same approach, Bossman et al. [47] assessed the stock-bond interrelations between Islamic and conventional markets, concluding that safe haven is applicable to the two asset classes in the studied COVID-19 crisis period. These works focus on the frequency domain with no details about the time domain. Besides, the period is limited to the COVID-19 era, which may not allow for distinguishing interdependence from contagion.

From the extant literature, it could be noticed that a great deal of attention has been offered to composite Islamic market indices with little attention to country-specific prices. Also, to the best of our knowledge, these studies are yet to or failed to employ methods that could infer contagion or stress interdependence among the Islamic and conventional bond markets. Hkiri et al. [54] attempted to analyse contagion but did not employ bonds. The extant research is still divided on whether a spillover is caused by interdependence or contagion (see [57–59], etc.). Furthermore, the COVID-19 pandemic has been blamed for several worldwide economic shocks (see [14, 60, 61], etc.). As a result, investigations of volatility spillovers across and within asset classes must take contagion into account and evaluate its amplitude or severity. The existing literature is yet to address this issue in the context of specific Islamic bond indices. In light of the COVID-19 pandemic, a contribution in this direction is not trivial.

Tiwari et al.'s [62] study employs the spillover methodology but it mainly focuses on green bonds, which may not qualify as a faith-based investment instrument. Aslam et al.'s [63] study focused on financial markets in Europe. Besides, their methodological approach was that of the DY-12, which has limitations that are overcome by the BK-18 spillover approach. Nonetheless, due to the distinct characteristics of IFMs, as mentioned earlier, comparing the connectivity of bonds from Islamic and conventional markets is essential for faith-based investors and regulators. Indicatively, the essence of this study is brought to light when we consider the conclusions from earlier works that assessed the impact of cross-market linkages in systemic crises era like the Brexit [64–66]. The focus of these studies was on conventional markets, with no evidence on how Islamic markets fare during such times and their linkages with their conventional counterparts. This gap is abridged in this study.

The idea that market participants operate on different investment horizons stems mainly from the evolution of investor preferences. This implies that focusing on either the time or frequency domain only is insufficient for horizon-based investors. Consequently, frequency bands that correspond to the short-, medium-, and long-term trading horizons are employed in this study. The use of several GARCH approaches, as held in the literature, and other spillover techniques other than the BK-18 fails to reveal these frequency dynamics. It is instructive to note that this is essential to delineate short-term spillovers from their medium- and long-term ones. Investment decisions hinged on time frequency are of particular importance to speculators who are particularly concerned with short-term gains and institutional investors who may be more interested in long-term cross-market dynamics. Lastly, rather than using aggregated indices for the conventional and Islamic bond markets, this study focuses on country-specific markets to uncover the unique dynamics that may exist in each market and pair of markets. This would provide investors with a more comprehensive view, allowing them to make better and competitive investment choices.

3. Methods and Materials

To uncover the time- and frequency-domain dynamics of the two asset classes under various market circumstances, the study uses the Baruník and Křehlík [49] (BK-18) spillover index to analyse the dynamic connectedness and spillovers between Islamic and conventional bond markets.

3.1. The BK-18 Spillover Index Approach. Baruník and Křehlík [49] used generalised forecast error variance decompositions (GFEVDs) to quantify connectivity, as inspired by Diebold and Yilmaz [50]. The matrix of a vector autoregressive (VAR) model with local covariance stationarity is used to decompose the data. We represent a K-variate procedure, $Y_t = (y_{1,t}, \ldots, y_{K,t})'$, given $t = 1, \ldots, T$ and a VAR(ρ) which may be expressed as

$$Y_t = \sum_{i=1}^{p} \phi_i y_{t-i} + \epsilon_{t,}. \quad (1)$$

Here coefficient matrices and white noise with (prospective nondiagonal) covariance matrix Π are denoted as ϕ_i and ϵ_i. A regression is carried out between each variable in system (1) and its "own" ρ lags and the ρ lags of all the remaining variables. Accordingly, ϕ holds wide-ranging information on the relationships between all variables. The expediency of working with a $(K \times K)$ matrix $(\mathbf{I}_K - \varnothing_1 L - \ldots - \varnothing_p L^p)$

with identity $\mathbf{I}_K$ must be noted. The VAR system is characterised by a moving average $MA(\infty)$ when the roots of the representative equation $|\theta(z)|$ lie outside of the unit circle.

$$Y_t = \psi(L)\epsilon_t, \tag{2}$$

with $\psi(L)$ depicting an infinitely lagged polynomial. The role of the kth variable, known as the GFEVD, in the variance of forecast error of element j can be written as

$$(\Theta_H)_{j,k} = \frac{\sigma_{kk}^{-1}\sum_{h=0}^{H}\left((\psi_h\Pi)_{j,k}\right)^2}{\sum_{h=0}^{H}(\psi_h\Pi_{h'})_{j,k}}, \tag{3}$$

where $h = 1, \ldots, H$ and $\sigma_{kk} = (\Pi_{kk})$. This could hold since the measure of connectedness is contingent on decomposed variances, which are the transformations of ψ_h and serve as the contribution of the shocks to the system. Because row contributions do not aggregate to 1, for the sake of completeness, a standardisation of matrix Θ_H is generated as

$$\left(\tilde{\Theta}_H\right)_{j,k} = \frac{(\Theta_H)_{j,k}}{\sum_{k=1}^{N}(\Theta_H)_{j,k}}. \tag{4}$$

The pairwise connectivity (4) may be aggregated for overall connectedness in a system. In line with Diebold and Yilmaz [50], this may be defined as the proportion of variation in predictions provided by errors other than own error (which is the same as the ratio of the off-diagonal components' sum to the whole matrix's sum) as shown in

$$C_H = 100 * \frac{\sum_{j\neq k}\left(\tilde{\Theta}_H\right)_{j,k}}{\sum\tilde{\Theta}_H} = 100 * \left(1 - \frac{Tr\{\tilde{\Theta}_H\}}{\sum\tilde{\Theta}_H}\right), \tag{5}$$

where $Tr\{.\}$ represents the operator for tracing and the arithmetic aggregate of all elements in the matrix is the denominator. As a result, connectedness denotes the forecast variance's relative contribution to the system's other variables. As a result, bidirectional connectivity may be assessed ("to" and/or "from" market i from all other markets k). The difference between "to" and "from" spillovers is also used to calculate "net" connectivity. As a result, a market with a positive net spillover acts as a "net transmitter," while one with a negative spillover acts as a "net receiver" of shocks.

The spectral representation of connectivity is shown at this point. With a frequency response function of $\psi(e)^{-i\omega} = \sum_h e^{-i\omega h}\psi_h$ of coefficients that could be transformed by Fourier transforms ψ_h with $i = \sqrt{-1}$, a spectral density of Y_t at frequency ω can be defined as $MA(\infty)$ filtered series:

$$S_{y(\omega)} = \sum_{h=-\infty}^{\infty} E(Y'Y_{t-h})e^{-i\omega h} = \psi\left(e^{-i\omega}\right)\Pi\psi'\left(e^{+i\omega}\right), \tag{6}$$

where $S_{y(\omega)}$ is the power spectrum which details the distribution of the variance of Y_t over the frequency components ω. The causation spectrum over $\omega \in (-\pi, \pi)$ is defined in (7), noting that it reflects the fraction of the ith variable attributable to shocks in the kth variable at a particular frequency ω. As a consequence,

$$(\mathscr{F}(\omega))_{j,k} = \frac{\sigma_{kk}^{-1}|\psi\left(e^{-i\omega}\right)\Pi_{j,k}|^2}{\left(\psi\left(e^{-i\omega}\right)\Pi\psi'\left(e^{+i\omega}\right)\right)_{j,j}}. \tag{7}$$

It could be understood as within-frequency causation due to the denominator. To get a natural decomposition of GFEVD to frequencies, we weigh $(\mathscr{F}(\omega))_{j,k}$ by the frequency share of the variance of the jth variable. We define the weighting function as

$$\Gamma_j = \frac{\left(\psi\left(e^{-i\omega}\right)\Pi\psi'\left(e^{+i\omega}\right)\right)_{j,j}}{1/2\pi\int_{-\pi}^{\pi}\left(\psi\left(e^{-i\lambda}\right)\Pi\psi'\left(e^{+i\lambda}\right)\right)_{j,j}d\lambda}. \tag{8}$$

It is summated to real-valued (according to Baruník and Křehlík (2018), the generalised causation spectrum is the squared modulus of the weighted complex numbers, resulting in a real-valued quantity) numbers up to 2π and represents the index of the jth variable at a particular frequency. Connectivity must be measured across periods in practical financial applications. As a result, rather than measuring connectedness at single frequencies, it is more appropriate to do so across frequency bands. We take a formal representation of frequency band, d, as $d = (a, b)$: $a, b \in (-\pi, \pi)$, $a < b$, for which we define the GFEVDs as

$$(\Theta_d)_{j,k} = \frac{1}{2\pi}\int_a^b \Gamma_j(\omega)(\mathscr{F}(\omega))_{j,k}d\omega\,. \tag{9}$$

A scaled (As seen in equations (5), (11), and (12), the scaling factor is 100. In the practical application of the connectedness in the BK-18 framework, it is also the minimal forecast horizon H.) generalised variance decomposition may be constructed in the same frequency band d as

$$\left(\tilde{\Theta}_d\right)_{j,k} = \frac{(\Theta_d)_{j,k}}{\sum_k(\Theta_\infty)_{j,k}}. \tag{10}$$

Then, the within-frequency and frequency connectivity across d are expressed in (11) and (12), respectively.

$$C_d^W = 100.\left(1 - \frac{Tr\{\tilde{\Theta}_d\}}{\sum\tilde{\Theta}_d}\right). \tag{11}$$

$$C_d^F = 100.\left(\frac{\sum\tilde{\Theta}_d}{\sum\tilde{\Theta}_\infty} - \frac{Tr\{\tilde{\Theta}_d\}}{\sum\tilde{\Theta}_\infty}\right) = C_d^W.\left(\frac{\sum\tilde{\Theta}_d}{\sum\tilde{\Theta}_\infty}\right). \tag{12}$$

It is important to note that C_d^W represents the connectivity that occurs inside a frequency band and is only weighted by the series' power on that frequency band. C_d^F, on the other hand, breaks down overall connectivity into discrete pieces that add up to the original connectedness metric, as presented by Baruník and Křehlík [49]. $(\pi + 0.00001, \pi/4, \pi/16, \pi/32, \pi/64, 0)$ are the frequency bands we utilise, which is in line with Baruník and Křehlík [49], Tiwari et al. [67], Tiwari et al. [68], Owusu Junior [57], and Owusu Junior et al. [58]. Table 1 shows the daily ranges that correspond to the relevant bands.

