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Borsa İstanbul Review

Borsa İstanbul Review 23-1 (2023) 1–21

http://www.elsevier.com/journals/borsa-istanbul-review/2214-8450

Full Length Article

COVID-19 and connectedness between Sustainable and Islamic equity markets

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Received 12 November 2021; revised 29 May 2022; accepted 6 June 2022
Available online 21 June 2022

Abstract

Because of the increasing importance of and demand for ethical investment, this paper investigates the dynamics of connectedness between sustainable and Islamic investment in nineteen countries that represent developed and emerging financial markets worldwide. To this end, we apply models proposed by Diebold and Yilmaz and Barunik and Krehlik to explore the overall and frequency-based connectedness between selected ethical investments. Our results reveal evidence of a moderate to strong intra country-level connectedness between sustainable and Islamic investment and limited cross-country connectedness between ethical investments. The time-varying connectedness analysis suggests enhanced connectedness during periods of market-wide turmoil, such as the European debt crisis, the Chinese financial crisis, and the COVID-19 pandemic. Moreover, the COVID-19 subsample analysis shows an enhanced and idiosyncratic country-level and cross-country connectedness structure between ethical investments, indicating the evolving nature of the relationship between sustainable and Islamic investment.

Keywords: COVID-19; Islamic equity; Sustainable investment; Time-frequency connectedness

1. Introduction

Since the World Health Organization (WHO) declared the COVID-19 outbreak a global pandemic on March 11, 2020, the global economic and financial system has been shaken. These verities of the outbreak have had dramatic impacts on financial markets around the world. The outbreak led to panic trading and, thereafter, catastrophic declines in various global stock markets. For instance, in March 2020, the US stock market hit the market-wide circuit breaker four times, whereas, prior to 2020, since its inception in 1988, this mechanism had been implemented only once, in 1997. In the same way, the FTSE in the UK dropped 24.8 percent, the worst quarter reported since 1987, and Japan's main index, the Nikkei, fell more than 20 percent from its high in December 2019. Nevertheless, during the period since the outbreak, ethical investment in equity markets has showed some resilience. According to Bloomberg, in the early stages of the pandemic, the average ESG (environmental, social, and governance) portfolio fell 12 percent, almost half the decrease of its conventional counterparts. In the later stages, even some segments of sustainable and responsible investment (SRI) reported a steady trend of increasing prices. Similarly, among Islamic investments, another type of ethical

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Peer review under responsibility of Borsa İstanbul Anonim Şirketi.

https://doi.org/10.1016/j.bir.2022.06.001

investment had better performance than its conventional counterparts during the first quarter of the pandemic (Haroon et al., 2021). In fact, Salisu and Shaik (2022) show that Islamic equities were effective for hedging pandemic risk. With this backdrop, although the pandemic caused extreme movements and drives interconnections between financial markets, many questions related to portfolio diversification and asset allocation remain unanswered.

In general, during periods of economic turbulence and higher uncertainty, such as the COVID-19 pandemic, market participants and policymakers both take a keen interest in understanding the risk-return spillovers between financial markets to safeguard investments and restore financial stability (Bouri et al., 2021). For example, the evidence shows that, during periods of economic slowdown, investors often rebalance their portfolios by switching from risky assets to safe-haven assets, which is called a "flight to safety" or "flight to quality" (Choudhry et al., 2015; Troster et al., 2019). This is particularly relevant to the COVID-19 pandemic, as the outbreak caused international chaos, in which economic activities were halted because of quarantine measures, policy uncertainty spiked, unemployment rose, and financial markets tumbled. These catastrophic events significantly upset asset allocation and portfolio diversification decisions. Hence, great interest has been expressed in understanding how the outbreak shaped the transmission of risk and the structural dynamics of returns networks for various assets. Many studies are attempting to capture the impacts of the unprecedented shocks caused by the COVID-19 outbreak on patterns in return connectedness across various assets (see, e.g., Adekoya & Oliyide, 2020; Bissoondoyal-Bheenick et al., 2020; Lin & Su, 2020; Sharif et al., 2020; So et al., 2021). Explorations of these issues have important implications related to risk management, asset allocation, and portfolio diversification.

Over the past two decades, ethical investment has attracted considerable attention from investors, policymakers, and academic researchers. Unlike conventional investment, ethical investment uses a set of screening methods, which include stocks based on integrity, trust, and societal and social value (Jawadi et al., 2018). In this regard, SRI and Islamic finance (IF) have emerged as the two major categories of ethical investment. First, according to the World Economic Forum Report (2011), SRI aims to generate superior financial returns by integrating long-term ESG benchmarks into investment. As a result, SRI has experienced remarkable growth worldwide: over the period 2012–2018, SRI assets in five major markets grew from $13.3 billion to $30.7 trillion (GSIA, 2018). The United Nations' initiative on responsible investing supports SRI and offers guidance for investors. Second, Islamic investment complies with the sharia principles and guidelines that regulate all aspects of human activity, including portfolio choices, dividends, and trading activity (Girard & Hassan, 2008).[1] Like the market for SRI, the sharia-compliant investment market has grown exponentially: the global value of Islamic funds reached $110 billion at the end of 2018 (IFDR, 2018).

The objectives and claims of SRI and Islamic investment have great similarities, as both modes of investment stress the promotion of social welfare through ethics (Erragraguy and Revelli, 2015). Williams and Zinkin (2010) argue that compatibility between Islamic ethics and general business ethics serves as the primary source of SRI. At the same time, they also claim that merely excluding sinful activities does not ensure compliance with Islamic social and ethical guidelines, and integration of ESG indicators into the investment process is necessary. Sairally (2007) surveys practitioners of Islamic finance and shows that promoting social responsibility at Islamic financial institutions reconciles Islamic financial institutions with the ethical origins of Islamic law. Forte and Miglietta (2007) assert that including ESG benchmarks in Islamic investment will mitigate environmental and ecological risks in Islamic investment, because they traditionally suffer because of their orientation toward industry and fossil fuels. However, the study points out the differences between Islamic investment and SRI in terms of econometric properties, asset allocation, and risk exposure. Erragragui & Revelli (2016) also argue that integrating SRI into sharia-compliant investment provides diversification benefits for investors because it decreases non-systemic risks due to differences between SRI and Islamic portfolio profiles. However, despite the great similarities, few studies examine the risk-return transmission between SRI and Islamic investment. Prior literature focuses on evaluating both categories of ethical investment (e.g., Abdelsalam et al., 2014; Qoyum et al., 2021; Reddy et al., 2017). Nevertheless, understanding the structural dynamics of the returns network of SRI and Islamic investment is crucial for determining their contribution to sustainable development and evaluating the efficiency of the underlying investment strategies for managing and hedging portfolio risks, ultimately determining investors' incentives in mobilizing resources for ethical investment.

Motivated by the lack of research on return connectedness between SRI and Islamic investment, this paper addresses the return transmission across the two asset categories. Moreover, we provide a global perspective on the return linkages between SRI and faith-based investment by using country sustainability and sharia-compliant stock indexes. Theoretically, it is assumed that, as ethical investment, SRI and Islamic investment contribute more to sustainable development than conventional investment. Azmi et al. (2019) show that combining SRI and Islamic investment offers investors more rewards, particularly during extreme market movement, such as periods of economic downturn and bullish markets. But others suggest that actual results diverge from the theory. Combining SRI and Islamic investment produces more portfolio constraints, costs, and fewer diversification opportunities, leading to additional risks and consequent uncertainty (Jawadi et al., 2019). In this regard, following the huge impact of the COVID-19 outbreak on financial markets, little research focuses on the impact of the outbreak on patterns of return connectedness across the two

[1] "The Islamic Shariah compliant investments are based on Islamic Shariah law and ethics which prohibit interest (Riba), excessive ambiguity and uncertainty (Gharar), speculation (Maysir) and prevention of participating in unethical industries" (Farid et al., 2021).

Table 1
Descriptive statistics for global sustainability equity indices.

		Mean (%)	Median	Max	Min	SD	ADF
Australia	AUS	0.014	0.032	81.221	−81.312	2.953	−40.562***
Belgium	BEL	0.130	0.000	357.056	−23.597	6.390	−59.150***
Brazil	BRA	0.016	0.000	16.794	−13.865	1.962	−23.235***
Canada	CAN	0.017	0.023	11.328	−10.712	1.099	−19.196***
Finland	FIN	0.008	0.000	13.921	−25.974	1.797	−57.566***
France	FRA	0.013	0.021	9.632	−13.470	1.405	−58.350***
Germany	GER	0.019	0.040	10.447	−13.471	1.401	−39.567***
India	IND	0.073	0.012	12.820	−31.688	1.833	−61.424***
Italy	ITA	0.012	0.020	10.373	−19.173	1.688	−40.676***
Japan	JPN	0.021	0.000	8.931	−13.455	1.383	−58.063***
Korea	KOR	0.020	0.000	8.820	−10.501	1.334	−39.947***
Netherland	NET	0.035	0.044	8.757	−22.397	1.326	−58.964***
Spain	SPN	−0.002	0.026	14.763	−15.846	1.603	−58.079***
Sweden	SWE	0.027	0.000	10.280	−11.987	1.681	−58.203***
Switzerland	SWI	0.017	0.016	5.458	−9.195	1.017	−57.616***
Taiwan	TAI	0.053	0.000	7.354	−46.720	1.524	−60.142***
Thailand	THL	0.031	0.000	24.278	−12.571	1.593	−59.099***
United Kingdom	UK	0.013	0.009	6.666	−9.149	1.089	−60.246***
United States	US	0.044	0.058	10.004	−27.193	1.356	−19.044***

Note: *** significant at 1%.

Table 2
Descriptive statistics for global Islamic equity indices.

		Mean (%)	Median	Max	Min	SD	ADF
Australia	AUS	0.012	0.052	5.976	−9.840	1.240	−64.979***
Belgium	BEL	0.018	0.035	6.813	−13.669	1.273	−56.589***
Brazil	BRA	0.015	0.000	14.397	−39.024	1.941	−64.617***
Canada	CAN	0.006	0.027	10.854	−12.292	1.268	−21.011***
Finland	FIN	0.005	0.003	9.836	−12.066	1.629	−57.312***
France	FRA	0.016	0.035	9.052	−12.440	1.318	−59.423***
Germany	GER	0.018	0.057	8.673	−12.353	1.350	−39.760***
India	IND	0.042	0.007	16.667	−17.557	1.321	−21.647***
Italy	ITA	−0.006	0.000	35.549	−18.564	1.850	−40.029***
Japan	JPN	0.026	0.000	7.735	−14.656	1.281	−59.523***
Korea	KOR	0.025	0.010	9.366	−30.456	1.377	−59.843***
Netherland	NET	0.046	0.058	9.636	−43.101	1.491	−59.349***
Spain	SPN	0.024	0.033	10.900	−13.596	1.485	−39.488***
Sweden	SWE	0.034	0.017	8.757	−11.502	1.408	−61.189***
Switzerland	SWI	0.022	0.007	5.207	−8.556	0.972	−57.441***
Taiwan	TAI	0.033	0.000	7.886	−26.358	1.232	−59.221***
Thailand	THL	0.019	0.000	20.692	−16.514	1.616	−24.830***
United Kingdom	UK	0.006	0.011	33.384	−14.899	1.512	−57.598***
United States	US	0.029	0.038	8.734	−11.827	1.209	−18.676***

Note: *** significant at 1%.

types of investment. Thus our study sheds light on the connectedness network before and during the COVID-19 outbreak by considering two types of ethical investment, namely sharia-compliant and SRI stocks due to their similar risk-return characteristics. In this spirit, the study performs a subsample analysis of the COVID-19 outbreak period to unveil the influence of pandemic on the returns and connectedness of ethical investment. For this purpose, the study examines time-frequency domain-based connectedness between SRI and sharia-compliant investment using the time-domain approach by Diebold and Yilmaz (DY; 2012, referred to below as DY12) and the frequency-domain approach by Barunik and Krehlik (BK; 2018; referred to below as BK18). Countless studies widely employ the approaches to document the risk-return spillovers between different financial markets and asset classes (see, e.g., Le et al., 2020; Naeem et al., 2020; Tiwari et al., 2018). In the analysis, we use daily returns on country sustainability and sharia-compliant indexes for nineteen countries, including developed and emerging markets.[2]

Our findings reveal strong linkages between sustainable and Islamic investment at the country level, indicating that these investments could serve as complementary assets in investment

[2] The countries are Australia, Belgium, Brazil, Canada, Finland, France, Germany, India, Italy, Japan, Korea, Netherland, Spain, Sweden, Switzerland, Taiwan, Thailand, the United Kingdom, and the United States.

