

Connectedness and spillovers in Islamic green finance under climate policy uncertainty

Ashraf Khan

*Venice School of Management, Ca' Foscari University of Venice, Venice, Italy, and
Department of Economics, Faculty of Economics and Business, Universitas Brawijaya,
Malang, Indonesia*

Indri Supriani

*Department of Economics, Faculty of Economics and Business,
Universitas Brawijaya, Malang, Indonesia, and*

Umaira Danish Dervi

Institute of Business Administration Karachi, Karachi, Pakistan

International
Journal of Islamic
and Middle
Eastern Finance
and Management

1385

Received 21 January 2025

Revised 1 July 2025

24 November 2025

5 February 2026

Accepted 6 February 2026

Abstract

Purpose – This study aims to investigate how climate policy uncertainty (CPU) is connected with green sukuk and equity markets in Southeast Asia. It assesses whether CPU acts as a meaningful transmitter of shocks to green sukuk and equity returns, or whether spillovers are driven primarily by financial market linkages.

Design/methodology/approach – The analysis uses daily data for Global CPU, Malaysian and Indonesian green sukuk and the benchmark equity indices of Malaysia and Indonesia from October 3, 2022–December 30, 2024. The authors use the Diebold and Yilmaz connectedness framework based on generalized forecast error variance decomposition ($H = 10$) with a 252-trading day rolling window, complemented by generalized impulse response functions with bootstrap confidence bands.

Findings – The static results indicate moderate system-wide spillovers, with a Total Connectedness Index of 13.95, and spillovers largely concentrated in the equity segment. Cross-country equity linkages constitute the dominant transmission channel, and equity shocks contribute notably to sukuk yield fluctuations, particularly for Indonesian green sukuk. CPU is largely self-driven and contributes only marginally to the forecast error variance of sukuk and equity returns. Rolling estimates reveal time-varying connectedness, with stronger spillovers in early 2024, while net connectedness measures show that CPU is persistently a net receiver of shocks and Malaysian equities more frequently act as net transmitters. Lastly, generalized impulse responses further indicate that CPU shocks generate small and short-lived movements in sukuk and equity returns.

Originality/value – This paper provides new evidence on the spillover structure linking CPU with green sukuk and equity markets in an emerging Islamic finance context. The findings suggest that spillovers are equity led and that CPU plays a limited role in driving return dynamics, with implications for portfolio allocation and for monitoring equity driven transmission during periods of elevated policy uncertainty.

Keywords Climate policy uncertainty, Green sukuk, Green finance, Connectedness, Generalized FEVD

Paper type Conceptual paper



© Ashraf Khan, Indri Supriani and Umaira Danish Dervi. Published by Emerald Publishing Limited. This article is published under the Creative Commons Attribution (CC BY 4.0) licence. Anyone may reproduce, distribute, translate and create derivative works of this article (for both commercial and non-commercial purposes), subject to full attribution to the original publication and authors. The full terms of this licence may be seen at <http://creativecommons.org/licences/by/4.0/>

JEL classification – G11, G15

International Journal of Islamic
and Middle Eastern Finance and
Management
Vol. 19 No. 5, 2026
pp. 1385-1401
Emerald Publishing Limited
1753-8394
DOI 10.1108/IMEFM-01-2025-0042

1. Introduction

Over the past decade, green finance is considered a critical mechanism to fund and mobilize capital to support environment-friendly projects (Muhmad *et al.*, 2024; Dervi *et al.*, 2022). Among green financial instruments, green bonds have experienced particularly rapid growth worldwide. Since the International Capital Markets Association introduced its Green Bond Principles in 2014 (ICMA, 2025), the green bond market expanded from around US\$500bn outstanding in 2018 to nearly US\$3tn by 2024. This growth has been supported by stronger regulatory frameworks and rising investor demand for green assets amid growing awareness of climate-related financial risks (Demski *et al.*, 2025).