Table 1: Interpretations to frequency bands.

Frequency	Bands	Days	Interpretation
d_1	3.14 ~ 0.79	1 ~ 4	Intraweek
d_2	0.79 ~ 0.20	4 ~ 16	Week-to-fortnight
d_3	0.20 ~ 0.10	16 ~ 32	Fortnight-to-month
d_4	0.10 ~ 0.05	32 ~ 64	Month-to-quarter
d_5	0.05 ~ 0.00	64 ~ ∞	Quarter-and-beyond

3.2. Data. The daily bond yield market indices for five key Islamic bond markets (India, Indonesia, Malaysia, Pakistan, and Qatar) and G6 (G6 instead of G7 because the bond yield for Germany had been negative since 22 March 2019, making it impracticable to compute log returns over the COVID-19 period. For unbiased estimates, Germany was, therefore, eliminated from the studied countries.) economies (Canada, France, Italy, Japan, UK, and USA) (in ascending order per country spellings) with available data were utilised in the study. The data set spanned between 22 August 2012 and 17 September 2021, yielding 1272 common data observations. The daily 10-year bond indices were supplied by EquityRT and are expressed in USD. The log-returns of the daily bond indices were computed as follows:

$$r_t = lnP_t - lnP_{t-1}. \tag{13}$$

In the above equation, r_t defines the continuously compounded returns, P_t represents the price of an asset (bond) in period t, and P_{t-1} represents the price of the asset in the previous period $t-1$.

A forecast horizon (H) of 100 days is utilised, as well as a 100-day rolling window. This aggregates to a little over a quarter of a year, and it is sufficient to accommodate for time differences in the bond markets. The rolling window framework eliminates the need for crisis start and end dates to be specified exogenously. By displaying the resultant spillover indices, we can account for significant changes in the form of spillovers throughout the sample period, as advocated by Yilmaz [69], Owusu Junior [57], and Owusu Junior et al. [58].

A trajectory of the bond yield indices for all the countries is presented in Figure 1. The Shapiro-Wilk test of normalcy confirms skewness and excess kurtosis (see Table 2). The resulting statistics for skewness and kurtosis, respectively, depict nonnormal and leptokurtic distributions across the markets studied. Asymmetries in return distributions are confirmed by these findings, offering a strong incentive to use the BK-18 approach, relative to the DY-12 time-invariant approach, to examine the dynamic and asymmetric connection between Islamic and conventional bonds. Traces of volatilities may also be seen in the time series returns plots in Figure 2, indicating that the series is generating time-varying risk.

The mean returns on bond yield over the entire sample were positive for all Islamic countries except for Qatar, even though it is almost zero. For all G6 bond yield markets, the mean returns over the studied period were negative but close to zero. An important revelation is made by the time series plots. We find the "Brexit effect" (We refer to the Brexit effect as the substantial losses borne by global investors on 24 June 2016 following the referendum that confirmed Britain's exit (Brexit) from the European Union (David, 2016). The Brexit caused investors in global stock markets to lose over US$2 trillion, making it the biggest single-day loss in history.) in 2016/17 where almost all the bond yield indices studied experienced a sharp drop followed by a sharp rise in the yields. This finding is consistent with the empirical literature that found that cross-market linkages were affected as a result of the Brexit referendum [64–66].

4. Results

4.1. Time-Frequency-Domain Analysis. By accounting for the development of total connection across time, the time-frequency-domain approach aids in determining whether or not there is contagion. We proceed by examining the impact of spillovers between the Islamic and G6 bond markets at different frequencies, which result from the decomposition of the data series. This decomposition tries to account for market players' various expectations and desires across various time periods. Tables 3–5 show the short-, medium-, and intermediate-term spillovers in the markets under study, classified into five frequency bands (intraweek, week-to-fortnight, fortnight-to-month, month to quarter, and quarter and beyond), respectively, for Islamic and G6 bond markets, Islamic only, and G6 only. The tables and plots of the pairwise net spillover effects between Islamic and G6 bonds, Islamic bonds alone, and G6 bonds are not presented here for want of space (These are available upon request to the corresponding author.).

The spillover effects for all markets (Islamic and G6) in Table 3 show that spillovers are relatively greater in the very short-term (intraweek) than in the medium-to long-term timeframes. For instance, the return spillover within the first band, 3.14 ~ 0.79, which approximates to 1 ~ 4 days is 18.76%. This return spillover reduces to 6.03%, 1.4%, 0.71%, and 0.35% in respect of the second (0.79 ~ 0.20), third (0.20 ~ 0.10), fourth (0.10 ~ 0.05), and fifth (0.05 ~ 0.00) bands, respectively, and corresponds to intraweek, week-to-fortnight, fortnight-to-month, month to quarter, and quarter and beyond, respectively. Similarly, the spillover is seen to be decreasing over time both among Islamic bonds only and among G6 bond markets only, with the volatilities in G6 bonds exhibiting high magnitudes. This result suggests that, in the initial few trading days, all bond markets react rapidly to shocks. The Islamic and G6 markets examined are, at best, more sensitive to market shocks within the intraweek band (3.14 ~ 0.79) during the studied period.

Note: (a) "Absolute to" measures return spillovers from market/country j to other markets. "Absolute from" measures return spillovers from other markets to market j. (b) Within to measures return spillovers from market j to other markets, including from own innovations to country k. Within from measures return spillovers from other markets to market j, including from own innovations to market k (see [57, 58, 67, 68]). The largest contributions of markets per frequency band are in bold italics. A positive "Net"

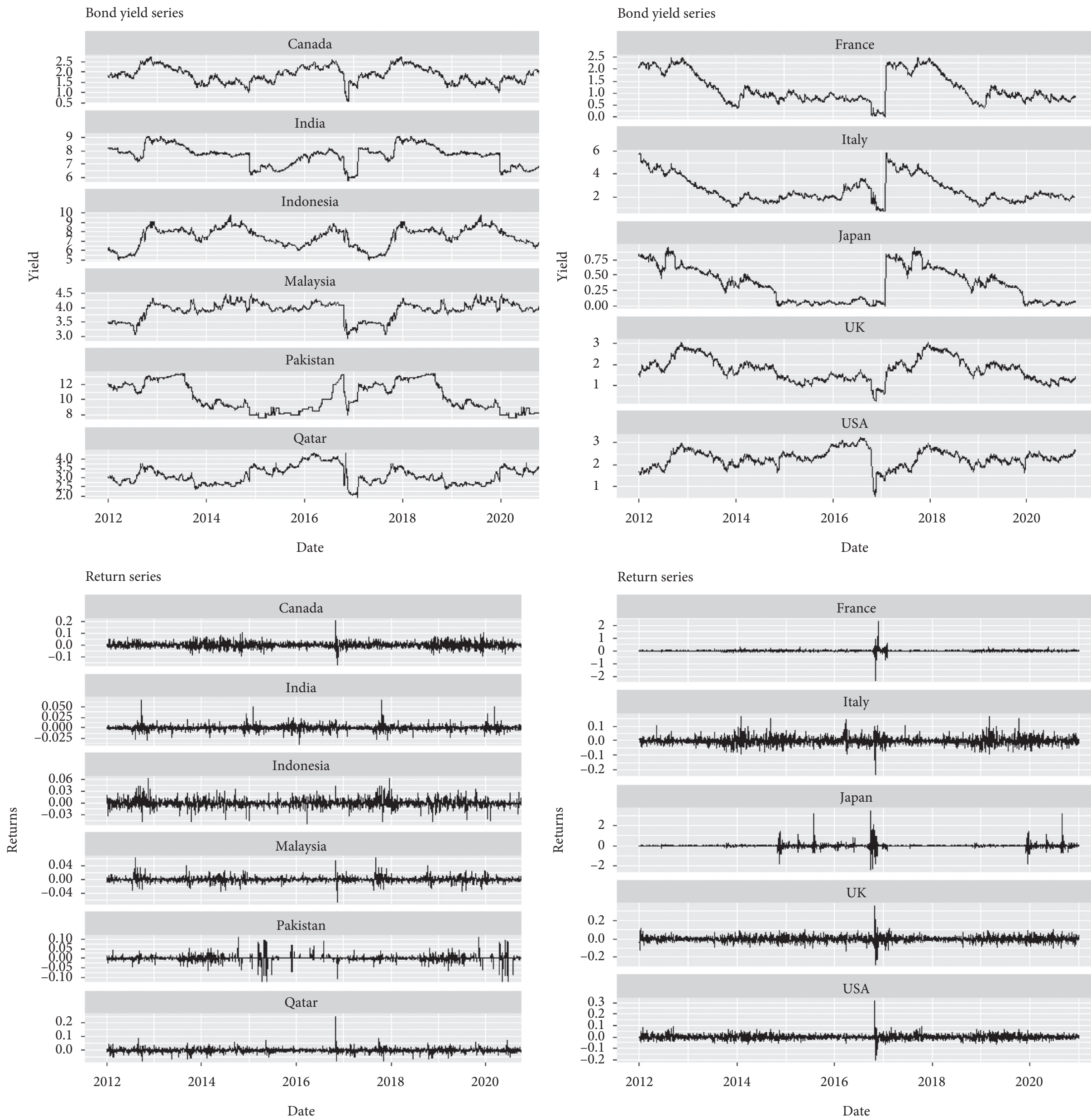
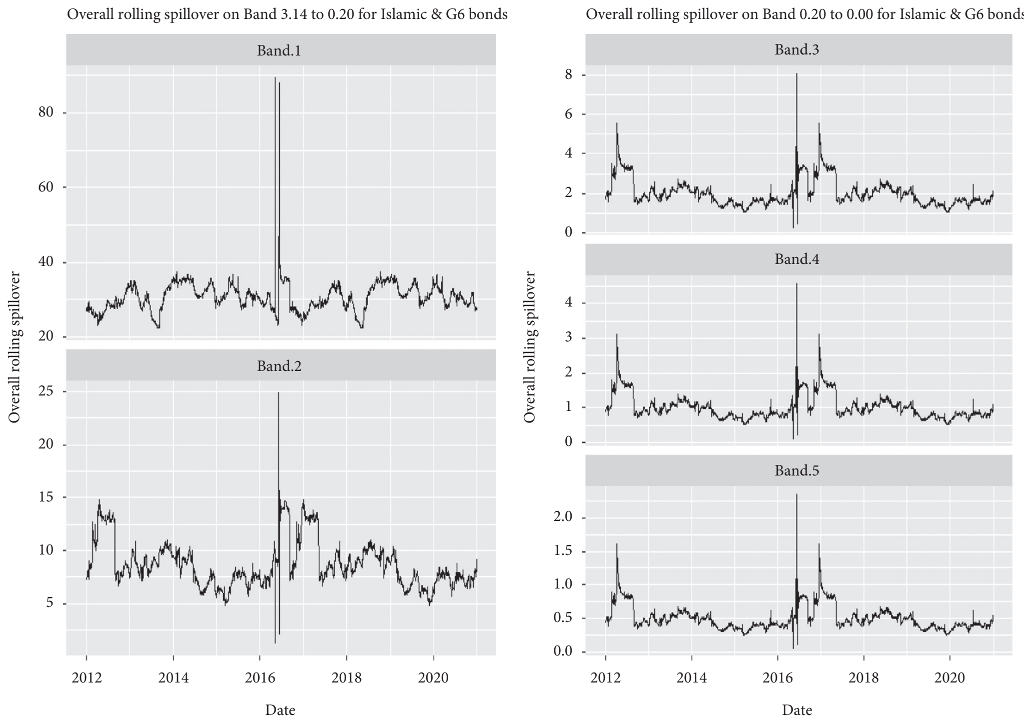