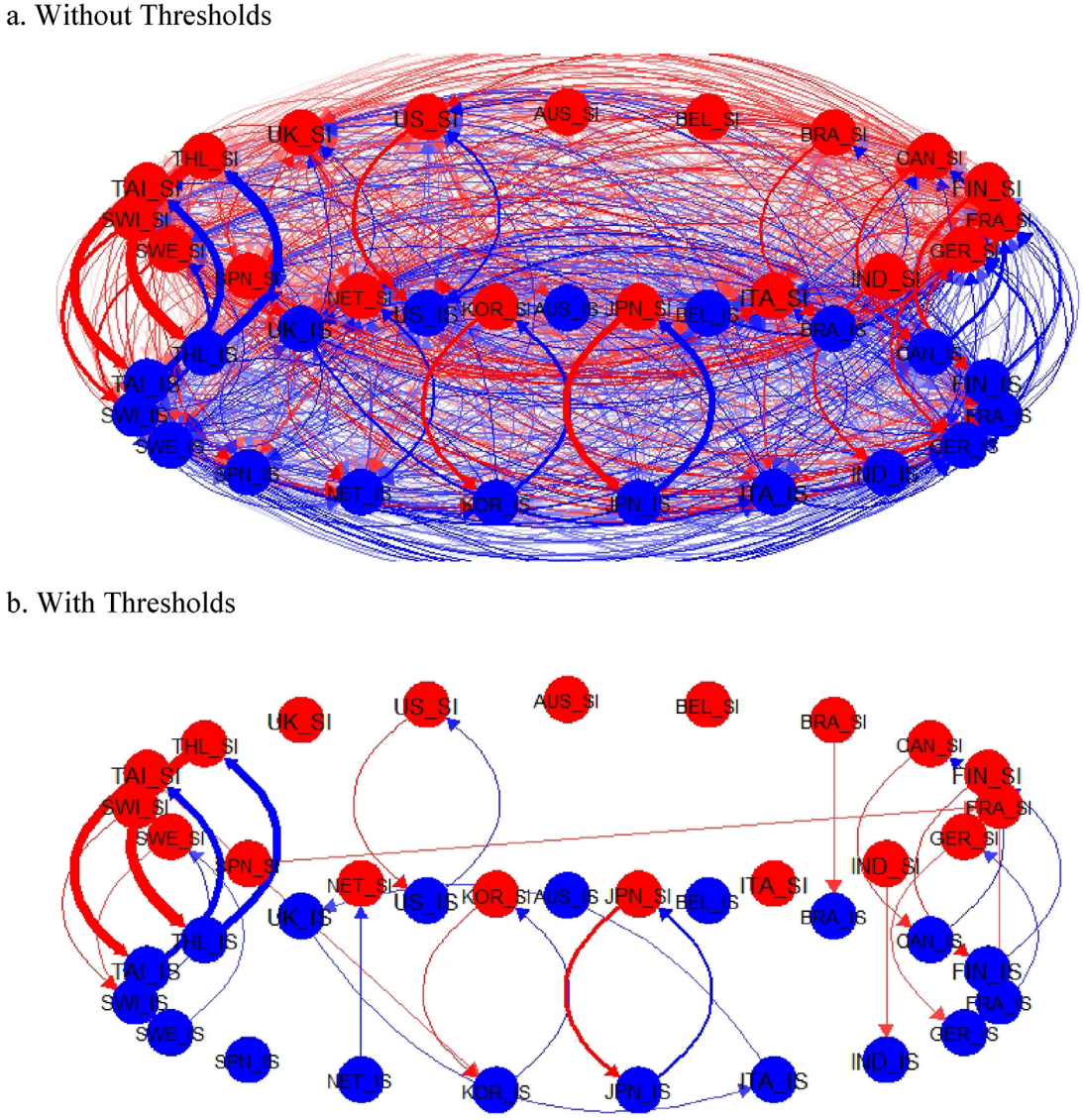


Fig. 1. The network of return connectedness using Diebold and Yilmaz (2012). *Note*: This figure shows the connectedness among 38 sampled equity markets, classified as either sustainable or Islamic. Red represents sustainable equities, and blue represents Islamic equities. In panel b, we only keep connectedness values larger than the average of the 100individual pairs with the largest connectedness.

portfolios. We see limited evidence of cross-country and cross-investment connectedness that indicate potential diversification opportunities for ethical equity investors across developed and developing markets. Moreover, our frequency-based connectedness analysis reveals that short-term spillovers drive the magnitude of country-level connectedness between sustainable and Islamic investment, whereas the cross-country connectedness is more pronounced at medium- and long-term frequencies. These findings offer useful insights for ethical investors operating in different investment horizons. Further, our subsample analysis of the COVID-19 pandemic period shows overall increased connectedness between sustainable and Islamic investment. However, some emerging markets, such as Thailand, India, and Brazil, show less connectedness, and developed countries, such as Australia and the Netherlands, experience an increase in connectedness. These observations suggest a more detailed analysis of connectedness behavior indifferent types of markets, that is, developed and emerging.

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 explains the data and methodology employed. Section 4 presents the results and findings of the study. Section 5 concludes the study.

2. Literature review

The early research on ethical investment excluded Islamic investment because the sharia-compliant funds entered the market long after SRI (Hayat &Kraeussl, 2011). Moreover, initial research on the performance evaluation of sharia-compliant funds treated these investments as a subset of SRI because of their similar characteristics. However, after the

Fig. 2. Summary measures of connectedness network. *Note*: This plot shows the three summary measures of the connectedness network: To, From, and Net. Net position is shown with a green dot with the line. ABB_SI means sustainable equity markets, and ABB_IS means Islamic equity markets.

tremendous expansion of the Islamic finance industry worldwide, SRI and sharia-compliant investment were explicitly recognized as distinct types of ethical investment. SRI connects financial goals with ESG benchmarks, and Islamic investment conforms to the following five principles: a prohibition of usury (*riba*), excessive uncertainty (*gharar*), speculation (*maysir*), sharing of risks and returns, and investing in impermissible activities. Theoretically, because SRI and sharia-compliant investment reduces portfolio choices related to diversification based on their ethical screening criteria, a large thread in the literature investigates the impact of ethical screening criteria on financial returns. In this regard, a sizable thread compares the performance of SRI with conventional funds (e.g., Alda, 2020; Benson & Humphrey, 2008; Climent & Soriano, 2011; Nakai et al., 2016; Schröder, 2007; Sjöström, 2011). However, no consensus has been reached about the comparative performance of SRI and conventional investment. Similarly, the performance of Islamic funds against conventional funds has been examined by many authors, with divergent findings (e.g., Abderrezak, 2008; Abdullah et al., 2007; Hoepner et al., 2011; Hussein, 2007; Mansor & Bhatti, 2011). Reddy et al. (2017) document the superior performance of SRI and Islamic funds against their conventional counterparts and also suggest that both funds performed better than conventional funds in the UK during the global financial crisis in 2007–2008.

Another stream of literature documents the financial performance of SRI and sharia-compliant investment. For instance, Abdelsalam et al. (2014) compare the financial performance of SRI and Islamic funds. Their findings suggest that SRI funds outperform Islamic funds for a set of inefficient funds, whereas sharia-compliant funds achieve better performance than the best mutual funds. By contrast, BinMahfouz and KabirHassan (2013) find no difference between the two types of ethical funds. Additionally, Erragragui et al. (2018) and Castro et al. (2020) argue that the performance of SRI and Islamic funds varies across bear and bull markets. Other studies examine the risk profile of SRI and Islamic investment. Among them, Al-Awadhi and Dempsey (2017) show that Islamic funds have lower risk than ESG funds, and Ashraf and Khawaja (2016), Erragragui et al. (2018), and Mansor et al. (2019) argue that Islamic funds are more stable and less risky than ESG funds.

A growing body of research also advocates integrating SRI criteria into Islamic finance because of their similar characteristics. Masih et al. (2018) argue that integrating ESG criteria into the Islamic screening process is crucial for the development of Islamic capital markets. This notion is supported by Bennett and Iqbal (2013), Moghul and Safar-Aly (2014), and Paltrinieri et al. (2020), who stress the importance of adding ESG benchmarks into the Islamic screening process. Azmi et al. (2019) find that integrating Islamic and SRI portfolios offer investors more rewards under different market states. Moreover, Qoyum et al. (2021) show that integrating Islamic and SRI screening approaches produces better portfolio performance in the Indonesian market and argues that combining ethical screening methods provides a reasonable implementation of Islamic principles in the modern investment paradigm. However, Erragragui & Revelli (2016), Elias (2017), and Erragragui et al. (2018) contend that integration of SRI and Islamic screening approaches has no impact on portfolio returns and costs for investors.

Our review indicates that the literature is largely silent on the information transmission between SRI and Islamic investment. Therefore, we contribute to the literature by revealing the structural dynamics of the returns network of SRI and Islamic investment before and during the COVID-19 pandemic.