More recently, green sukuk have gained prominence as Shariah-compliant alternatives that combine the environmental objectives of green finance with the risk-sharing, asset-backed principles of Islamic finance. By prohibiting interest-based transactions and linking financial claims to real economic activities, green sukuk offer a distinctive pathway for financing sustainable infrastructure in Muslim-majority and dual economies (Ulfah *et al.*, 2024). Lee *et al.* (2025) further distinguish Green Sukuk from Green Bonds by highlighting their unique return profiles, suggesting that these instruments are not merely “Islamic versions” of green bonds but distinct financial assets.

Malaysia and Indonesia have emerged as global pioneers in the development of the green sukuk market. Malaysia introduced the world’s first green sukuk in 2017 under its Sustainable and Responsible Investment (SRI) framework [1], while Indonesia became the first country to issue sovereign green sukuk in international markets in 2018 [2]. Both countries have successfully used these instruments to finance renewable energy, water treatment and climate-resilient infrastructure (Hariz *et al.*, 2025; Santoso, 2020). As a result, Malaysia and Indonesia now represent the most active and mature green sukuk markets worldwide, offering a unique empirical setting to study the behavior of Shariah-compliant green instruments in secondary markets.

Despite the growing importance of green sukuk, empirical evidence on their financial characteristics and risk behavior remains limited. Existing studies have largely focused on conceptual frameworks, issuance structures and Shariah compliance (Dusuki and Abdullah, 2007), while relatively little is known about how green sukuk perform once they are traded in secondary markets. In particular, there is scant empirical research examining how green sukuk respond to macroeconomic and policy-related uncertainty, a factor shown to significantly affect asset prices and risk premia in conventional markets.

Economic and climate policy uncertainty (CPU) can influence green sukuk markets through multiple channels. Heightened uncertainty may increase risk aversion, yet recent evidence suggests that Green Sukuk may serve as a hedge during periods of global stress, such as the COVID-19 pandemic (Billah and Adnan, 2024). Whether green sukuk behave as defensive assets during periods of elevated CPU remains an open empirical question. Furthermore, the asymmetric impact of these uncertainties where markets react differently to positive versus negative policy shocks, requires sophisticated modeling.

Against this backdrop, this study examines the impact and dynamic comovement of global CPU with green sukuk markets in Malaysia and Indonesia. Using the Diebold and Yilmaz (2012), Diebold and Yilmaz, (2014) spillover index and Generalized Impulse Response functions (GIRF), we analyze both the direct effect of uncertainty on green sukuk performance and the time-varying nature of their relationship across different market conditions. By focusing on the two leading green sukuk issuing countries, the paper provides the comparative empirical evidence on how Shariah-compliant green instruments respond to external climate uncertainty shocks.

This study makes three main contributions to the literature. First, it extends the growing body of research on green finance by providing market-based empirical evidence on green sukuk, an area that remains underexplored relative to conventional green bonds. Second, it contributes to the literature on CPU and financial markets by examining its role in shaping the behavior of Islamic sustainable finance instruments. Third, by comparing Malaysia and Indonesia, the paper offers insights into whether green sukuk exhibit consistent risk characteristics across leading issuing jurisdictions, thereby informing investors, regulators and policymakers involved in the expansion of Islamic green capital markets.

The remainder of the paper is structured as follows. Section 2 reviews the related literature. Section 3 describes the data and empirical methodology. Section 4 presents the empirical results. Section 5 discusses the additional analysis while Section 6 concludes the study.

2. Literature review

2.1 *Concept of green finance in Islamic finance*

Islamic finance is another means of financial intermediation that involves the prohibition of interest (Riba), excessive uncertainty (gharar), gambling (maysir and qimar) and investing in nonethical businesses such as tobacco, alcohol, pornography and it is based on asset-backed risk-sharing models. Islamic finance promotes investing in businesses that are favorable and in the welfare of society. While Green finance is ethical financing that is used for sustainable development, renewable energy, introducing environment-friendly policies and products (Chowdhury, *et al.*, 2013). However, Islamic finance is considered more orthodox in view of non-Muslims, but it also promotes investing in ethical businesses and activities that are favorable for society. Though Green finance doesn't prohibit Riba but also doesn't completely favor its incorporation by not denying the fact of exploitation of debtors by creditors.