Figure 1: Time series plots of bond yield indices and returns for Islamic and G6 markets.

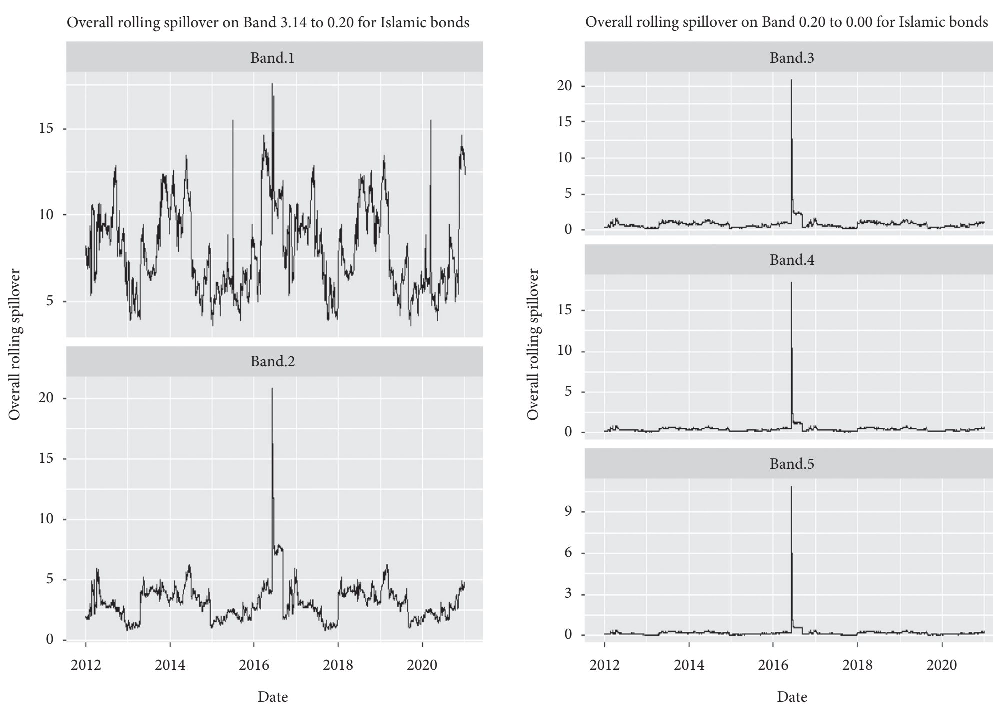
Table 2: Descriptive summary.

Islamic	India	Indonesia	Malaysia	Pakistan	Qatar	
Observations	1272	1272	1272	1272	1272	
Mean	0.0001	0.0006	0.0001	0.0001	−0.0001	
Std. dev	0.0063	0.0099	0.0074	0.0145	0.0161	
Skewness	1.1291	0.1774	0.401	−0.3095	3.3397	
Kurtosis	15.4656	4.6015	15.2639	24.8583	51.5892	
Normtest.W*	0.8707	0.9352	0.8257	0.5507	0.7767	
G6	Canada	France	Italy	Japan	UK	USA
Observations	1272	1272	1272	1272	1272	1272
Mean	−0.001	−0.0012	−0.0011	−0.0014	−0.0006	−0.0003
Std. dev	0.0244	0.127	0.0286	0.2663	0.0349	0.0241
Skewness	0.3292	0.6811	−0.1962	2.2319	0.3779	1.8045
Kurtosis	7.0369	178.9996	9.7366	57.6261	16.9531	34.547
Normtest.W*	0.9457	0.366	0.915	0.4834	0.8751	0.826

*estimates are significant at the 1% level of significance.

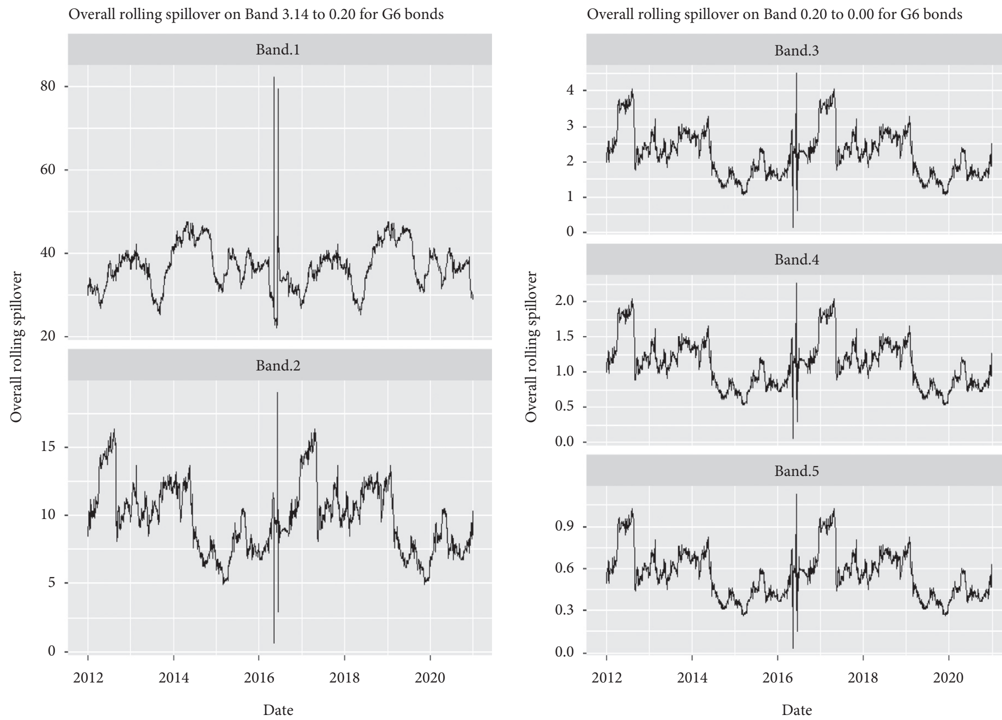


(a)



(b)

Figure 2: Continued.



(c)

Figure 2: Overall rolling spillovers across time horizons. (a) Panel A: Islamic and G6 bond markets. (b) Panel B: Islamic bond markets. (c) Panel C: G6 bond markets.

suggests that the country/market is a net transmitter, while a negative "Net" denotes net recipient market/country.

These results are consistent with the EMH such that, in the short term, asset prices fully reflect all pertinent information [9, 10], resulting in high market dynamics at high frequencies. Mensi et al. [24] used a similar approach to find that short-term spillovers have relative importance over intermediate-term spillovers for Islamic and conventional markets, particularly BRICS countries. These findings contrast with those of Hassan et al. [70] who used TGARCH and GFEVD to calculate time- and frequency-domain volatility spillover for Islamic and conventional financial markets but found that the overall volatility spillover is primarily driven by a long-term component and, as a result, suggested that investors with short- and medium-term investment goals consider these assets.

When the chosen Islamic and G6 economies are examined jointly, USA (4.71%), UK (4.36%), and Canada (3.83%) are the biggest contributors of shocks to the studied markets at the high frequency (short term) spillover band. These economies continue to be the principal transmitters of shocks in all other spillover bands, with the exception that the size of spillovers transmitted by Canada surpasses that of UK in the remaining spillover bands. Pakistan, on the other hand, is the lowest contributor to the shocks between the bond markets examined across all spillover bands. This means that the Pakistani bond market is less susceptible to shocks than other traditional bond markets, making it a good choice for diversification amid market stress. Following that, we isolate the two main markets to investigate the transmission of volatility between and within them. From the Islamic bond markets alone, we discovered that Malaysia and Qatar contribute the most to bond market return spillovers across all frequency domains, whereas Pakistan contributes the least. USA, Canada, and UK were shown to be the major sources of volatility spillovers throughout the G6 markets. Japan, on the other hand, was determined to provide a little amount of volatility spillover to the G6 markets. In comparison, we find that the G6 bond markets have higher magnitudes of volatility across all time periods than the Islamic bond markets. The findings confirm Roukiane and Marzouki's [51] conclusion that Islamic bonds are less risky/volatile than conventional bonds.