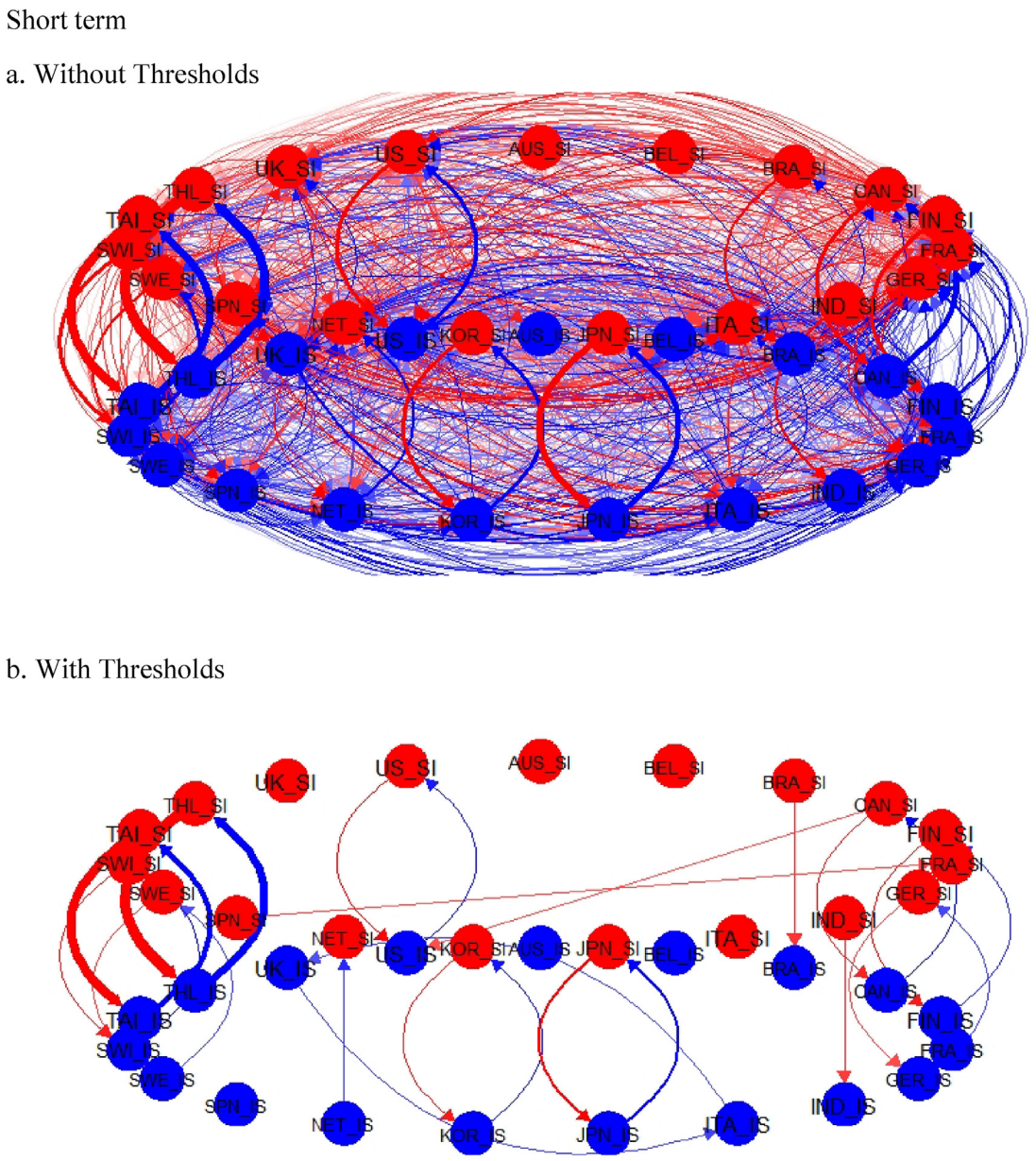


Fig. 3. The network of return connectedness using Barunik and Krehlik (2018). Short term. *Note*: See notes to Fig. 1.

3. Methodology

The data in this study are analyzed in two main sections. In the first section, the connectedness between sustainable and Islamic equity markets is tested following the approach by Diebold and Yilmaz (2012) and Baruník and Křehlík (2018). In the second section, we examine the effects of the factors of sustainability on Islamic equity markets with a nonlinear causality test.

3.1. Diebold and Yilmaz (2012)

In this study, we use the total transmission approach by Diebold and Yilmaz (2012) to test the various indicators retrieved from the forecast-error variance decomposition (FEVD) matrix that is centralized by the generalized vector autoregressive (VAR) model, taking into consideration the n-variate covariance stationary VAR (p) model as follows:

$$x_t = \sum_{i=1}^{p} \gamma_i x_{t-i} + \varepsilon_t \tag{1}$$

where $\varepsilon_t \sim N(0,\ \Sigma)$. The moving average component of the VAR process is represented by the following MA (∞) process:

$$x_t = \sum_{i=0}^{\infty} \omega_i \varepsilon_{t-i}$$

where ω_i is an $n \times n$ coefficient matrix calculated recursively using $\omega_i = \gamma_1 \omega_{i-1} + \gamma_2 \omega_{i-2} + \ldots + \gamma_p \omega_{i-p}$, and ω_0 represents

Fig. 4. Summary measures of connectedness network. Short term. *Note*: See notes to Fig. 2.

the identity matrix. With the assistance of the MA coefficient, we use the generalized FEVD, which permits splitting the H-step-ahead prediction error of each factor and is attuned to the shocks in different systems.

We prefer the method by Koop et al. (1996) and Pesaran and Shin (1998) to obtain orthogonality because the Cholesky factor depends on the order of the variables. The factor j contributes to the H-step-ahead generalized variance of the predicted error of each factor i and is denoted as $\tau_{ij}(H)$ and calculated as follows:

$$\tau_{ij}(H)=\frac{\sigma_{jj}^{-1}\sum_{h=0}^{H-1}\left(e_i^{'}\omega_h\sum e_j\right)^2}{\sum_{h=0}^{H-1}\left(e_i^{'}\omega_h\sum\omega_h^{'}e_i\right)^2} \tag{2}$$

where the jth diametrical component of the standard deviation is represented by σ_{jj}. $\sum$ represents the covariance matrix of errors. e_i takes a value of 1 for the ith component and a value of 0, otherwise. Moreover, the matrix of the coefficient multiplies the error of h-lagged in the infinite moving average, which is represented as non-orthogonalized (VAR) ω_h.

We measure the pairwise directional transmission, $\tau_{ij}(H)$, as follows:

$$\mathrm{T}_{i\leftarrow j}^{H}=\tau_{ij}(H) \tag{3}$$

The ratio of the off-diagonal sum of rows to the sum of all the elements indicates the total directional transmission as follows:

$$\mathrm{T}_{i\leftarrow\bullet}^{H}=\frac{1}{N}\sum_{\substack{j=1\\ j\neq i}}^{N}\tau_{ij}(H) \tag{4}$$

Furthermore, the ratio of the sum of the off-diagonal column to the sum of all the elements represents the total directional transmission to others from j as follows:

$$\mathrm{T}_{\bullet\leftarrow j}^{H}=\frac{1}{N}\sum_{\substack{i=1\\ i\neq j}}^{N}\tau_{ij}(H) \tag{5}$$

In addition, the transmission of the system-wide total can be represented as a proxy for the sum of the from-others (to-others) components of the variance decomposition matrix to the sum of all its components:

$$\mathrm{T}^{H}=\frac{1}{N}\sum_{\substack{i,j=1\\ i\neq j}}^{N}\tau_{ij}(H) \tag{6}$$

3.2. Baruník and Křehlík (2018)

Using the spectral representation of variance decomposition, the connectedness's frequency dynamics are described as frequencies in the short, medium, and long term. These variances are built on the frequency of responses to shocks. Hence, the theory indicates the frequency response function, $\eta(e^{-ifg}) = \sum_g e^{-iwg}\eta_g$, which can be retrieved as the Fourier transform of the coefficients η_g, with $i = \sqrt{-1}$. The spectral density of AB at frequency f hence can be represented as the Fourier transform for MA(∞) filtered series as follows:

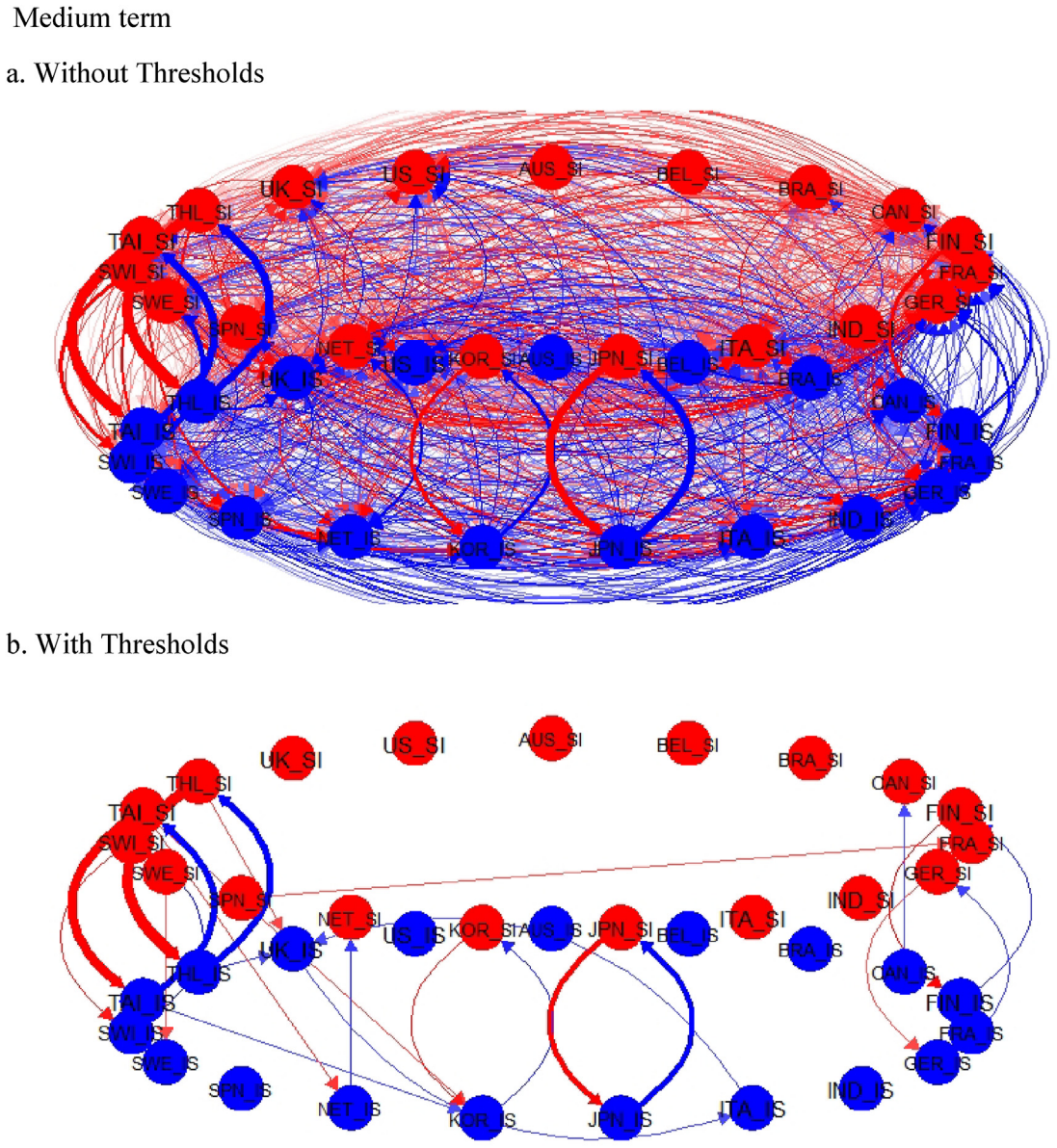


Fig. 5. The network of return connectedness using Barunik and Krehlik (2018). Medium term. *Note*: See notes to Fig. 1.

$$S_{AB}(f) = \sum_{g=-\infty}^{\infty} E\left(AB_t AB'_{t-g}\right)e^{-ifg} = \aleph\left(e^{-if}\right)\sum \aleph'\left(e^{+if}\right) \tag{7}$$

The dynamics of frequency is based on the quantity power spectrum's key as $S_{AB}(f)$ as it shows how variance in AB_t is distributed across the frequency components ω. Moreover, frequency is explained as by decomposition that can be described through a spectral decomposition of covariance, for example, $E(AB_t, AB'_{t-g}) = \int_{-\varphi}^{\varphi} S_\gamma(f)e^{ifg}df$.

Baruník and Křehlík (2018) explain the derivation of the quantities comprehensively, whereas this study explains the estimation indicators of connectedness at different frequencies. Therefore, the standard Fourier transform tests the spectral quantities. The interval's cross-spectral density $d = (a, b) : a, b \in (-\varphi, \varphi), a < b$ is estimated as:

$$\sum_f \hat{\eta}(f)\widehat{\sum}\hat{\eta}'(f) \tag{8}$$

for $f \in \{\lfloor aG/2\pi \rfloor, \ldots, \lfloor bG/2\pi \rfloor\}$ where

$$\hat{\eta}(f) = \sum_{g=0}^{G-1} \hat{\eta}_g e^{-2i\varphi f/G} \tag{9}$$

and $\widehat{\sum} = \hat{\varepsilon}'\hat{\varepsilon}/(T-x)$, where x illustrates the degrees of freedom for the correction, depending on the VAR specification.