Islamic financial institutions (IFIs) and shariah-compliant firms require people to make investments in congruence with Islamic values and take decisions that may not be in their economic or self-interest rather for the welfare of the society or community. According to Dusuki and Abdullah (2007), IFIs are expected to follow basic shariah principles i.e. justice, ethical and moral conduct, compassion and promotion of general welfare. However, shariah rules are more holistic and complete, and IFIs are inclined to adopt the Islamic outlook of corporate social responsibility (CSR). IFIs encourage socially responsible investments (SRIs) by forcing firms to perform activities in line with shariah principles of justice and equity and select portfolios that are more socially responsible.

There is also an impact of religious beliefs on green finance. From a religious perspective, the literature suggests that the religious beliefs of entrepreneurs can enhance the legitimacy of their business ventures and strategically they engage more in ethical investments (Mohd Zain *et al.*, 2024; Wilson, 1997). Schueth (2003) traced out the origins of green finance from biblical times. Nonetheless, the contemporaneous view of showing disapproval toward few corporate practices started in the 18th century when various religious groups demanded that their funds should not be used to aid sinful businesses, that is, gambling, liquor and tobacco (Louche, 2004).

IFIs and shariah-compliant firms that are mainly guided by religious values are more stringent in investing their funds in line with shariah principles and Islamic values. They promote by pushing firms to align their activities with the moral concepts of justice and fairness in Islam by selecting a socially responsible portfolio for investment purposes. Therefore, in the context of IFIs, the concept of social responsibility and ethicality is infused with a more holistic approach (Dusuki, 2008).

Because Shariah principles shape the ethical boundaries of permissible financial activity, IFIs are expected to embed these values into investment screening and portfolio construction. To follow Islamic guidelines, it is crucial for IFIs to screen green investments and scrutinize industries strictly to exclude businesses that are harmful to society (Mounir, 2021). However, IFIs approach to screen such investments exhibit more sensitivity because of certain sharia principles in the light of the Holy Quran to exclude Riba (Interest), Gharar (uncertainty) and Qimar/Maisir (Gambling) from such transactions (Li, *et al.*, 2019; Ullah, *et al.*, 2014).

2.2 *Difference among conventional bond, green bond and Islamic bond*

The main difference between Conventional and Green bonds is of objectives since Green bonds are solely introduced for the financing of Greenfield environment-friendly projects while Conventional bonds do not screen out any type of nonenvironment-friendly businesses. However, Islamic bonds or Sukuk prohibit alcohol, weapons, gambling and pork-based businesses (Paltrinieri *et al.*, 2023). Moreover, shariah principles do not explicitly prohibit the manufacturing and production of bricks and chemical industries, the process of which are harmful to the environment and sustainability.

Islamic bonds have not been known to prohibit “Halal” business activities having some nonenvironment-friendly practices and impact. Though principles of ethicality are inherent in principles of Islamic finance, however, practically there is no incorporation of any such screening criteria known till date in financing products.

2.3 *Difference between green bonds and green sukuk*

Green bonds are fixed-income securities that raise capital for environment-friendly projects or sustainability (Tang and Zhang, 2020). These bonds work in the same way as conventional bonds and also have the same characteristics as standard bonds in terms of rating, pricing, processing and execution. The only difference is that their proceeds must be dedicated to climate and environment-friendly projects (Dong and Yu, 2024). These bonds also carry the same rating as an issuer’s other debt and are backed by the entire balance sheet so that investors won’t have to be fully exposed to the risk of the underlying project.

Conversely, Green Sukuk are Shariah-compliant bonds or certificates designed as investment instruments that adhere to Shariah principles. They are introduced to finance sustainable environmental initiatives and eco-friendly projects, including biogas plants, wind farms, renewable energy production, solar energy, waste management on land and in oceans, agricultural efficiency, the construction of energy-efficient buildings, ecosystem and natural resource management and other ventures that support environmental preservation or mitigate climate change risks, such as global warming (Pirgaip and Arslan-Ayaydin, 2024). The primary objective of developing Green Sukuk is to align with Shariah’s emphasis on protecting the global environment.