The results show that USA gets the greatest degree of volatility spillover in the short term, particularly in the spillover range of 3.14 to 0.79, after examining the markets collectively in terms of receivers of bond market return volatilities. UK receives the most volatility spillover between the chosen Islamic and G6 bond markets between bands 2 and 5. Across all spillover bands, Pakistan's bond market admits the fewest spillovers from its Islamic and G6 counterparts. When the two wide bond markets are examined separately, Malaysia suffers the most volatility spillovers from other Islamic bond markets in the spillover range of 3.14 ~ 0.79, while Indonesia receives the most volatility spillovers in bands 2 to 5. The Pakistani bond market has the fewest volatility spillovers from its Islamic counterparts across all frequency domains. Canada has the most volatility spillover in the G6 markets in the very short term (3.14 ~ 0.79), whereas UK has the most volatility

TABLE 3: Total and Net spillover indices across frequency bands for Islamic and G6 bonds.

	India	Indonesia	Malaysia	Pakistan	Qatar	Canada	France	Italy	Japan	UK	USA	FROM_ABS(a)	FROM_WTH(b)
Spillover band: 3.14 to 0.79; corresponds to 1 day to 4 days (intraweek)													
India	71.07	0.75	0.78	0.06	1.11	0.23	0.09	0.06	0.08	0.22	0.37	0.34	0.46
Indonesia	0.4	57.04	2.01	0.16	1.17	0.1	0.03	0.18	0.06	0.21	0.18	0.41	0.56
Malaysia	0.51	1.6	49.45	0.11	1.47	1.39	1.27	0.65	0.07	0.91	2.51	0.95	1.3
Pakistan	0.02	0.05	0.25	82.8	0.04	0.07	0.4	0.27	0.03	0.4	0.05	0.14	0.19
Qatar	0.6	0.66	0.8	0.19	52.36	2.05	1.71	0.1	0.74	2.65	4.03	1.23	1.68
Canada	0.03	0.03	0.23	0.09	0.76	33.73	2.77	0.77	0.36	13.08	22.27	3.67	5.01
France	0.05	0.02	1.25	0.06	1.61	3.29	52.87	6.01	0.74	10.72	4.59	2.58	3.52
Italy	0.03	0.01	0.26	0.38	0.27	1.43	9.16	59.45	0.23	3.6	1.34	1.52	2.07
Japan	0.19	0.07	0.08	0.01	0.85	1.16	1.27	0.54	74.18	1.39	1.68	0.66	0.9
UK	0.02	0.08	0.29	0.28	1.9	12.11	7.55	1.35	0.77	34.86	14.76	3.56	4.85
USA	0.02	0.02	0.44	0.02	1.06	20.36	2.87	0.44	0.7	14.81	31.83	3.7	5.05
TO_ABS(a)	0.17	0.3	0.58	0.12	0.93	3.83	2.47	0.94	0.34	4.36	4.71	18.76	
TO_WTH(b)	0.23	0.41	0.79	0.17	1.27	5.23	3.37	1.29	0.47	5.95	6.42		25.6
Net	−0.169	−0.110	−0.372	−0.020	−0.299	0.162	−0.110	−0.578	−0.314	0.806	1.003		
Spillover band: 0.79 to 0.20; corresponds to 4 days to 16 days (week-to-a-fortnight)													
India	16.88	0.06	0.12	0	0.61	0.19	0.01	0.01	0.03	0.05	0.2	0.12	0.61
Indonesia	0.36	22.03	2.13	0.12	1.34	0.25	0.04	0.18	0.04	0.07	0.35	0.44	2.32
Malaysia	0.46	1.01	19.02	0.08	1.14	1.49	0.74	0.49	0.02	1.03	2.55	0.82	4.28
Pakistan	0	0.01	0.02	11.03	0	0.01	0.12	0.13	0	0.01	0.02	0.03	0.16
Qatar	0.19	0.26	0.63	0.02	14.55	2.08	0.42	0.13	0.19	2.3	3.38	0.87	4.57
Canada	0.01	0.01	0.03	0.01	0.15	8.96	0.24	0.16	0.04	3.27	5.69	0.87	4.57
France	0.01	0	0.26	0.02	0.33	0.46	9.22	1.73	0.23	0.85	0.49	0.4	2.09
Italy	0	0	0.03	0.01	0.01	0.26	1.31	15.32	0.01	0.24	0.09	0.18	0.93
Japan	0.01	0	0.03	0	0.32	0.65	0.43	0.22	10.3	0.66	0.87	0.29	1.52
UK	0	0	0.03	0	0.17	4.68	0.6	0.33	0.04	7.59	5.31	1.02	5.32
USA	0.01	0	0.08	0	0.14	6.26	0.42	0.19	0.03	3.83	8.8	1	5.21
TO_ABS(a)	0.1	0.12	0.31	0.02	0.38	1.48	0.39	0.32	0.06	1.12	1.72	6.03	
TO_WTH(b)	0.51	0.65	1.6	0.13	2	7.77	2.06	1.7	0.3	5.85	9.02		31.59
Net	−0.020	−0.319	−0.513	−0.006	−0.491	0.611	−0.006	0.146	−0.233	0.103	0.727		
Spillover band: 0.20 to 0.10; corresponds to 16 days to 32 days (fortnight-to-month)													
India	3.74	0.01	0.02	0	0.14	0.05	0	0	0.01	0.01	0.05	0.03	0.59
Indonesia	0.1	5.27	0.57	0.03	0.36	0.08	0.01	0.05	0.01	0.01	0.1	0.12	2.73
Malaysia	0.12	0.25	4.54	0.02	0.28	0.39	0.18	0.12	0	0.27	0.67	0.21	4.82
Pakistan	0	0	0	2.37	0	0	0.03	0.03	0	0	0	0.01	0.15
Qatar	0.05	0.06	0.15	0	3.29	0.53	0.09	0.03	0.04	0.57	0.84	0.22	4.96
Canada	0	0	0.01	0	0.03	2.03	0.04	0.03	0.01	0.74	1.28	0.2	4.49
France	0	0	0.06	0	0.08	0.09	2.02	0.39	0.05	0.17	0.1	0.09	1.98
Italy	0	0	0	0	0	0.04	0.27	3.39	0	0.03	0	0.03	0.76
Japan	0	0	0.01	0	0.07	0.15	0.09	0.05	2.19	0.15	0.2	0.07	1.51
UK	0	0	0	0	0.03	1.06	0.11	0.07	0.01	1.68	1.19	0.23	5.17
USA	0	0	0.02	0	0.03	1.41	0.08	0.04	0	0.85	1.96	0.22	5.08

Table 3: Continued.

	India	Indonesia	Malaysia	Pakistan	Qatar	Canada	France	Italy	Japan	UK	USA	FROM_ABS(a)	FROM_WTH(b)
TO_ABS(a)	0.03	0.03	0.08	0.01	0.09	0.35	0.08	0.08	0.01	0.26	0.4	1.4	
TO_WTH(b)	0.58	0.68	1.76	0.14	2.11	7.96	1.89	1.72	0.27	5.87	9.26		32.23
Net	−0.000	−0.089	−0.134	−0.001	−0.124	0.151	−0.004	0.042	−0.054	0.030	0.182		
Spillover band: 0.10 to 0.05; corresponds to 32 days to 64 days (month-to-quarter)													
India	1.87	0	0.01	0	0.07	0.02	0	0	0	0	0.02	0.01	0.59
Indonesia	0.05	2.65	0.29	0.02	0.18	0.04	0.01	0.03	0	0	0.05	0.06	2.77
Malaysia	0.06	0.13	2.29	0.01	0.14	0.2	0.09	0.06	0	0.14	0.34	0.11	4.88
Pakistan	0	0	0	1.18	0	0	0.01	0.01	0	0	0	0	0.15
Qatar	0.03	0.03	0.08	0	1.65	0.27	0.05	0.02	0.02	0.29	0.42	0.11	4.99
Canada	0	0	0	0	0.02	1.01	0.02	0.02	0	0.37	0.64	0.1	4.48
France	0	0	0.03	0	0.04	0.05	1.01	0.2	0.03	0.08	0.05	0.04	1.97
Italy	0	0	0	0	0	0.02	0.13	1.69	0	0.02	0	0.02	0.74
Japan	0	0	0	0	0.04	0.08	0.05	0.02	1.09	0.08	0.1	0.03	1.5
UK	0	0	0	0	0.01	0.53	0.05	0.04	0	0.84	0.6	0.11	5.16
USA	0	0	0.01	0	0.01	0.71	0.04	0.02	0	0.43	0.98	0.11	5.07
TO_ABS(a)	0.01	0.01	0.04	0	0.05	0.17	0.04	0.04	0.01	0.13	0.2	0.71	
TO_WTH(b)	0.58	0.68	1.77	0.14	2.12	7.97	1.87	1.73	0.27	5.87	9.28		32.29
Net	0.000	−0.046	−0.068	0.00	−0.063	0.076	−0.002	0.022	−0.027	0.016	0.092		
Spillover band: 0.05 to 0.00; corresponds to 64 days to infinite days (quarter and beyond)													
India	0.94	0	0.01	0	0.03	0.01	0	0	0	0	0.01	0.01	0.58
Indonesia	0.02	1.33	0.14	0.01	0.09	0.02	0	0.01	0	0	0.03	0.03	2.78
Malaysia	0.03	0.06	1.14	0.01	0.07	0.1	0.04	0.03	0	0.07	0.17	0.05	4.89
Pakistan	0	0	0	0.59	0	0	0.01	0.01	0	0	0	0	0.15
Qatar	0.01	0.02	0.04	0	0.83	0.13	0.02	0.01	0.01	0.15	0.21	0.05	5
Canada	0	0	0	0	0.01	0.51	0.01	0.01	0	0.19	0.32	0.05	4.48
France	0	0	0.01	0	0.02	0.02	0.5	0.1	0.01	0.04	0.02	0.02	1.97
Italy	0	0	0	0	0	0.01	0.07	0.85	0	0.01	0	0.01	0.74
Japan	0	0	0	0	0.02	0.04	0.02	0.01	0.54	0.04	0.05	0.02	1.5
UK	0	0	0	0	0.01	0.27	0.03	0.02	0	0.42	0.3	0.06	5.15
USA	0	0	0	0	0.01	0.35	0.02	0.01	0	0.21	0.49	0.06	5.06
TO_ABS(a)	0.01	0.01	0.02	0	0.02	0.09	0.02	0.02	0	0.06	0.1	0.35	
TO_WTH(b)	0.59	0.68	1.78	0.14	2.13	7.98	1.87	1.73	0.27	5.87	9.28		32.3
Net	0.000	−0.023	−0.034	0.000	−0.031	0.038	−0.001	0.011	−0.013	0.008	0.046		