The decomposition of the impulse response function (IRF) is estimated at a given frequency band as $\hat{\eta}(d) = \sum\hat{\eta}(f)$. Therefore, the variance in the generalized decompositions can be examined for a desired frequency group as:

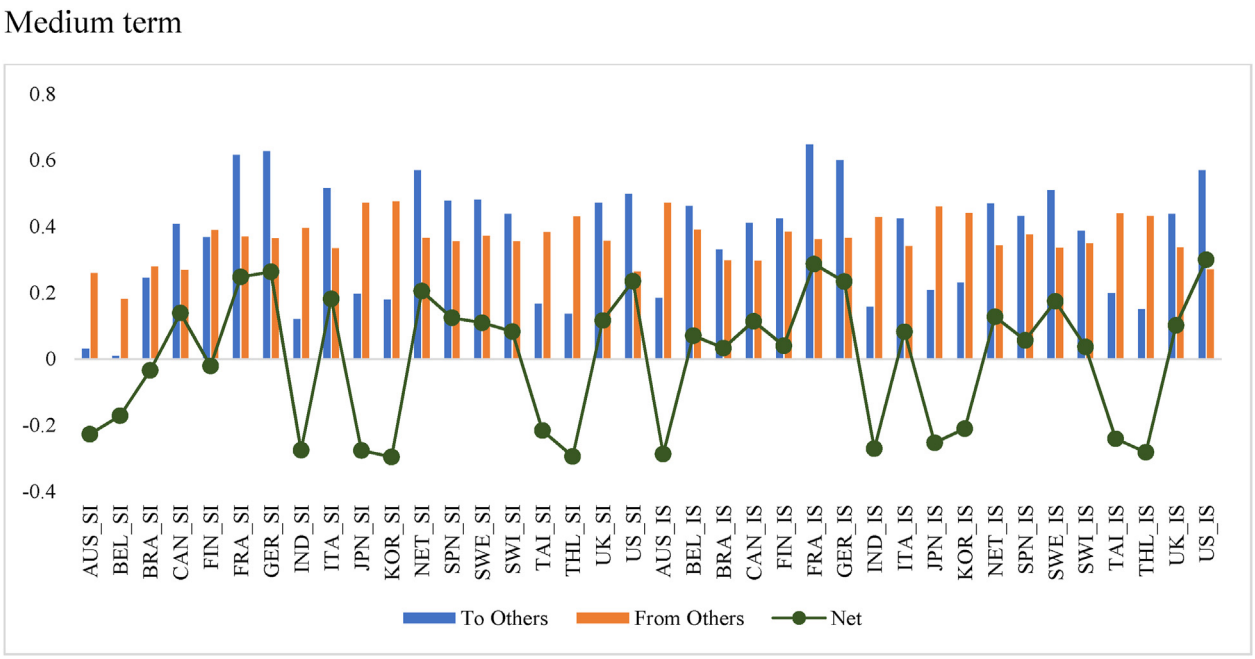


Fig. 6. Summary measures of connectedness network. Medium term. *Note*: See notes to Fig. 2.

$$(\widehat{\partial}_d)_{j,l} = \sum_f \widehat{\rho}_j(f)(\widehat{\kappa}(f))_{j,l} \tag{10}$$

where, $(\widehat{\kappa}(f))_{j,l} = \widehat{\delta}_{ll}^{-1}((\widehat{\eta}(f)\widehat{\sum})_{j,l})^2/(\widehat{\eta}(f)\widehat{\sum}\eta'(f))_{j,j}$ shows the estimation of the generalized causation spectrum, and $\widehat{\rho}_j(f) = (\widehat{\eta}(f)\widehat{\sum}\eta'(f))_{j,j}/(\varnothing)_{j,j}$ represents the estimation of the calculated fraction; $\varnothing = \sum_f \widehat{\eta}(f)\widehat{\sum}\widehat{\eta}'(f)$. Therefore, based on the frequency group, the indicators of the connectedness can be retrieved with alternative estimations, $(\widehat{\partial}_k)_{j,l}$ in the traditional measures.

4. Data and descriptive statistics

To estimate the connectedness spillovers among Islamic and sustainable investment, we use country-level Islamic and sustainable equity indices. First, we proxy for Islamic investments with MSCI global Islamic indexes, and the underlying indices are extracted from country-level MSCI indexes. The indices comply with sharia guidelines, and the returns on the underlying Islamic portfolios are estimated. Second, we use country-level Dow Jones Sustainability Indices (DJSI) to proxy for sustainable investment. The indices help investors integrate their sustainability preferences into the investment portfolios. In fact, the category of portfolios enables investors to influence the sustainability practices of the companies. In our main analysis, we use daily data from January 1, 2009, to November 25, 2020, for the sustainable and Islamic indices of nineteen countries: Australia, Belgium, Brazil, Canada, Finland, France, Germany, India, Italy, Japan, Korea, the Netherlands, Spain, Sweden, Switzerland, Taiwan, Thailand, the United Kingdom, and the United States.

Tables 1 and 2 present the descriptive statistics and augmented Dickey-Fuller (ADF) unit-root test statistics for selected indices. In Table 1, sustainable equity investment has the highest average returns in Belgium and India, followed by Taiwan and the US, and the lowest mean returns in Spain and Finland. In terms of return variation, the highest standard deviation for sustainable equity indices is achieved by Belgium and Australia, whereas Switzerland and the UK have the lowest.

Table 2 shows that Islamic equity investment has the highest average returns in the Netherlands and India, followed by Sweden and Taiwan, from the lowest mean returns in Italy and Finland. In terms of return variation, Brazil and Italia have the highest standard deviation, whereas Switzerland and the US have the lowest. Moreover, in the last columns of Tables 1 and 2, the highly significant ADF test statistics confirm the stationarity of the data series.

5. Empirical results

5.1. Network-based connectedness

We apply the well-known DY12 model to estimate the connectedness between country-level sustainable and Islamic investment indices. Fig. 1a presents the connectedness network for the full sample in which the arrows' thickness and direction represent the strength and direction of spillovers, respectively. The network shows moderate to strong connectedness between country-level sustainability and Islamic indices, with some weak cross-country spillover. We use thresholding[3] to identify economically sizable spillovers. Fig. 1b illustrates the post-thresholding network, which shows a varying level of connectedness between sustainability and Islamic investment in

[3] Values lower than the average in the first 100-largest individual pairwise connectedness is set at 0.

the sample countries. For example, Thailand, Taiwan, and Japan show strong two-way spillovers between sustainability and Islamic investment. Most of the sample countries—comprising Sweden, Switzerland, the US, Korea, Canada, Finland, France, and Germany—have weak to moderate connectedness between the two types of investment. Some countries, such as India and Brazil, also have one-way spillovers in which sustainability investment transmits spillovers to Islamic investment, and the opposite is true in the Netherlands. By contrast, countries such as Spain, the UK, Australia, Belgium, and Italy lack connectedness between sustainability and Islamic investment. Fig. 1b also shows some evidence of cross-country spillovers between Islamic and sustainable investment. For instance, Islamic investment in the UK and Italy show two-way spillovers, and sustainability investment in Spain transmits spillovers to its counterpart in France. Interestingly, the sustainable investment in Taiwan transmits spillovers to Islamic investment in Korea, which is the only instance of cross-country and cross-investment connectedness.

Additionally, we estimate the spillover from others, the spillover to others, and the net spillover for all sustainable and Islamic investment to identify the net transmitters and receivers. Fig. 2 reveals that France and Germany are the leading net spillover transmitters in sustainable and Islamic investment, whereas Japan, Taiwan, and Korea emerge as the leading net receivers. Notably, the sustainable and Islamic investment in Europe, excluding sustainable investment in Belgium, is a net transmitter, and so are both types of investment in the UK, the US, and Canada. However, this investment in the Asia-Pacific region is a net receiver.

Overall, our analysis of connectedness for the full sample reveals strong linkage between sustainable and Islamic investment at the country level, which indicates that these investments could serve as complementary assets. Similarly,

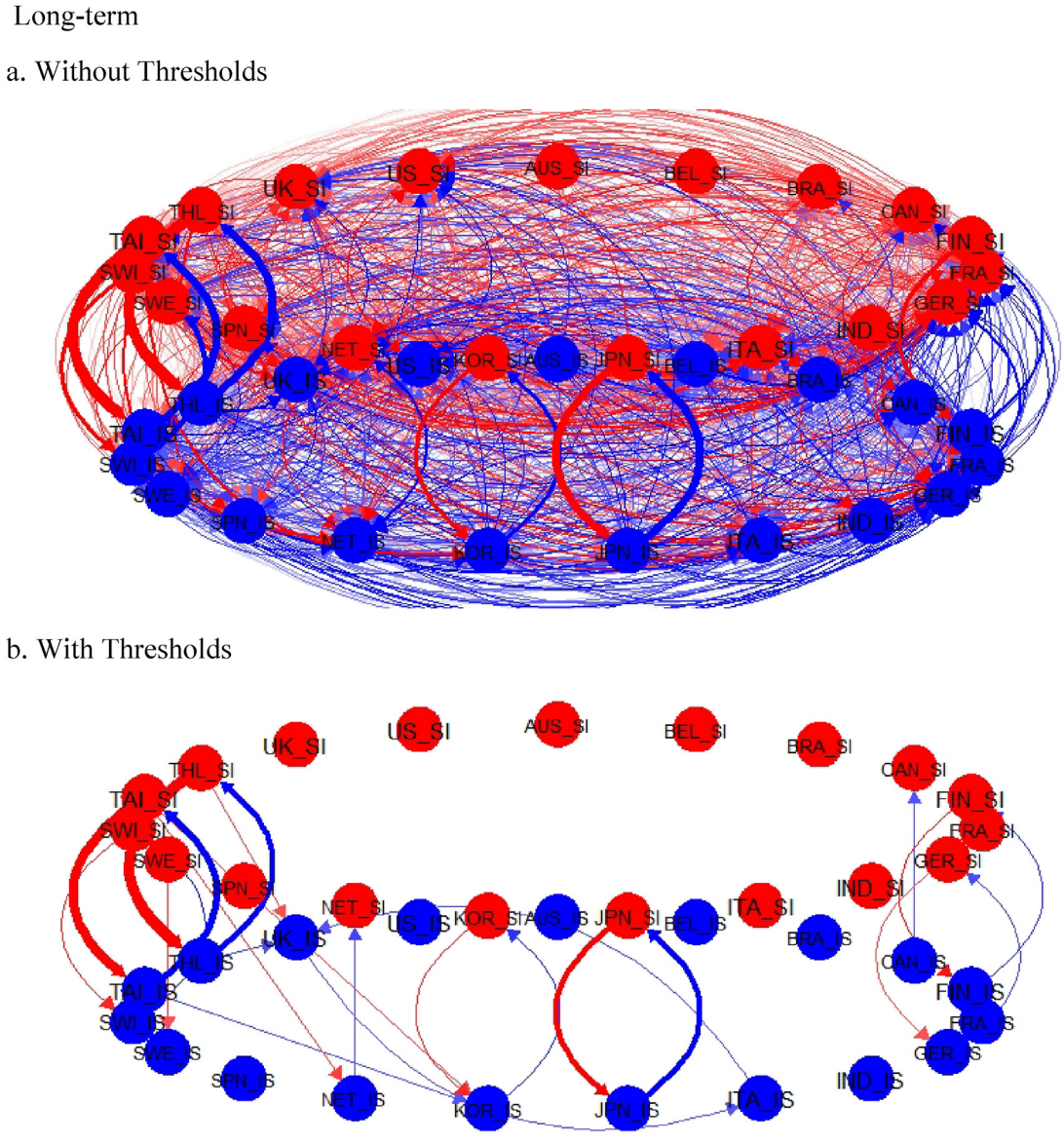


Fig. 7. The network of return connectedness using Barunik and Krehlik (2018). Long-term. *Note*: See notes to Fig. 1.