The selection criteria of SRIs or green investments ensure human rights and safeguarding the environment unlike those of Islamic mutual funds. Islamic finance began to support green financing in the last decade. Malaysian government dedicated funding of \$1bn for green energy projects in 2010 and the Malaysian securities commission developed the framework of SRI Sukuk in 2014 as a reliable SRI vehicle for socially responsible Islamic investors (Mehta, *et al.*, 2020).

Green Sukuk are similar to green bonds in their social responsibility toward the environment and human welfare criteria but are adhered to sharia laws and principles in features. One such feature of green sukuk is that they grant sukuk holders the right of ownership in underlying assets or earnings from assets. Green sukuk marks a mix between

sharia-compliant user-friendly asset-backed attributes of Islamic finance and positive features of green bonds with their socially responsible and environment-friendly attribute.

The World bank introduced a concept of green bonds in 2008 to provide ethical investors an innovative way to support environment-friendly projects which gave rise to green financial instruments. Green sukuk, in this regard, presents a tremendous opportunity to invest in environment-friendly projects. Concepts of Islamic finance fit well with sustainable environment concepts, ethicality and general welfare of the society which may attract more investors to invest in green projects via Green Sukuk. In addition, green sukuk has got the potential to reflect tangible impact and reliability of Islamic finance globally ([Alam et al., 2016](#)).

2.4 Empirical literature on green sukuk

Green Sukuk has emerged as a pivotal financial instrument at the intersection of Islamic finance and environmental sustainability. [Rahim and Mohamad \(2018\)](#) and [Santoso \(2020\)](#) highlight the role of Green Sukuk in financing renewable energy and infrastructure projects, particularly in Indonesia and Malaysia. As an alternative to conventional green bonds, Green Sukuk must comply with Shariah principles, which prohibit interest (riba) and excessive uncertainty (gharar). This structure may contribute to a more resilient investment profile during periods of market stress ([Ulfah et al., 2024](#)). [Lee et al. \(2025\)](#) further show that Green Sukuk and green bonds behave as distinct financial assets with different return characteristics, implying that Green Sukuk can provide diversification benefits within green portfolios.

The interconnectedness between green assets and traditional markets has also become a central theme in the recent literature. [Billah and Adnan \(2024\)](#) examine the dynamic connectedness among Green Sukuk, Islamic equities and conventional Sukuk. Their results indicate that Green Sukuk act as net transmitters of shocks in the short run, but evolve into net receivers over the medium to long term, suggesting that Green Sukuk may serve as effective hedging instruments within Islamic financial markets during episodes of economic turmoil.

Similarly, [Hariz et al. \(2025\)](#) use copula-based methods and find that Green Sukuk spreads are significantly influenced by financial stress and uncertainty indices, indicating strong dependence on uncertainty conditions. [Belkhir et al. \(2025\)](#) investigate asymmetric effects of Economic Policy Uncertainty (EPU) and Geopolitical Risk (GPR) on Green Sukuk and energy markets. Using a Quantile VAR framework, they identify uncertainty indices as systemic transmitters of shocks, particularly in bearish and bullish market states. These findings imply that CPU, as a more targeted form of policy risk, may exert a nonlinear influence on Green Sukuk pricing and its comovement with equity indices.

The sensitivity of equity markets to green financial news is also well documented. [Khairisma et al. \(2025\)](#) report that although only a small share of firms exhibits immediate statistically significant reactions to Green Sukuk issuance, issuers aligned with Climate Action (SDG 13) tend to experience more positive abnormal returns. However, [Siswanto \(2018\)](#) cautions that a “green image” does not necessarily dominate macroeconomic fundamentals; price dynamics often reflect profitability considerations and broader economic policy conditions more strongly than climate concerns alone.