Note: (a) "Absolute to" measures return spillovers from market/country j to other markets. "Absolute from" measures return spillovers from other markets to market j. (b) Within to measures return spillovers from market j to other markets, including from own innovations to country k. Within from measures return spillovers from other markets to market j, including from own innovations to market k (see [57, 58, 67, 68]). The largest contributions of markets per frequency band are in bold italics. A positive "Net" suggests that the country/market is a net transmitter, while a negative "Net" denotes net recipient market/country.

Table 4: Total and Net spillover indices across frequency bands for Islamic bonds.

	India	Indonesia	Malaysia	Pakistan	Qatar	FROM_ABS(a)	FROM_WTH(b)
Spillover band: 3.14 to 0.79; corresponds to 1 day to 4 days (intraweek)							
India	71.7	0.8	1.01	0.06	1.31	0.64	0.9
Indonesia	0.45	57.51	2.17	0.17	1.27	0.81	1.15
Malaysia	0.79	1.92	56.79	0.11	2.1	0.98	1.4
Pakistan	0.03	0.04	0.19	84.31	0.03	0.06	0.08
Qatar	1.02	0.86	1.55	0.18	65.93	0.72	1.03
TO_ABS(a)	0.46	0.72	0.98	0.11	0.94	3.21	
TO_WTH(b)	0.65	1.03	1.4	0.15	1.34		4.56
Net	−0.178	−0.087	0.00	0.047	0.219		
Spillover band: 0.79 to 0.20; corresponds to 4 days to 16 days (week-to-a-fortnight)							
India	17.06	0.07	0.18	0	0.78	0.21	0.99
Indonesia	0.39	22.35	2.41	0.11	1.55	0.89	4.27
Malaysia	0.62	1.23	22.6	0.07	2.14	0.81	3.89
Pakistan	0	0.01	0.02	11.17	0	0.01	0.04
Qatar	0.33	0.34	1.38	0.03	19.46	0.41	1.98
TO_ABS(a)	0.27	0.33	0.8	0.04	0.9	2.33	
TO_WTH(b)	1.29	1.58	3.83	0.2	4.29		11.18
Net	0.061	−0.563	−0.014	0.034	0.482		
Spillover band: 0.20 to 0.10; corresponds to 16 days to 32 days (fortnight-to-month)							
India	3.78	0.01	0.04	0	0.18	0.05	0.94
Indonesia	0.11	5.39	0.66	0.03	0.43	0.25	4.96
Malaysia	0.16	0.32	5.55	0.02	0.57	0.21	4.3
Pakistan	0	0	0.01	2.39	0	0	0.04
Qatar	0.08	0.08	0.36	0.01	4.56	0.11	2.15
TO_ABS(a)	0.07	0.08	0.21	0.01	0.24	0.61	
TO_WTH(b)	1.41	1.67	4.32	0.21	4.77		12.38
Net	0.023	−0.162	0.001	0.009	0.129		
Spillover band: 0.10 to 0.05; corresponds to 32 days to 64 days (month-to-quarter)							
India	1.89	0	0.02	0	0.09	0.02	0.93
Indonesia	0.05	2.71	0.34	0.01	0.22	0.13	5.03
Malaysia	0.08	0.16	2.8	0.01	0.29	0.11	4.34
Pakistan	0	0	0	1.19	0	0	0.04
Qatar	0.04	0.04	0.18	0	2.29	0.05	2.17
TO_ABS(a)	0.04	0.04	0.11	0.01	0.12	0.31	
TO_WTH(b)	1.42	1.68	4.37	0.22	4.81		12.5
Net	0.012	−0.083	0.001	0.004	0.066		
Spillover band: 0.05 to 0.00; corresponds to 64 days to infinite days (quarter and beyond)							
India	0.95	0	0.01	0	0.05	0.01	0.93
Indonesia	0.03	1.36	0.17	0.01	0.11	0.06	5.04
Malaysia	0.04	0.08	1.4	0	0.15	0.05	4.35
Pakistan	0	0	0	0.59	0	0	0.04
Qatar	0.02	0.02	0.09	0	1.15	0.03	2.17
TO_ABS(a)	0.02	0.02	0.05	0	0.06	0.16	
TO_WTH(b)	1.42	1.68	4.38	0.22	4.82		12.52
Net	0.006	−0.042	0.000	0.00	0.033		

Note: (a) "Absolute to" measures return spillovers from market/country *j* to other markets. "Absolute from" measures return spillovers from other markets to market *j*. (b) Within to measures return spillovers from market *j* to other markets, including from own innovations to country *k*. Within from measures return spillovers from other markets to market *j*, including from own innovations to market *k* (see [57, 58, 67, 68]). The largest contributions of markets per frequency band are in bold italics. A positive "Net" suggests that the country/market is a net transmitter, while a negative "Net" denotes net recipient market/country.

spillovers in bands 2 to 5 (0.79 ~ 0.00). Japan (Italy) acknowledges the fewest short-term (intermediate to long term) volatility spillovers from its counterparts among the G6 bond markets.

Evaluations of the findings are presented in Tables 3–5, which show the markets' net transmitters and receivers of bond return volatilities. The findings indicate that Canada, USA, and UK are the net transmitters of spillovers between the Islamic and G6 economies in the near run, within the spillover band of 3.14 ~ 0.79. All of the Islamic markets, as well as the other G6 markets, were shown to be net shock receivers. Pakistan and Qatar (India, Indonesia, and

Table 5: Total and Net spillover indices across frequency bands for G6 bonds.

	Canada	France	Italy	Japan	UK	USA	FROM_ABS(a)	FROM_WTH(b)
Spillover band: 3.14 to 0.79; corresponds to 1 day to 4 days (intraweek)								
Canada	34.26	2.78	0.79	0.37	13.25	22.59	6.63	8.69
France	3.43	55.32	6.22	0.79	11.01	4.78	4.37	5.73
Italy	1.43	9.06	59.87	0.25	3.71	1.34	2.63	3.45
Japan	1.26	1.28	0.54	75.3	1.53	1.87	1.08	1.42
UK	12.3	7.62	1.4	0.77	35.84	14.94	6.17	8.08
USA	20.67	2.87	0.45	0.72	15.03	32.33	6.62	8.68
TO_ABS(a)	6.52	3.94	1.57	0.48	7.42	7.59	27.51	
TO_WTH(b)	8.54	5.16	2.05	0.63	9.72	9.94		36.04
Net	−0.115	−0.434	−1.066	−0.599	1.252	0.962		
Spillover band: 0.79 to 0.20; corresponds to 4 days to 16 days (week-to-a-fortnight)								
Canada	9.08	0.24	0.16	0.04	3.31	5.76	1.59	9.31
France	0.47	9.58	1.76	0.24	0.86	0.5	0.64	3.75
Italy	0.28	1.34	15.61	0.01	0.25	0.08	0.33	1.91
Japan	0.63	0.43	0.22	10.51	0.62	0.83	0.45	2.66
UK	4.89	0.62	0.37	0.04	7.91	5.59	1.92	11.25
USA	6.4	0.42	0.2	0.03	3.92	9.03	1.83	10.75
TO_ABS(a)	2.11	0.51	0.45	0.06	1.49	2.13	6.75	
TO_WTH(b)	12.38	2.99	2.65	0.36	8.77	12.48		39.62
Net	0.523	−0.13	0.127	−0.392	−0.423	0.296		
Spillover band: 0.20 to 0.10; corresponds to 16 days to 32 days (fortnight-to-month)								
Canada	2.06	0.05	0.04	0.01	0.75	1.3	0.36	9.42
France	0.09	2.09	0.4	0.05	0.16	0.09	0.13	3.48
Italy	0.05	0.28	3.49	0	0.04	0.01	0.06	1.71
Japan	0.14	0.09	0.05	2.24	0.14	0.19	0.1	2.71
UK	1.13	0.12	0.08	0.01	1.78	1.29	0.44	11.55
USA	1.46	0.09	0.05	0	0.89	2.03	0.41	10.92
TO_ABS(a)	0.48	0.1	0.1	0.01	0.33	0.48	1.51	
TO_WTH(b)	12.66	2.77	2.68	0.33	8.7	12.64		39.79
Net	0.123	−0.027	0.037	−0.09	−0.108	0.065		
Spillover band: 0.10 to 0.05; corresponds to 32 days to 64 days (month-to-quarter)								
Canada	1.03	0.02	0.02	0	0.38	0.65	0.18	9.43
France	0.04	1.04	0.2	0.03	0.08	0.04	0.07	3.46
Italy	0.03	0.14	1.74	0	0.02	0	0.03	1.69
Japan	0.07	0.05	0.03	1.12	0.07	0.09	0.05	2.71
UK	0.57	0.06	0.04	0	0.89	0.65	0.22	11.58
USA	0.73	0.04	0.02	0	0.44	1.02	0.21	10.94
TO_ABS(a)	0.24	0.05	0.05	0.01	0.16	0.24	0.75	
TO_WTH(b)	12.69	2.75	2.69	0.33	8.7	12.65		39.81
Net	0.062	−0.013	0.019	−0.045	−0.055	0.033		
Spillover band: 0.05 to 0.00; corresponds to 64 days to infinite days (quarter and beyond)								
Canada	0.51	0.01	0.01	0	0.19	0.33	0.09	9.43
France	0.02	0.52	0.1	0.01	0.04	0.02	0.03	3.45
Italy	0.01	0.07	0.87	0	0.01	0	0.02	1.69
Japan	0.04	0.02	0.01	0.56	0.03	0.05	0.03	2.71
UK	0.28	0.03	0.02	0	0.45	0.32	0.11	11.58
USA	0.37	0.02	0.01	0	0.22	0.51	0.1	10.94
TO_ABS(a)	0.12	0.03	0.03	0	0.08	0.12	0.38	
TO_WTH(b)	12.69	2.75	2.69	0.33	8.7	12.66		39.81
Net	0.031	−0.007	0.009	−0.023	−0.027	0.016		