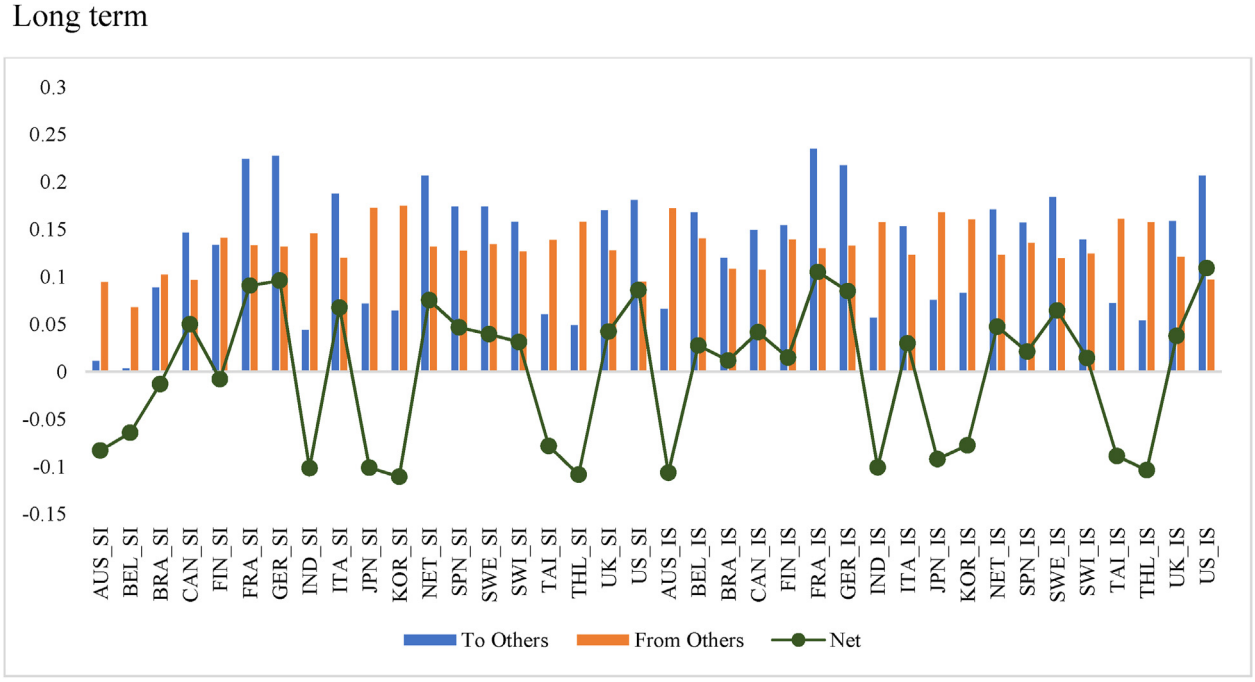


Fig. 8. Summary measures of connectedness network. Long-term. *Note*: See notes to Fig. 2.

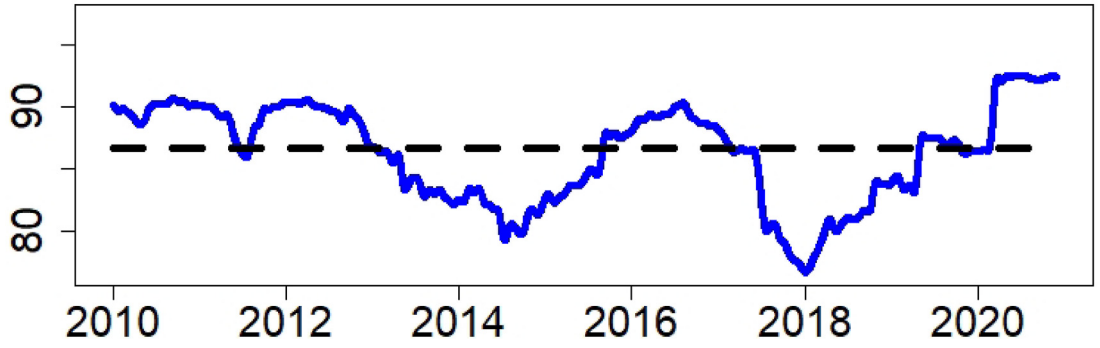


Fig. 9. Total time-varying connectedness using Diebold and Yilmaz (2012). *Note*: This figure shows the rolling-window version of total connectedness. The rolling-window length is roughly a year (260 days).

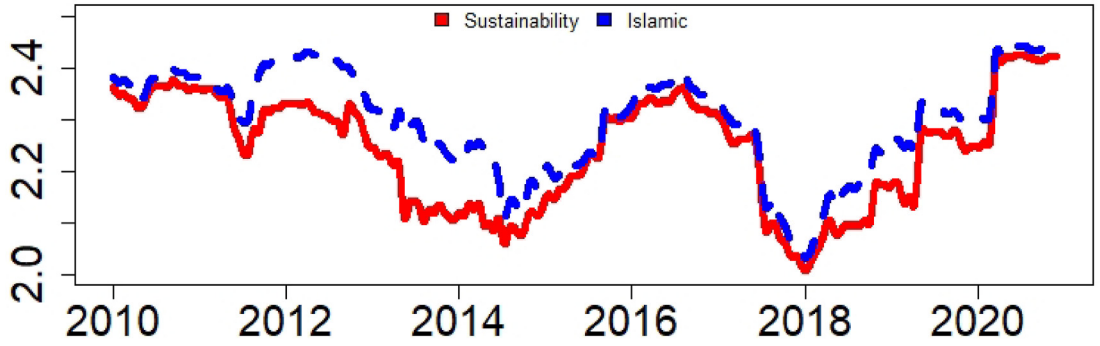


Fig. 10. Average connectedness FROM others to sustainable and Islamic equity markets. *Note*: This figure shows the rolling-window version of FROM others connectedness. The rolling-window length is roughly a year (260 days).

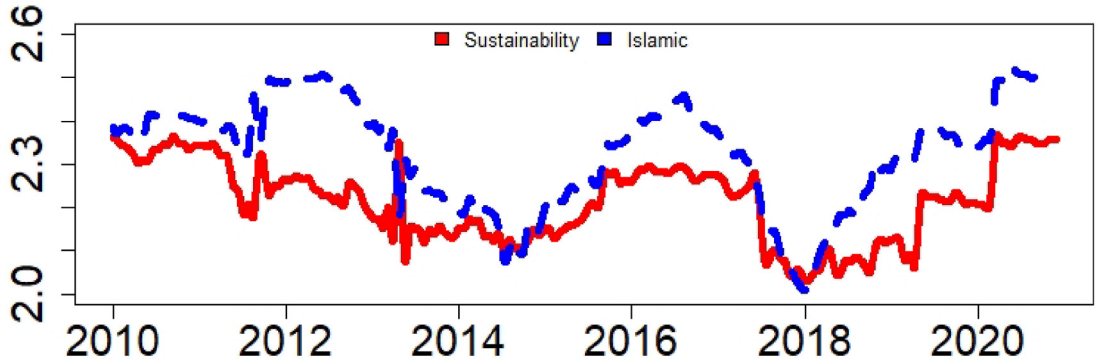


Fig. 11. Average connectedness TO others from sustainable and Islamic equity markets. *Note*: This figure shows the rolling-window version of TO others connectedness. The rolling-window length is roughly a year (260 days).

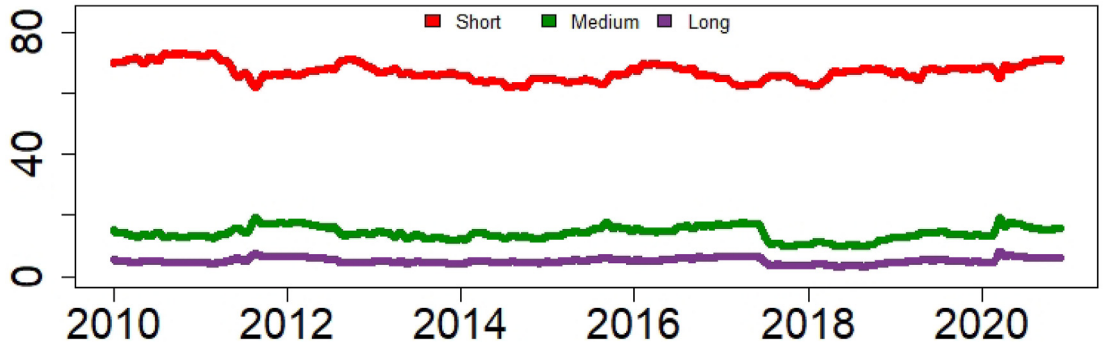


Fig. 12. Frequency connectedness using Barunik and Krehlik (2018). *Note*: This figure shows the rolling-window version of frequency connectedness. The rolling-window length is roughly a year (260 days).

Azmi et al. (2019) and Qoyum et al. (2021) find that combining socially responsible and Islamic investment generates better returns than standalone portfolios of sustainable, Islamic, and conventional investment. However, some countries lack connectedness between sustainability and Islamic investment, indicating that they could also serve as alternative investments. Moreover, we observe very limited evidence of cross-country and cross-investment connectedness, which indicates potential diversification opportunities for ethical equity investors across developed and developing markets.

5.2. Frequency-based connectedness

Next, to ascertain the influence of different time horizons on the level of connectedness between sustainable and Islamic investment, we employ the BK18 model to decompose the connectedness into short-, medium-, and long-term frequencies. Fig. 3a and b presents a short-run connectedness network before and after hard thresholding, respectively. The connectedness network illustrates a moderate level of connectedness between sustainable and Islamic investment at the country level. The cross-country connectedness depicts spillovers running from Canadian and French sustainable investment to Islamic investment in US and sustainable investment in Spain. In addition, Islamic investments by the UK and Italy have two-way spillovers.

Moreover, Fig. 4 shows the net spillovers of sustainable and Islamic investment in the short term. Except for sustainable investment by Belgium, investment from Europe is a net transmitter of spillover, and the same is true of the UK and the US. Conversely, sustainable and Islamic investment from Asian-Pacific countries is a net receiver of spillover, and the same is the case for Brazil and Canada.

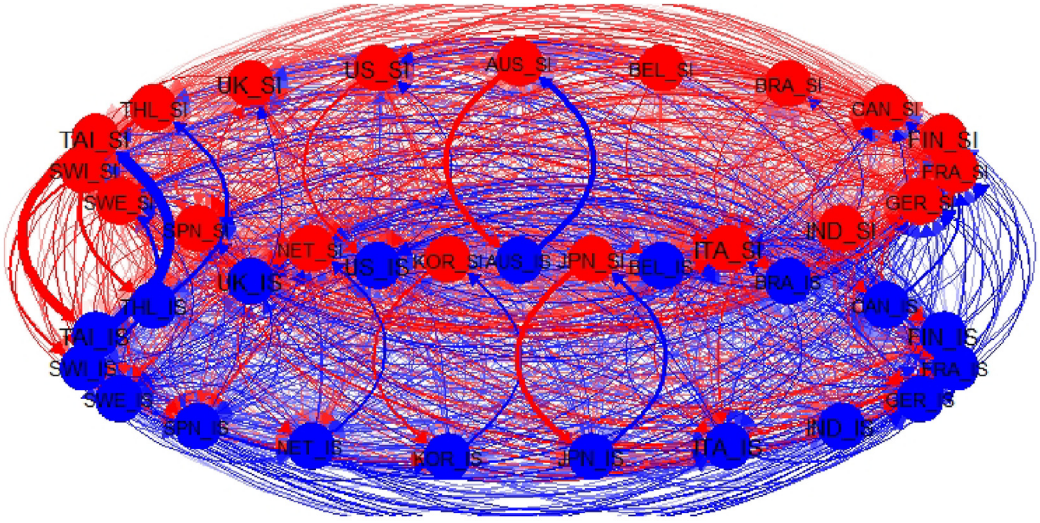
Fig. 5a and b demonstrate a medium-term connectedness network before and after thresholding, which shows somewhat less country-level connectedness than short-term connectedness. We note the following differences in the country-level connectedness from the short-term horizon. Sustainable and Islamic investments from the US are no longer connected, nor are the two types of investment in Brazil and India. The two-way connectedness in the Canadian (Swedish) market is now confined to one-way spillovers running from Islamic (sustainable) investment to sustainable (Islamic) investment. The medium-term connectedness network shows enhanced cross-country spillovers that are not seen in the short-term analysis. The UK's Islamic investment transmits spillovers to its Korean counterpart. Moreover, sustainable investment from Taiwan transmits spillovers to

Islamic investment in Korea and the Netherlands, and the same is true between sustainable investment from Thailand and Islamic investment from the UK. Further, our medium-term analysis of net spillover in Fig. 6 is similar to the short-term analysis in terms of the net transmitters and receivers. However, the magnitude of the net spillovers is smaller, indicating that short-term spillovers are more pronounced than medium-term spillovers.