Despite growing evidence on EPU and GPR, focused research on the role of CPU remains limited, particularly regarding how CPU shapes the time-varying relationship between Green Sukuk and equity indices.

3. Data and methodology

3.1 Data

To examine the interaction between CPU, green sukuk markets and regional equity markets, we compile a daily data set for Indonesia and Malaysia. The green sukuk segment is proxied by two sovereign benchmark issues: Indonesia’s green sukuk (ISIN: US71567RAN61) and Malaysia’s green sukuk (ISIN: MYBGT2200033). Equity market conditions are captured by the Jakarta SE Main Board Index (Indonesia) and the FTSE Bursa Malaysia KLCI Index (Malaysia). We obtain the daily sukuk yields and equity price level data from Refinitiv.

The sample spans October 3, 2022–December 30, 2024 ($n = 517$), which is determined by the common availability of all series and yields a balanced sample for the connectedness framework. This period also covers an economically relevant phase characterized by post-2022 monetary tightening and heightened attention to climate-policy developments, which provides a suitable environment to study uncertainty spillovers across markets.

We transform all variables into stationary return-like processes prior to estimation. Equity returns are computed as daily log returns, such as:

$$r_t = 100 \times \Delta \ln (P_t)$$

Since sukuk data are yields rather than prices, we use daily yield changes expressed in basis points as given below:

$$\Delta y_t = 100 \times (y_t - y_{t-1})$$

We denote them by ID_GS (Indonesian Green Sukuk) and MY_GS (Malaysian Green Sukuk). For CPU, we use the Global CPU index developed by [Ji et al. \(2024\)](#) and [Ma et al. \(2024\)](#), constructed via text-mining of news coverage across G20 economies. Because CPU is an uncertainty index rather than a traded asset price and may take negative values depending on normalization, we model daily changes in CPU as given below:

$$\Delta CPU_t = CPU_t - CPU_{t-1}$$

[Table 1](#) presents summary statistics for the daily series for CPU, green sukuk yield changes (MY_GS and ID_GS) and equity returns (ID_STOCK and MY_STOCK) over the sample period. Mean values are economically small for sukuk and equity markets, with MY_GS averaging 0.02, ID_GS -0.15 , ID_STOCK -0.01 and MY_STOCK 0.04, consistent with the well-known feature that daily returns and yield changes fluctuate around a low drift. CPU has a negative mean of -0.63 , reflecting that the index is analyzed in changes rather than levels and therefore captures short-run increases and decreases in uncertainty.

We also observe substantial dispersion differences across series. CPU exhibits the largest variability (standard deviation 192.42) and a wide range from -686.17 to 740.86 , consistent with the news driven nature of uncertainty measures that can jump in response to policy announcements and geopolitical developments. Within the sukuk segment, Indonesian green sukuk displays markedly higher volatility (standard deviation 9.82, range -52.78 – 42.36) than Malaysian green sukuk (standard deviation 0.50, range -1.90 – 2.52), indicating much larger day to day fluctuations in Indonesian yield changes. Equity returns volatility lies between these fixed income series, with standard deviations of 0.93 for ID_STOCK and 0.78 for MY_STOCK, and ranges of -3.91 – 2.66 and -3.06 – 5.77 , respectively.

Furthermore, skewness is close to zero for CPU (0.03), suggesting approximate symmetry, whereas MY_GS (0.54) and MY_STOCK (0.94) are right skewed, indicating

Table 1. Summary statistics

Series	<i>N</i>	Mean	Std	Min	Max	Skewness	Kurtosis_excess
CPU	517	−0.63	192.42	−686.17	740.86	0.03	0.69
MY_GS	517	0.02	0.50	−1.90	2.52	0.54	4.30
ID_GS	517	−0.15	9.82	−52.78	42.36	−0.20	3.59
ID_STOCK	517	−0.01	0.93	−3.91	2.66	−0.24	0.74
MY_STOCK	517	0.04	0.78	−3.06	5.77	0.94	6.63