Malaysia) were shown to be net transmitters (recipients) of high-frequency shocks to the examined Islamic bond markets. Except for Indonesia, all other markets between bands 2 and 5 were net spillover broadcasters. Across all frequency bands, Indonesia was shown to be a constant net receiver of shocks from its equivalent Islamic bond markets.

Canada, UK, and USA (France and Japan) were net transmitters (recipients) of spillovers across all frequency bands in the G6 bond markets. Italy was discovered to be a net receiver of shocks in the high-frequency range (short term) but not in the intermediate to long term. The results indicate that volatility spillovers between and within Islamic and/or G6 bond markets are time- and frequency-dependent, which is in line with the HMH [12]. Mensi et al. [24] came to the same result, revealing that volatility spillovers between Islamic and conventional markets, from the BRICS countries, were dependent on time scales and frequencies. Investors who keep assets in traditional markets in pursuit of competitive returns are likely to adapt to Islamic bonds in difficult times, according to this finding, which is consistent with the AMH and CMH of Lo [11] and Owusu Junior et al. [14], respectively. This observation corroborates Akhtar et al.'s [52] conclusion that adding at least one Islamic asset significantly reduces volatility correlations during financial crises.

Figure 2 depicts the return volatility of Islamic and G6 bond markets over time. Panel A depicts the time-frequency dynamics of return volatility for both Islamic and G6 bonds, whereas Panels B and C depict the return volatility of Islamic and G6 bonds, respectively.

The volatility spillovers are dominant in the short term for all samples, according to the plots. Across the frequency bands, we have a similar pattern of spillovers with varying magnitudes. We see fluctuations in spillover in Panel A (the all-markets sample), but they are mostly between 25% and 35% in the short term, with an increase to almost 90% by 2017. Volatility spillover clusters are observable for all markets across all time periods, but they vary when the markets are examined individually. We see a reasonably stable pattern of spillovers between 2018 and 2020. Around 2021, there was a marginal increase in spillovers between the two wide bond markets, Islamic and G6. In contrast to Islamic bonds, a separate study of the two bond markets shows that G6 bonds are prone to high volatility spillovers. We find that, in the short term (in the spillover band 1), spillovers across Islamic bond markets are largely between 5% and 15%, which, despite their lower magnitude, appear to be more volatile than spillovers across G6 bond markets, which are instead high in magnitudes ranging between 25% and 45% over the studied period. For the two distinct markets, a similar observation is made in band 2 (0.79 ~ 0.20, representing week-to-fortnight). With Islamic bonds, we have a stable pattern and modest magnitudes of volatilities in bands 3 to 5 (intermediate to long term), while, with G6 bond markets, we see significantly higher volatilities.

In the intermediate to long term, our findings indicate that conventional bonds are more volatile than Islamic equities. These results are consistent with the findings of Roukiane and Marzouki [51] who concluded that Islamic bonds exhibit fewer volatilities than conventional bonds. Similarly, the findings are consistent with the observations made by Hkiri et al. [54] that Islamic indices disconnect from their conventional equivalents during turbulent periods. Apart from providing support for our findings, the plots (Figure 2) demonstrate that the results are similar to those presented in Tables 3–5. Across all frequencies, we find minimal evidence of sporadic volatilities for Islamic bonds during the COVID-19 era. Although Islamic bond markets had plenty of volatility clusters in the short term (bands 1 and 2), there was no indication of prolonged volatility during COVID-19. Despite the relatively low volatility clusters in bands 1 and 2, we detect occasional volatility spillovers across all frequencies in the G6 bond markets throughout the COVID-19 pandemic period.

Furthermore, by inference, we find contagion across all spillover bands on three occasions. The first is spotted in 2016/2017 (see Figure 2). Notably, our findings show the evolution of contagion in 2017, with significant increases in spillover connectivity between the investigated Islamic and G6 bond markets, corroborating Forbes and Rigobon's [71, 72] definition of contagion. We see rising volatilities (almost 90%) for all markets at high frequencies (in the near term), which decreases through spillover bands 2–4. According to Mensi et al. [24], this contagion may be attributed to China's economic downturn in 2017 and/or global investors' significant losses on June 24, 2016, after the vote that confirmed Britain's exit from the European Union [73]. Global stock markets lost nearly US$2 trillion as a result of the Brexit, making it the largest single-day loss in history. Additionally, across spillover bands 3, 4, and 5, Figure 2 shows evidence of delayed contagious effects from the EDC of 2011/12 and the COVID-19 pandemic.

We attribute the marginal increase of spillover connections in 2013 and 2019/2020, respectively, to the 2011/12 EDC and the COVID-19 pandemic's unstable market circumstances. The debt market was disrupted as a result of COVID-19, and bond purchasers suffered losses that would be difficult to recover, as Gupta et al. [5] advocated. Pursuant to the findings, we deduce the delayed contagion theory proposed in the works of Boako and Alagidede [74], Ijasan et al. [75], Owusu Junior [57], and Owusu Junior et al. [58] based on the dramatic increases in spillovers across the bands that occurred in 2017, succeeding the Brexit effect [64–66]. Figure 2 shows that there are signs of contagion in the distinct spillover plots for Islamic and G6 bonds. It is important to notice that USA, Canada, and UK are the origins of the inferred contagion across all time horizons, since they are the biggest contributors/transmitters of shocks across all markets examined.

Overall, our findings indicate that spillovers predominate in high frequency/spillover bands 1 and 2 (3.14 ~ 0.79 and 0.79 ~ 0.20, respectively), which reflect the short term. The entire spillovers across and within the Islamic and G6 bond markets, in other words, could be attributed to the short term. In comparison, whereas Islamic bonds are more likely to be immune to the shocks presented to global financial markets during the COVID-19 pandemic in the intermediate-to-long-term horizon, G6 bonds are more vulnerable to shocks due to the presence of sporadic volatility clusters revealed across all spillover bands in the studied period. The extant literature such as Akhtar et al. [52], Hkiri et al. [54], Naeem et al. [56], and Roukiane and Marzouki [51], supports our results. Hkiri et al. [54], for example, found that although the contagion hypothesis remains true for both Islamic and conventional indices, Islamic indices dissociate from their conventional counterparts during turbulent periods. Akhtar et al. [52] also showed that Islamic assets have high capabilities to reduce volatility correlations of assets in a portfolio during financial crises and this could be realised when at least one Islamic asset is contained in the portfolio.

5. Conclusions

The Baruník and Křehlík [49] (BK-18) spillover index was used in this research to look at the dynamic connectivity of spillovers between Islamic and conventional bond markets in order to illustrate the time- and frequency-domain dynamics of the two asset classes under various market circumstances. We use daily bond market indices for five major Islamic bond markets (India, Malaysia, Indonesia, Pakistan, and Qatar) and G6 economies (Canada, France, Italy, Japan, UK, and USA) from August 22, 2012, to September 17, 2021.

Through the BK-18 spillover index, we discovered that spillovers in the very short term (intraweek-to-fortnight) are relatively greater than those in the medium-to-long-term horizons, indicating that all bond markets examined react rapidly to shocks in the first few trading days. As a result, the Islamic and conventional bond markets examined are more sensitive to market shocks in the short term than in the long term, confirming Fama's [9, 10] EMH. We find that, in both Islamic and conventional (G6) bond markets, short-term spillovers are more important than intermediate-term spillovers. In the high-frequency band, USA, UK, and Canada (in order of spillover magnitude) are the most significant transmitters of shocks to the Islamic and G6 bond markets, particularly in the first spillover band (3.14 0.79, equivalent to 1 ~ 4 trading days). In the medium- and long-term timeframes, these nations are shown to be the biggest suppliers of shocks to the chosen Islamic and G6 stock markets, with the main distinction being that Canada's shock transmission surpasses that of UK. Among the markets examined, Pakistan is both the least contributor and least receiver of shocks. USA was discovered to be the biggest short-term receiver of spillovers, whereas UK absorbs the largest intermediate-to-long-term shocks.