Further, Fig. 7a and b illustrate the long-term connectedness between sustainable and Islamic investment. Long-term connectedness presents a picture that is very similar to that of our medium-term analysis in terms of country-level and cross-country connectedness. The only notable change is the absence of spillovers in sustainable investment from Spain to France. Furthermore, Fig. 8 depicts the long-term net spillovers for sustainable and Islamic investment, and the results are similar to our midterm results.

In summary, the frequency-based connectedness analyses show that the short-term frequency shows higher connectedness in terms of country-level connectedness between sustainable and Islamic investment. Short-term connectedness also shows a higher magnitude of spillovers to and from each investment to other investments and the reverse. These results indicate that short-term spillovers drive the connectedness between sustainable and Islamic investment. Moreover, the medium- and long-term frequencies show greater cross-country spillover, indicating that sustainable and Islamic investments from different countries influence each other only overlong-term horizons. These findings provide useful insights for investors operating in different time horizons who wish to adjust their portfolio strategies. For instance, short-term investors can benefit from cross-country diversification opportunities, whereas medium- and long-term investors can use country diversification avenues available from ethical investment.

a. Without Thresholds



b. With Thresholds

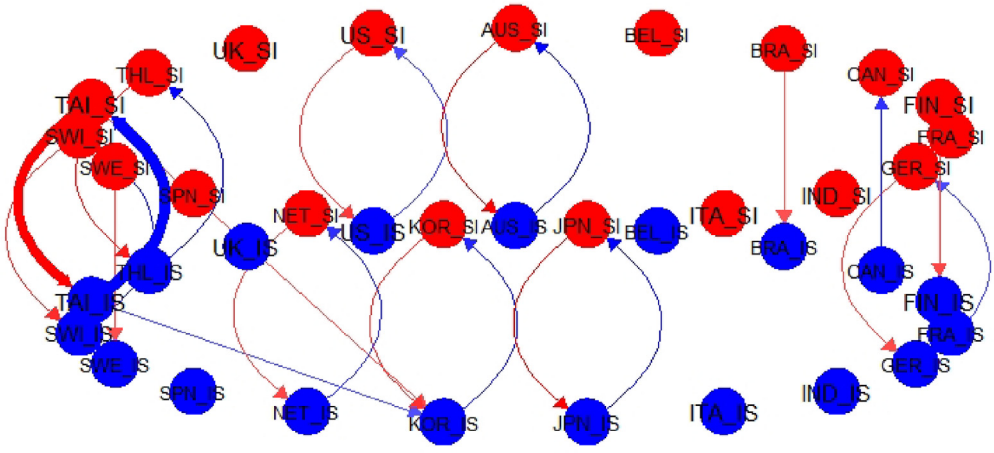


Fig. 13. The network of return connectedness using Diebold and Yilmaz (2012), COVID Subsample. *Note*: See notes to Fig. 1.

5.3. Dynamic connectedness analysis

The results above present a static picture of connectedness between sustainable and Islamic investment, but connectedness may be influenced by various factors, such as market trends, economic and political events, and market developments in those investments. To capture the effect of these factors on connectedness, we estimate time-varying connectedness using a rolling-window analysis with a window of260 days. Fig. 9 gives a total connectedness index graph, showing higher connectedness among sustainable and Islamic investment, with an average connectedness score of 85. The connectedness index shows consistently high connectedness during the sample period, though with periods of higher and lower connectedness. Notably, the period that covers the European debt crisis has higher connectedness, as the total connectedness index rose to 90 percent. In the prior analysis, we noted that European sustainable and Islamic investment is a net transmitter of spillover; hence, any disruption in the European financial market also affects overall connectedness. Fig. 9 shows relatively lower connectedness between the end of the European debt crisis until the onset of the Chinese financial market crisis in 2015, which sent shock waves to financial markets worldwide, especially the Asian financial market. Connectedness is higher during the period that covers the Chinese financial crisis, when the index rose to around 90

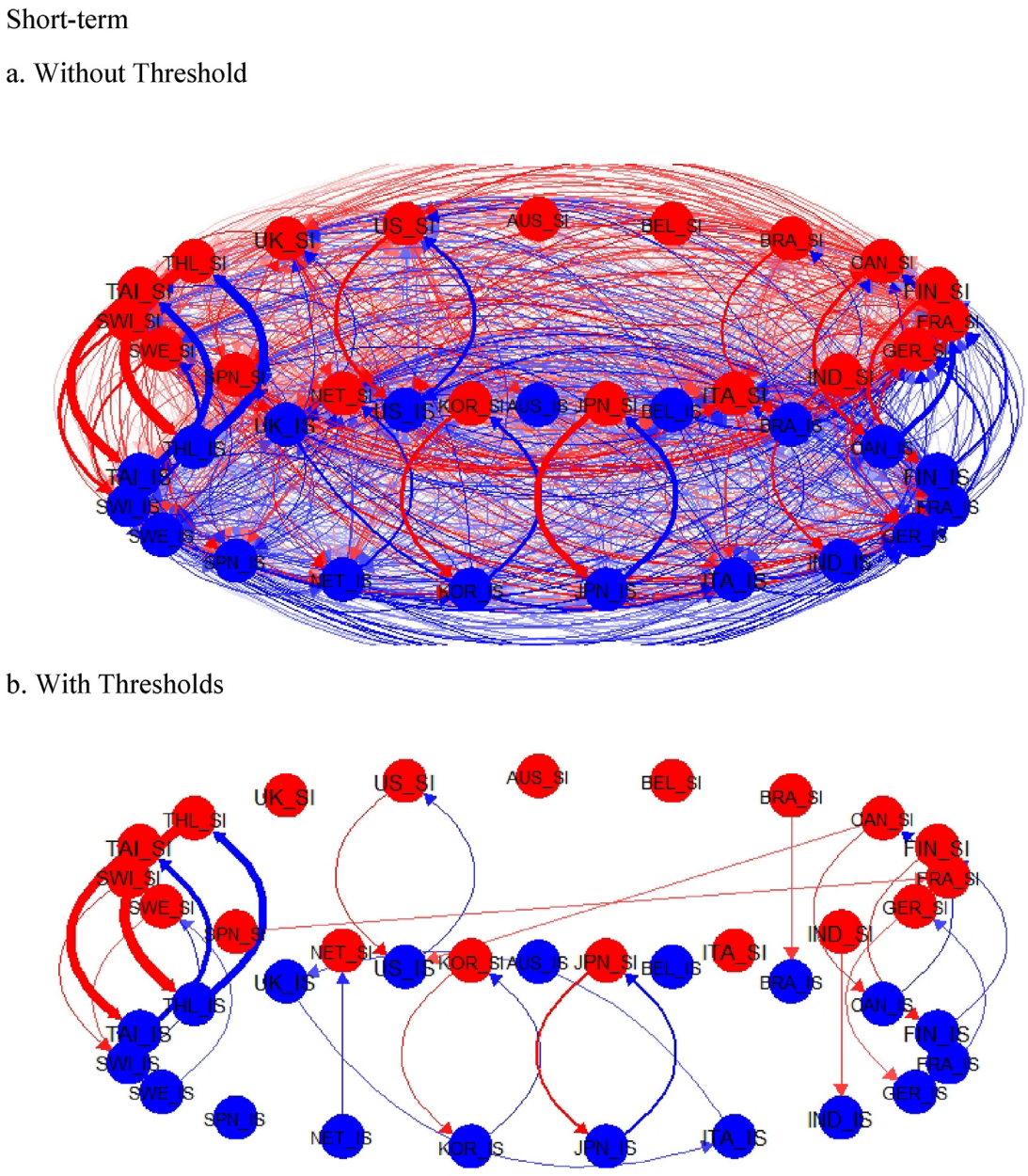


Fig. 14. The network of return connectedness using Barunik and Krehlik (2018), COVID subsample. Short-term. *Note*: See notes to Fig. 1.

percent. In addition, the time of the Chinese financial crisis overlaps with that of the Greek government's inability to agree with its creditors. Thus, the Asian and European market disruptions are due to increased connectedness between sustainable and Islamic investment.

Furthermore, a sharp increase in total connectedness is seen during the period that covers the pandemic crisis, with the spillover index approaching 95 percent—the highest connectedness during the sample period. These findings are consistent with recent literature that reports increased connectedness among financial markets and asset classes around the world (e.g., Bouri et al., 2021; Fassas, 2020; Gunay, 2021; Zhang & Hamori, 2021). This finding also indicates that ethical investment, like other asset classes, is prone to financial contagion. Thus ethical investors need to adopt appropriate portfolio diversification strategies to safeguard their returns during periods of financial market contagion such as during the COVID-19 pandemic.

Next, we estimate the net spillover dynamic connectedness of the sample indices. Figs. 10 and 11 illustrate net spillovers from others and net spillovers to others, respectively, showing that the Islamic indices send and receive higher spillovers than sustainable indices during the sample period. This observation indicates that Islamic investment plays a greater role in the interconnectedness between Islamic and sustainable investment. Thus investors in ethical investment should be cautious about the changes in Islamic equity investment, as it could increase the contagion effect in the event of a market-wide disturbance.

Further, Fig. 12 shows the frequency-based dynamic connectedness for short-, medium-, and long-term horizons. A

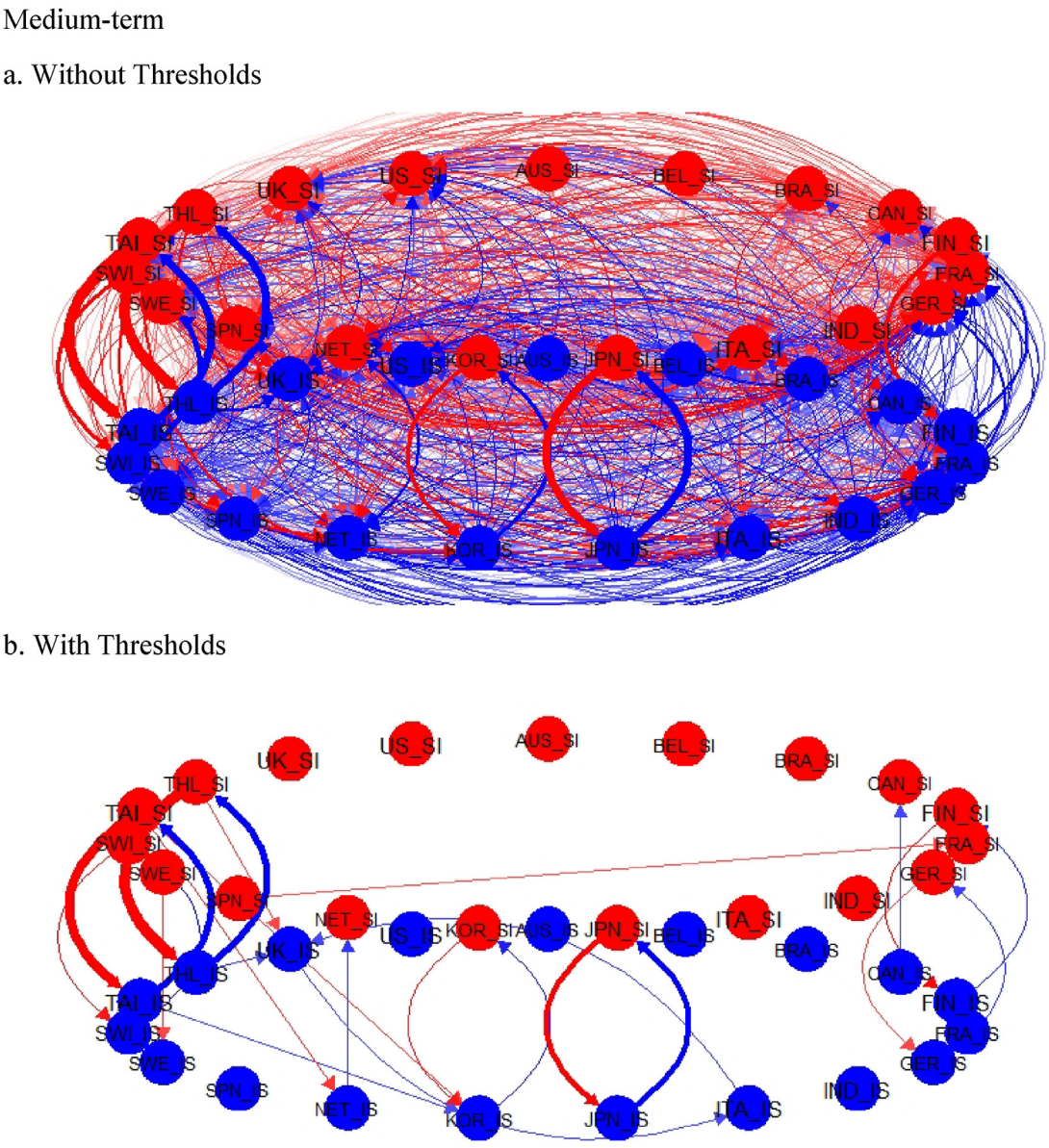


Fig. 15. The network of return connectedness using Barunik and Krehlik (2018), COVID subsample. Medium-term. *Note*: See notes to Fig. 1.

broader look at the figure confirms that the short-term connectedness mainly drives the magnitude of connectedness as its level of connectedness is higher than that of medium- and long-term connectedness. These findings reinforce our frequency-based network connectedness results indicating higher connectedness between country-level sustainable and Islamic investment at a short-term frequency.

5.4. COVID-19 subsample analysis

The COVID-19 pandemic crisis caused unprecedented disturbance in financial markets around the world. Many subsequent studies show enhanced connectedness across a variety of assets (see, e.g., Adekoya & Oliyide, 2020; Bissoondoyal-Bheenick et al., 2020; Lin & Su, 2020; Sharif et al., 2020; So et al., 2021). These observations show the need for independent analysis of the connectedness of sustainable and Islamic investment during the period of the pandemic. In doing so, we estimate the total sample and frequency-based connectedness between selected sustainable and Islamic investments. Fig. 13 illustrate the connectedness network for the full sample, which shows moderate spillovers between country-level investments. A comparison of the network for the pandemic period with the network for the full sample period reveals some changes in the structure of connectedness. For example, Australia and the Netherlands have two-way connectedness between sustainable and Islamic investment in the pandemic period but not in the full sample period. In contrast, Finland, Canada, and Sweden have a reduction in connectedness, from two-way connectedness to either limited or no connectedness. Moreover, we also observe a reduction in the strength of connectedness by Asian countries, such as

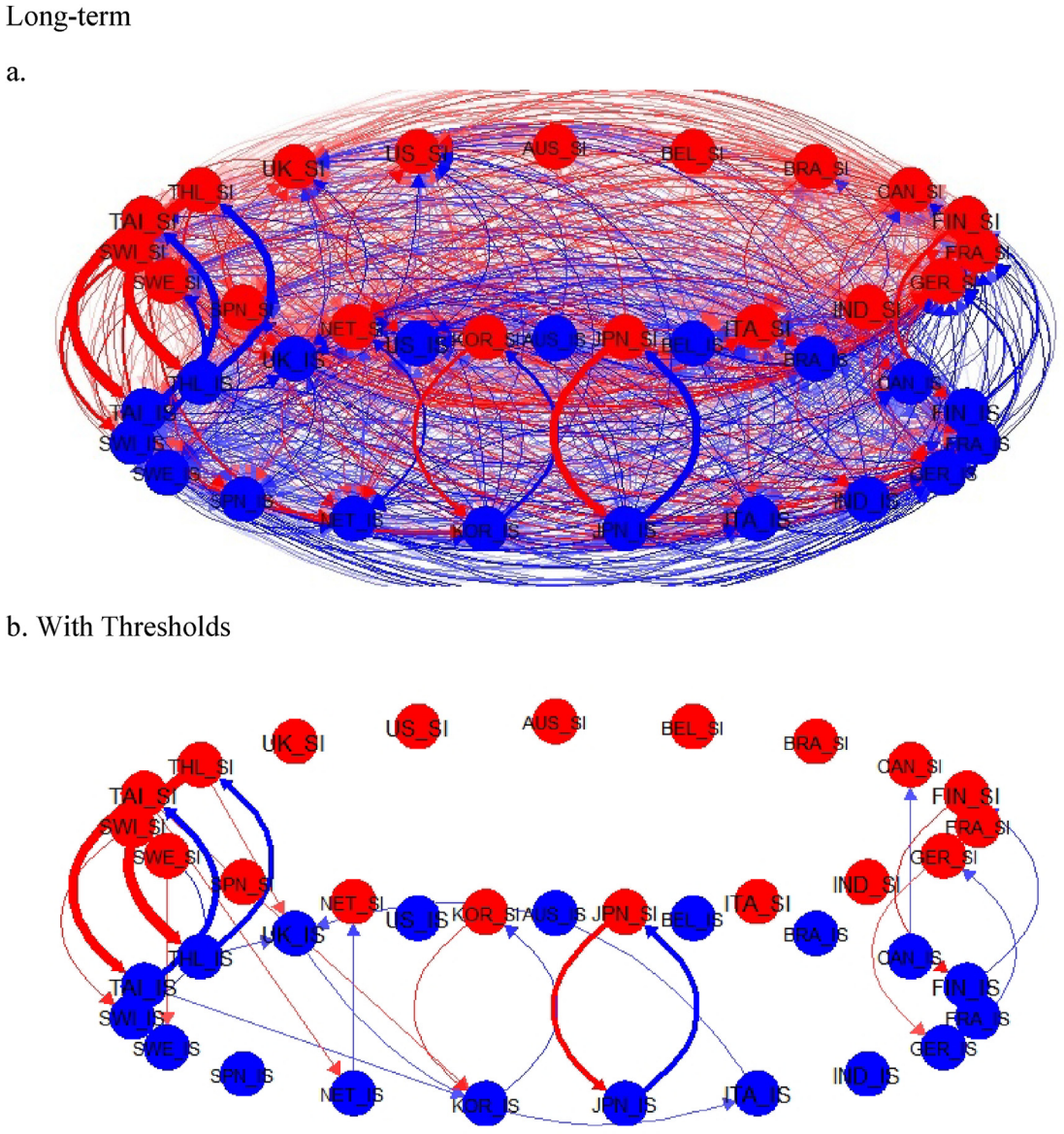
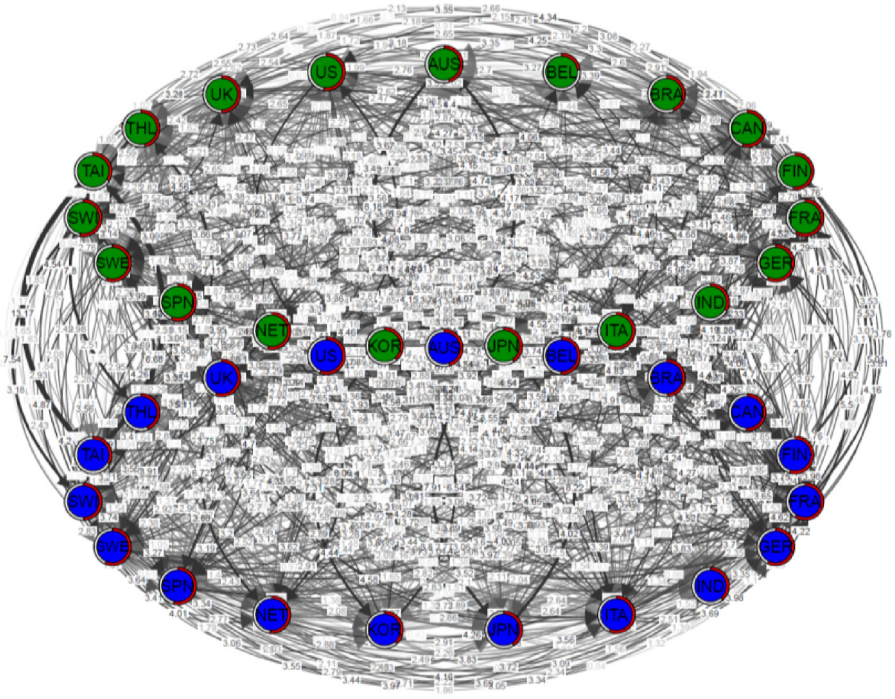


Fig. 16. The network of return connectedness using Barunik and Krehlik (2018), COVID subsample. *Note*: See notes to Fig. 1.

a. Without Thresholds



b. With Thresholds

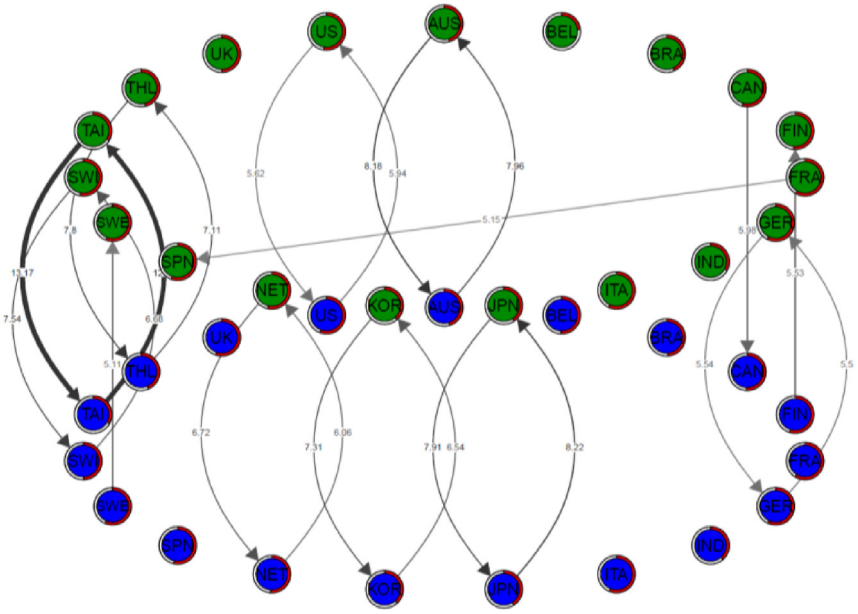
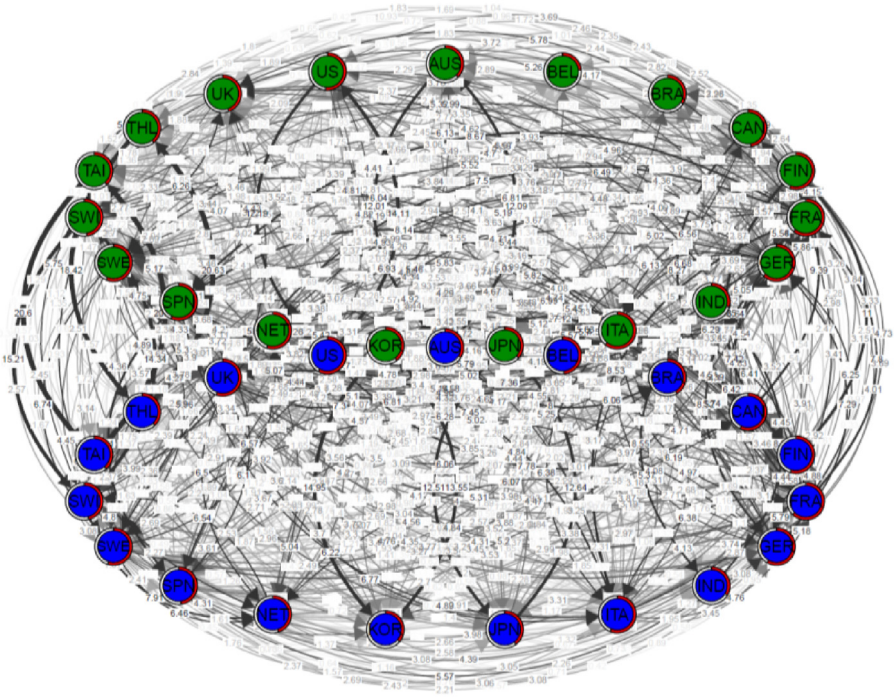