Furthermore, volatility spillovers across Islamic bond markets are widespread (stable) only at high (low) frequencies throughout the COVID-19 timeframe. In G6 bond markets, on the other hand, spillovers are more visible and amplified throughout all spillover bands (short term, medium term, and long term). As a result, we find that, during market turbulences, conventional bond markets have more variable returns than Islamic bond markets across all time horizons. Based on our results, we propose that the nature of volatility spillovers between and within Islamic and/or G6 bond markets is time-varying and frequency-dependent, which is consistent with the HMH of Müller et al. [12], Lo's [11] AMH, and Owusu Junior et al.'s [14] CMH. The works of Akhtar et al. [52], Hkiri et al. [54], Naeem et al. [56], and Roukiane and Marzouki [51], among others, provide additional support for our findings. More importantly, in line with Forbes and Rigobon [71, 72], Ijasan et al. [75], Owusu Junior [57], Owusu Junior et al. [58], and Owusu Junior et al. [59], we infer contagion incidences (evidenced by substantial increases in spillovers), which are supplied by USA, Canada, and UK within the years 2013, 2016/17, and 2020/21. These are attributable to the EDC of 2011/12, the Brexit referendum [64–66], and the COVID-19 pandemic, respectively, and substantiate the delayed contagion hypotheses of Boako and Alagidede [74], Ijasan et al. [75], Owusu Junior [57], and Owusu Junior et al. [58].

Investors and governments will benefit greatly from our findings. Spillovers are time-varying and asymmetric, which should be noted by bond and equity investors. Specifically, amid financial and health crises, investors may utilise knowledge about market patterns and volatility to hedge their positions against lower asset returns, especially in the near term (up to about eight trading days), when spillover is more intense. According to the HMH and CMH, equity investors may change their investment strategy owing to heterogeneous occurrences and Islamic bonds may satisfy this objective. Notably, in the intermediate-to-long-term horizon, Islamic bonds provide diversification benefits relative to the G6 bonds. When forecasting bond yield volatility and constructing asset portfolios, portfolio managers should incorporate the information on policy amendments resulting from market shocks like the COVID-19 pandemic. During financial turmoil, policymakers should pay close attention to spillovers due to their capability of undermining cross-market connectedness. Portfolio and fund managers and policymakers could forecast the impact of their policies and reforms by using data on frequency dynamic spillover intensities and directions.

Data Availability

The bond yield indices for all the studied markets we extracted from EquityRT, which can be seen at https://equityrt.com/.

Conflicts of Interest

The author states that there are no competing interests of any kind.

References

[1] C. Giles, S. Fleming, and M. Arnold, "OECD warns coronavirus could halve global growth," Financial Times, 2020, https://www.ft.com/content/1356af8c-5c6c-11ea-8033-fa40a0d65a98.

[2] R. Baldwin and B. W. Di Mauro, "Economics in the time of COVID-19: a new eBook," 2020, https://fondazionecerm.it/wp-content/uploads/2020/03/CEPR-Economicsin-the-time-of-COVID-19_-A-new-eBook.pdf.

[3] C. T. Albulescu, "COVID-19 and the United States financial markets' volatility," *Finance Research Letters*, vol. 38, Article ID 101699, 2021.

[4] Y. Guo, P. Li, and A. Li, "Tail risk contagion between international financial markets during COVID-19 pandemic," *International Review of Financial Analysis*, vol. 73, Article ID 101649, 2021.

[5] R. Gupta, S. Subramaniam, E. Bouri, and Q. Ji, "Infectious disease-related uncertainty and the safe-haven characteristic of US treasury securities," *International Review of Economics & Finance*, vol. 71, pp. 289–298, 2021.

[6] L. Yarovaya, A. H. Elsayed, and S. Hammoudeh, "Determinants of spillovers between Islamic and conventional financial markets: exploring the safe haven assets during the COVID-

19 pandemic," *Finance Research Letters*, vol. 43, Article ID 101979, 2021.
[7] P. K. Ozili and T. Arun, "Spillover of COVID-19: impact on the global economy," *SSRN Electronic Journal*, 2020.
[8] I. E. Desai, "Sukuk and Covid 19 – how Islamic bonds can help?," 2020, https://www.linkedin.com/pulse/sukuk-covid-19-how-islamic-bonds-can-help-ebrahim-desai.
[9] E. F. Fama, "Efficient capital markets: a review of theory and empirical work," *The Journal of Finance*, vol. 25, no. 2, pp. 383–417, 1970.
[10] E. F. Fama, "Market efficiency, long-term returns and behavioural finance," *The Journal of Finance*, vol. 25, pp. 383–417, 1998.
[11] A. W. Lo, "The adaptive markets hypothesis," *Journal of Portfolio Management*, vol. 30, no. 1, pp. 15–29, 2004.
[12] U. A. Müller, M. M. Dacorogna, R. D. Davé, R. B. Olsen, O. V Pictet, and J. E. Von Weizsäcker, "Volatilities of different time resolutions—analyzing the dynamics of market components," *Journal of Empirical Finance*, vol. 4, no. 2–3, pp. 213–239, 1997, https://www.sciencedirect.com/science/article/pii/S0927539897000078.
[13] D. G. Baur and B. M. Lucey, "Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold," *Financial Review*, vol. 45, no. 2, pp. 217–229, 2010.
[14] P. Owusu Junior, S. Frimpong, A. M. Adam et al., "COVID-19 as information transmitter to global equity markets: evidence from CEEMDAN-based transfer entropy approach," *Mathematical Problems in Engineering*, vol. 2021, Article ID 8258778, 19 pages, 2021.
[15] G. E. D. Siahaan and R. Robiyanto, "Bond as a safe haven during market crash: examination of COVID-19 pandemic in ASEAN-5," *Jurnal Manajemen dan Kewirausahaan*, vol. 23, no. 1, pp. 1–9, 2021.
[16] I. Yousaf, E. Bouri, S. Ali, and N. Azoury, "Gold against Asian stock markets during the COVID-19 outbreak," *Journal of Risk and Financial Management*, vol. 14, no. 4, 2021.
[17] S. Bahloul and I. Khemakhem, "Dynamic return and volatility connectedness between commodities and Islamic stock market indices," *Resources Policy*, vol. 71, Article ID 101993, 2021.
[18] I. Musialkowska, A. Kliber, K. Świerczyńska, and P. Marszałek, "Looking for a safe-haven in a crisis-driven Venezuela," *Transforming Government: People, Process and Policy*, vol. 14, no. 3, pp. 475–494, 2020.
[19] R. Selmi, W. Mensi, S. Hammoudeh, and J. Bouoiyour, "Is Bitcoin a hedge, a safe haven or a diversifier for oil price movements? A comparison with gold," *Energy Economics*, vol. 74, pp. 787–801, 2018.
[20] S. J. Hussain Shahzad, E. Bouri, D. Roubaud, and L. Kristoufek, "Safe haven, hedge and diversification for G7 stock markets: gold versus bitcoin," *Economic Modelling*, vol. 87, pp. 212–224, 2020.
[21] G. Tweneboah, P. Owusu Junior, and S. P. Kumah, "Modelling the asymmetric linkages between spot gold prices and African stocks," *Research in International Business and Finance*, vol. 54, Article ID 101246, 2020.
[22] B. H. Chang, A. Sharif, A. Aman, N. M. Suki, A. Salman, and S. A. R. Khan, "The asymmetric effects of oil price on sectoral Islamic stocks: new evidence from quantile-on-quantile regression approach," *Resources Policy*, vol. 65, 2020.
[23] C. Liu, M. A. Naeem, M. U. Rehman, S. Farid, and S. J. H. Shahzad, "Oil as hedge, safe-haven, and diversifier for conventional currencies," *Energies*, vol. 13, no. 17, pp. 1–19, 2020.
[24] W. Mensi, K. H. Al-Yahyaee, X. V. Vo, and S. H. Kang, "Modeling the frequency dynamics of spillovers and connectedness between crude oil and MENA stock markets with portfolio implications," *Economic Analysis and Policy*, vol. 71, pp. 397–419, 2021.
[25] E. Bouri, P. Molnár, G. Azzi, D. Roubaud, and L. I. Hagfors, "On the hedge and safe haven properties of Bitcoin: is it really more than a diversifier?" *Finance Research Letters*, vol. 20, pp. 192–198, 2017.
[26] A. Urquhart and H. Zhang, "Is Bitcoin a hedge or safe haven for currencies? An intraday analysis," *International Review of Financial Analysis*, vol. 63, pp. 49–57, 2019.
[27] L. Baele, G. Bekaert, K. Inghelbrecht, and M. Wei, "Flights to safety," *Review of Financial Studies*, vol. 33, no. 2, pp. 689–746, 2020.
[28] D. G. Baur and B. M. Lucey, "Flights and contagion-An empirical analysis of stock-bond correlations," *Journal of Financial Stability*, vol. 5, no. 4, pp. 339–352, 2009.
[29] S. Bethke, M. Gehde-Trapp, and A. Kempf, "Investor sentiment, flight-to-quality, and corporate bond comovement," *Journal of Banking & Finance*, vol. 82, pp. 112–132, 2017.
[30] M. Bianconi, J. A. Yoshino, and M. O. Machado de Sousa, "BRIC and the U.S. financial crisis: an empirical investigation of stock and bond markets," *Emerging Markets Review*, vol. 14, no. 1, pp. 76–109, 2013.
[31] X. Chen, Z. Wang, X. Li, Z. Liu, and K. Li, "The impact of Covid-19 on the securities market: evidence from Chinese stock and bond markets," *Procedia Computer Science*, vol. 187, pp. 294–299, 2021.
[32] R. Connolly, C. Stivers, and L. Sun, "Stock market uncertainty and the stock-bond return relation," *Journal of Financial and Quantitative Analysis*, vol. 40, no. 1, pp. 161–194, 2005.
[33] S. Dajcman, "Comovement between stock and bond markets and the 'flight-to-quality' during financial market turmoil - a case of the Eurozone countries most affected by the sovereign debt crisis of 2010-2011," *Applied Economics Letters*, vol. 19, no. 17, pp. 1655–1662, 2012.
[34] F.-L. Lin, S.-Y. Yang, T. Marsh, and Y.-F. Chen, "Stock and bond return relations and stock market uncertainty: evidence from wavelet analysis," *International Review of Economics & Finance*, vol. 55, pp. 285–294, 2018.
[35] H. Ngo Thai, "Quantile dependence between green bonds, stocks, bitcoin, commodities and clean energy," *Economic Computation & Economic Cybernetics Studies & Research*, vol. 55, no. 3, pp. 71–86, 2021.
[36] H. Ohmi and T. Okimoto, "Trends in stock-bond correlations," *Applied Economics*, vol. 48, no. 6, pp. 536–552, 2016.
[37] S. Papadamou, A. P. Fassas, D. Kenourgios, and D. Dimitriou, "Flight-to-quality between global stock and bond markets in the COVID era," *Finance Research Letters*, vol. 38, Article ID 101852, 2021.
[38] V. D. Skintzi, "Determinants of stock-bond market comovement in the Eurozone under model uncertainty," *International Review of Financial Analysis*, vol. 61, pp. 20–28, 2019.
[39] M. Tachibana, "Flight-to-quality in the stock–bond return relation: a regime-switching copula approach," in *Financial Markets and Portfolio Management*vol. 34, Berlin, Germany, Springer, 2020.
[40] J. Yang, Y. Zhou, and W. K. Leung, "Asymmetric correlation and volatility dynamics among stock, bond, and securitized real estate markets," *The Journal of Real Estate Finance and Economics*, vol. 45, no. 2, pp. 491–521, 2012.