Fig. 17. The network of return connectedness using Diebold and Yilmaz (2012), COVID first wave subsample. *Note*: This figure shows the connectedness among 38 sampled equity markets, classified as either sustainable or Islamic. Green means sustainable equities, and blue means Islamic equities. In panel b, we only keep connectedness values larger than the average of the 100individual pairs with the largest connectedness. Red in the node implies a contribution from the variable under consideration to the other variables of the system. In addition, the network is constructed for the period from March 2020 to February 2021.

a. Without Thresholds



b. With Thresholds

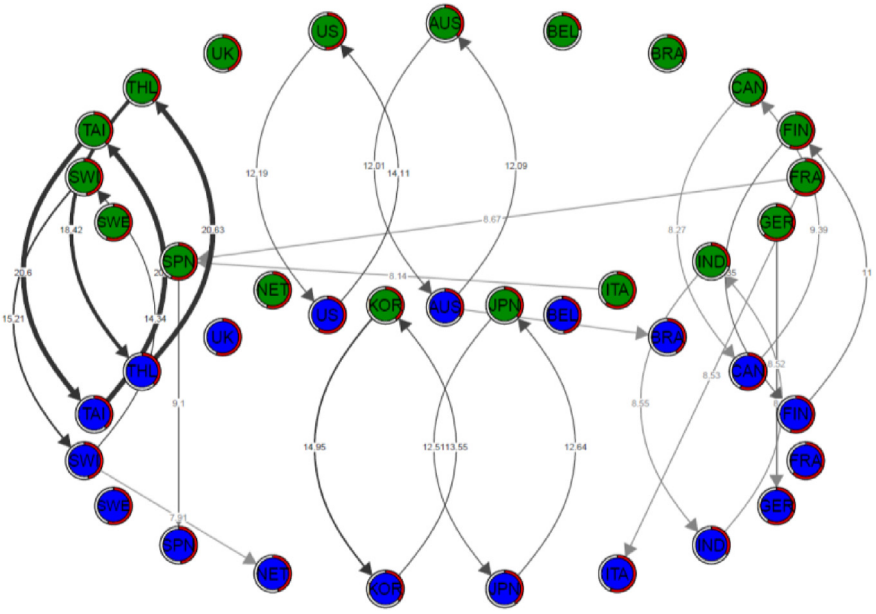


Fig. 18. The network of return connectedness using Diebold and Yilmaz (2012), COVID second wave subsample. *Note*: This figure shows the connectedness among 38 sampled equity markets, classified as either sustainable or Islamic. Green means sustainable equities, and blue means Islamic equities. In panel b, we only keep connectedness values larger than the average of the 100individual pairs with the largest connectedness. Red in the node implies a contribution from the variable under consideration to the other variables of the system. In addition, the network represents the period March to November 2021.

Japan, Thailand, and Taiwan. Cross-country spillovers in the pandemic period are limited to the Taiwan/Korean pair in which sustainable and Islamic investment from Taiwan transmits spillovers to Korean Islamic investment. These findings indicate varying patterns during the pandemic period in the connectedness between sustainable and Islamic investment, showing that ethical investors from different financial markets reacted differently. This observation suggests that investor behavior in different markets can determine the connectedness between financial investments during periods of financial market contagion. These observations are in line with recent studies that show varying stock market reactions from investors in countries with different cultural characteristics, such as uncertainty avoidance and individualism (Fernandez-Perez et al., 2021; Shear et al., 2020).

Further, we analyze the connectedness between sustainable and Islamic investment in different time horizons during the COVID-19 period. Fig. 14 show a short-term connectedness network with moderate to strong country-level connectedness, excluding some cases in which sustainable and Islamic investment is not connected. Moreover, the cross-country spillovers are limited, for example, sustainable investment from Spain and Canada transmits spillovers to French and US sustainable and Islamic investment, respectively. We also note two-way spillovers between Islamic investment from the UK and Italy.

Moreover, the medium-term frequency connectedness networks shown in Fig. 15 have some changes in the connectedness structure within- and cross-country. For instance, Brazil, India, Canada, and Sweden have weakened connectedness between sustainable and Islamic indices, and these investments are no longer connected to the US market. In addition, the cross-country spillovers show changes in the connectedness structure. Cross-country spillovers from Asian sustainable investment to European and Asian Islamic investments are enhanced: sustainable investment from Taiwan transmits spillovers to Islamic investment from Korea and the Netherlands. Finally, Fig. 16 illustrate the long-term frequency connectedness network, with a very similar picture of medium-term connectedness, indicating that the connectedness does not vary between medium- and long-term frequencies. This supports our earlier suggestion that short-run spillovers drive connectedness between sustainable and Islamic investment (Fig. 17).

5.5. Robustness analysis

Many empirical papers have extensively documented the disastrous impacts of the COVID-19 pandemic on global stock markets, especially in the early stages of its transmission (e.g., Ahmad et al., 2021a, 2021b; Al-Awadhi et al., 2020; Zhang et al., 2020). The widespread panic due to the outbreak caused quick sell-offs and havoc in stock markets around the world, because behavior-driven trading strategies converted the pandemic into a black swan event for market participants. In addition, contagion effects driven by a market sentiment of fear quickly transmitted across international markets, and stock returns plunged. Moreover, information spillovers between markets reached their peak because of news and social media content. As a consequence, portfolio diversification opportunities for investors and portfolio managers were reduced across international markets. In response to the pandemic, policymakers around the world announced several rate cuts (in the US, the Federal Reserve announced a 0 percent interest rate policy) and quantitative easing programs to calm the markets. In addition, as lockdowns and travel bans were relaxed, and economic activities restarted, equity prices also began to rebound (Farid et al., 2021). With this backdrop, we also conduct an analysis of return connectedness among sustainable and Islamic investment during the first and second waves of

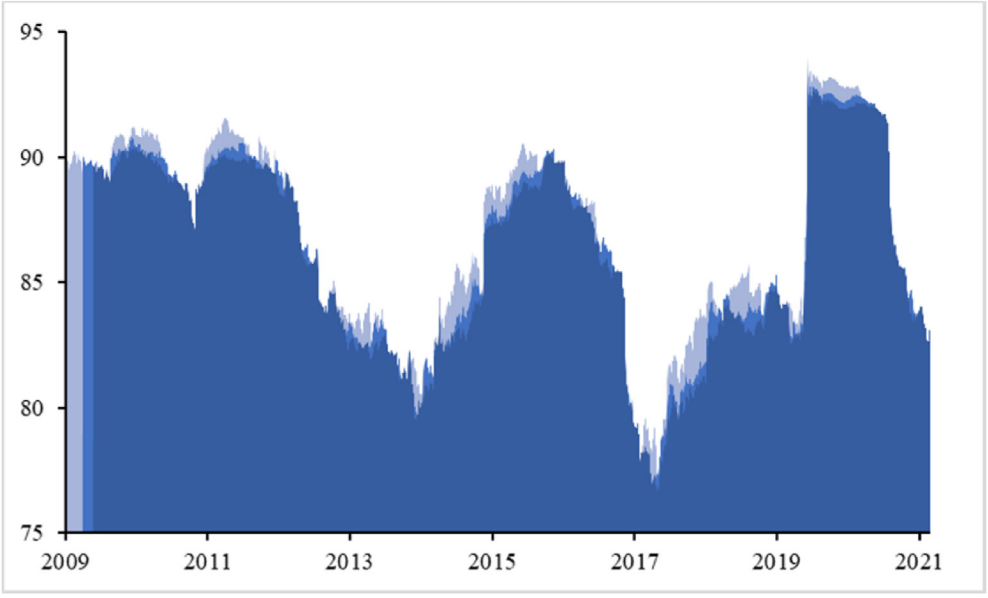


Fig. 19. Robustness test. *Notes*: This figure shows the results for each combination of window-length $w \in \{200; 260; 300\}$ and forecast-horizon $h \in \{75; 100; 125\}$.

COVID-19 transmission. This helps us understand the heterogeneous responses of the underlying stock markets to these different waves of COVID-19. For this purpose, we construct two return connectedness networks between Islamic and sustainable investment using the DY method. The first network is constructed for the period from March 2020 to February 2021, and the second network covers the period March to November 2021. A comparison of the first wave network to second wave network reveals the matching results. For example, both waves have some instances of strong spillovers among Islamic and sustainable investments in Taiwan and Thailand, whereas most of the underlying markets have moderate linkage across the two types of investment. Further, we observe various instances of moderate cross-country and cross-market spillovers among both Islamic and sustainable investments during both waves of the pandemic. Finally, our results demonstrate weak linkages among the underlying investments, highlighting portfolio diversification and hedging options for portfolio managers and investors.

In order to ensure the robustness of our findings, we also estimate our results with different lags and rolling windows (Fig. 18). The findings are illustrated in Fig. 19. The results confirm our main findings and show the time-varying nature of the connectedness among Islamic and sustainable investments. Moreover, the return linkages among the underlying markets soared during the periods of economic and financial meltdown. The highest level of spillovers occurred during the pandemic, which indicates the influential role of the outbreak in driving return linkages among both types of investments. Overall, these findings confirm the evidence presented earlier and should dispel any doubt regarding the validity of the results.

6. Conclusion

This paper explores return spillovers between sustainable and Islamic investment around the world. In doing so, we apply the well-established DY12 and BK18 connectedness models to look at the overall and frequency-based connectedness between sustainable and Islamic equity investment by nineteen countries that represent developed and emerging financial markets. Further, we perform a subsample analysis for the period of the COVID-19 pandemic to examine connectedness dynamics during market-wide turmoil.

Our results reveal moderate to strong country-level connectedness between sustainable and Islamic investment, and we show that this connectedness is short-lived. In addition, our results show that cross-country connectedness is more pronounced in the medium- and long-term horizons. Moreover, our time-varying connectedness analysis reveals that market-wide disturbances, such as the European debt crisis, the Chinese financial crisis, and the COVID-19 pandemic heightened connectedness between ethical investments. The patterns and magnitude of country-level and cross-country connectedness varies during the pandemic period, indicating the evolving nature of the relationship between ethical investments.

Our findings offer valuable insights regarding the evolving nature of the relationship between ethical investment in different countries that represent developed and emerging financial markets. Thus, these findings could help a variety of investors formulate profitable investment strategies during normal and bearish market conditions. Moreover, the analysis of the pandemic period offers a novel investigation regarding the connectedness structure of ethical investment amid widespread financial market contagion. Thus, it timely informs policymakers and investors about the likely effects of a financial crisis on the time and frequency connectedness of ethical investment.

Compliance with ethical standards

We confirm that we have complied with ethical standards.

Declaration of competing interest

We confirm that we do not have any conflict of interest.

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