[41] R. A. Bhuiyan, M. Puspa, B. Saiti, and G. M. Ghani, "Comparative analysis between global sukuk and bond indices: value-at-risk approach," *Journal of Islamic Accounting and Business Research*, vol. 11, no. 6, pp. 1245–1256, 2020.
[42] M. K. Hassan, A. Paltrinieri, A. Dreassi, S. Miani, and A. Sclip, "The determinants of co-movement dynamics between sukuk and conventional bonds," *The Quarterly Review of Economics and Finance*, vol. 68, pp. 73–84, 2018.
[43] N. N. S. Mustafa, S. Samsudin, F. Shahadan, and A. K. J. Yi, "Flight-to-quality between stock and bond markets: pre and post global financial crisis," *Procedia Economics and Finance*, vol. 31, no. 15, pp. 846–855, 2015.
[44] J. C. Reboredo and N. Naifar, "Do Islamic bond (sukuk) prices reflect financial and policy uncertainty? A quantile regression approach," *Emerging Markets Finance and Trade*, vol. 53, no. 7, pp. 1535–1546, 2017.
[45] F. Balli, A. de Bruin, and M. I. H. Chowdhury, "Spillovers and the determinants in Islamic equity markets," *The North American Journal of Economics and Finance*, vol. 50, Article ID 101040, 2019.
[46] A. Bossman, "Information flow from COVID-19 pandemic to Islamic and conventional equities: an ICEEMDAN-induced transfer entropy analysis," *Complexity*, vol. 2021, Article ID 4917051, 20 pages, 2021.
[47] A. Bossman, S. K. Agyei, P. Owusu Junior et al., "Flights-to-and-from-quality with Islamic and conventional bonds in the COVID-19 pandemic era: ICEEMDAN-based transfer entropy," *Complexity*, vol. 2022, Article ID 1027495, 25 pages, 2022.
[48] M. K. Hassan, H. G. Djajadikerta, T. Choudhury, and M. Kamran, "Safe havens in Islamic financial markets: COVID-19 versus GFC," *Global Finance Journal*, Article ID 100643, 2021.
[49] J. Baruník and T. Křehlík, "Measuring the frequency dynamics of financial connectedness and systemic risk," *Journal of Financial Econometrics*, vol. 16, no. 2, pp. 271–296, 2018.
[50] F. X. Diebold and K. Yilmaz, "Better to give than to receive: predictive directional measurement of volatility spillovers," *International Journal of Forecasting*, vol. 28, no. 1, pp. 57–66, 2012.
[51] B. Roukiane and A. E. Marzouki, "Maturities and dynamic volatility of Sukuk comparative study between a Sukuk and a conventional bond index," *Asian Development Policy Review*, vol. 6, no. 4, pp. 226–242, 2018.
[52] S. M. Akhtar, M. Jahromi, and K. John, "Intensity of volatility linkages in Islamic and conventional markets," in *SSRN Electronic Journal*, 2017.
[53] M. Ghaemi Asl and M. M. Rashidi, "Dynamic diversification benefits of Sukuk and conventional bonds for the financial performance of MENA region companies: empirical evidence from COVID-19 pandemic period," *Journal of Islamic Accounting and Business Research*, vol. 12, no. 7, pp. 979–999, 2021.
[54] B. Hkiri, S. Hammoudeh, C. Aloui, and L. Yarovaya, "Are Islamic indexes a safe haven for investors? An analysis of total, directional and net volatility spillovers between conventional and Islamic indexes and importance of crisis periods," *Pacific-Basin Finance Journal*, vol. 43, pp. 124–150, 2017.
[55] M. Yousfi, A. Dhaoui, and H. Bouzgarrou, "Risk spillover during the COVID-19 global pandemic and portfolio management," *Journal OfRisk and Financial Management*, vol. 14, no. 222, pp. 2–29, 2021.
[56] M. A. Naeem, M. Billah, M. Marei, and F. Balli, "Quantile connectedness between Sukuk bonds and the impact of COVID-19," *Applied Economics Letters*, pp. 1–10, 2021.
[57] P. Owusu Junior, *Emerging Financial Markets: Spatial Risks, Elicitability of Risk Models, and Shape Shift Contagion*, University of the Witwatersrand, South Africa, 2020.
[58] P. Owusu Junior, I. Alagidede, and G. Tweneboah, "Shape-shift contagion in emerging markets equities: evidence from frequency- and time-domain analysis," *Economics and Business Letters*, vol. 9, no. 3, pp. 146–156, 2020.
[59] P. O. Junior, G. Tweneboah, and A. M. Adam, "Interdependence of major exchange rates in Ghana: a wavelet coherence analysis," *Journal of African Business*, vol. 20, no. 3, pp. 407–430, 2019.
[60] A. M. Adam, "Susceptibility of stock market returns to international economic policy: evidence from effective transfer entropy of Africa with the implication for open innovation," *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 6, no. 3, 2020.
[61] S. K. Agyei, Z. Isshaq, S. Frimpong, A. M. Adam, A. Bossman, and O. Asiamah, "COVID-19 and food prices in sub-Saharan Africa," *African Development Review*, vol. 33, pp. 1–12, 2021.
[62] A. K. Tiwari, E. J. Aikins Abakah, D. Gabauer, and R. A. Dwumfour, "Dynamic spillover effects among green bond, renewable energy stocks and carbon markets during COVID-19 pandemic: implications for hedging and investments strategies," *Global Finance Journal*, vol. 51, Article ID 100692, 2022.
[63] F. Aslam, P. Ferreira, and K. S. Mughal, "Intraday volatility spillovers among European financial markets during COVID-19," *International Journal OfFinancial Studies*, vol. 9, 2021.
[64] X. Chen, Y. Tian, and R. Zhao, "Study of the cross-market effects of Brexit based on the improved symbolic transfer entropy GARCH model — an empirical analysis of stock – bond correlations," *PLoS ONE*, vol. 12, no. 8, pp. 1–14, 2017.
[65] E. F. Guedes, P. Ferreira, A. Dionísio, and G. F. Zebende, "An econophysics approach to study the effect of BREXIT referendum on European Union stock markets," *Physica A: Statistical Mechanics and Its Applications*, vol. 523, pp. 1175–1182, 2019.
[66] S. Kadiric and A. Korus, "The effects of Brexit on credit spreads: evidence from UK and Eurozone corporate bond markets," *International Economics and Economic Policy*, vol. 16, no. 1, pp. 65–102, 2019.
[67] A. K. Tiwari, J. Cunado, R. Gupta, and M. E. Wohar, "Volatility spillovers across global asset classes: evidence from time and frequency domains," *The Quarterly Review of Economics and Finance*, vol. 70, pp. 194–202, 2018.
[68] A. K. Tiwari, M. Shahbaz, H. M. Hasim, and M. M. Elheddad, "Analysing the spillover of inflation in selected Euro-area countries," *Journal of Quantitative Economics*, vol. 17, no. 3, pp. 551–577, 2019.
[69] K. Yilmaz, "Return and volatility spillovers among the East Asian equity markets," *Journal of Asian Economics*, vol. 21, no. 3, pp. 304–313, 2010.
[70] K. Hassan, A. Hoque, M. Wali, and D. Gasbarro, "Islamic stocks, conventional stocks, and crude oil: directional volatility spillover analysis in BRICS," *Energy Economics*, vol. 92, Article ID 104985, 2020.
[71] K. Forbes and R. Rigobon, "Measuring contagion: conceptual and empirical issues," *International Financial Contagion*, Springer, Berlin, Germany, pp. 43–66, 2001.

[72] K. J. Forbes and R. Rigobon, "No contagion, only interdependence: measuring stock market comovements," *The Journal of Finance*, vol. 57, no. 5, pp. 2223–2261, 2002.
[73] J. E. David, "Brexit costs investors $2 trillion, the worst one-day drop ever – British pound sterling falls below Friday's 31-year low amid uncertainty," 2016, https://desdemonadespair.net/2016/06/brexit-costs-investors-2-trillion-wors.html.
[74] G. Boako and P. Alagidede, "Co-movement of Africa's equity markets: regional and global analysis in the frequency-time domains," *Physica A: Statistical Mechanics and its Applications*, vol. 468, pp. 359–380, 2017.
[75] K. Ijasan, P. Owusu Junior, G. Tweneboah, and A. M. Adam, "How does South Africa's real estate investment trusts integrate with major global REITs markets? A time-frequency approach," *Scientific African*, vol. 14, Article ID e00993, 2021.
[76] D. G. Baur and T. K. McDermott, "Is gold a safe haven? International evidence," *Journal of Banking & Finance*, vol. 34, no. 8, pp. 1886–1898, 2010.
[77] N. N. Taleb, *The Black Swan: The Impact of the Highly Improbable*, vol. 2, Random House, New York, NY, USA, 2007https://scholar.google.com/scholar_lookup?title=The Black Swan%3A The Impact of the Highly Improbable&author=N Taleb&publication_year=2009.