Note(s): This is table reports summary statistics for daily climate policy uncertainty changes (CPU), green sukuk yield changes (MY_GS, ID_GS), and equity returns (ID_STOCK, MY_STOCK), *N* = 517. The table reports mean, standard deviation, minimum, maximum, skewness and excess kurtosis

relatively more frequent large positive observations. ID_GS (−0.20) and ID_STOCK (−0.24) exhibit mild left skewness, implying comparatively more downside realizations. Excess kurtosis is positive for all series, indicating fat tails and a higher incidence of extreme outcomes than implied by the normal distribution. Tail thickness is particularly pronounced for MY_STOCK (6.63) and MY_GS (4.30), while ID_GS (3.59) also shows substantial leptokurtosis. These distributional features support the use of the Diebold and Yilmaz connectedness framework based on the generalized forecast error variance decomposition, together with bootstrap based inference for impulse responses, which are robust to nonnormality and tail risk.

3.2 Methodology

3.2.1 Diebold and Yilmaz connectedness based on generalized FEVD. We measure spillovers among CPU, green sukuk and equity markets using the [Diebold and Yilmaz \(2012, 2014\)](#) connectedness framework, implemented via generalized forecast error variance decomposition (GFEVD). Let

$$x_t = [\Delta CPU_t, ID_GS_t, MY_GS_t, ID_STOCK_t, MY_STOCK_t]'$$

denote the $N \times 1$ vector of stationary variables (with $N = 5$). We estimate a VAR (2) with an intercept:

$$x_t = c + A_1 x_{t-1} + A_2 x_{t-2} + u_t$$

where u_t is the vector of reduced form forecast errors. The generalized approach of [Pesaran and Shin \(1998\)](#) is used to compute the H-step-ahead variance shares, which avoids ordering sensitivity and is therefore well suited to systems where a defensible causal ordering is not obvious.

Let $\theta_{ij}^g(H)$ denote the generalized share of the H-step forecast error variance of variable i attributable to shocks in variable j . Following standard practice, the variance shares are row-normalized so that

$$\sum_{j=1}^N \theta_{ij}^g(H) = 100 \text{ for each } i.$$

From the GFEVD matrix, we compute the connectedness measures as follows. Directional connectedness received by variable i from all others (FROM) is:

$$C_{i\leftarrow\cdot}(H) = \frac{1}{N} \sum_{j=1, j \neq i}^N \theta_{ij}^g(H)$$

Directional connectedness transmitted by variable i to all others (TO) is:

$$C_{\leftarrow i}(H) = \frac{1}{N} \sum_{j=1, j \neq i}^N \theta_{ji}^g(H)$$

Net connectedness is defined as:

$$C_i^{net}(H) = C_{\leftarrow i}(H) - C_{i\leftarrow\cdot}(H)$$

where positive (negative) values indicate that a variable is a net transmitter (net receiver) of shocks. Finally, the Total Connectedness Index (TCI) is:

$$TCI(H) = \frac{1}{N} \sum_{i=1}^N \sum_{j=1, j \neq i}^N \theta_{ij}^g(H)$$

which summarizes the average contribution of cross-variable spillovers to the system's forecast error variance.

In the empirical implementation, we compute GFEVD at a fixed forecast horizon of $H = 10$ trading days. To capture time variation, we re-estimate the VAR (2) using a rolling window of 252 trading days and recompute TCI and net directional connectedness at each step.

3.2.2 Generalized impulse response functions. To complement the variance-decomposition evidence with economically interpretable dynamics, we compute generalized impulse response functions (GIRFs) (Koop *et al.*, 1996; Pesaran and Shin, 1998). GIRFs trace the response of each variable in x_t to a one-standard-deviation innovation in ΔCPU , without imposing an ordering-based orthogonalization. Responses are traced over an impulse-response horizon of 20 trading days.

Statistical inference is obtained via a residual bootstrap for VAR models. Specifically, we resample the estimated residual vectors with replacement, generate synthetic series recursively from the estimated VAR parameters, re-estimate the VAR for each bootstrap sample and recompute GIRFs. We construct 95% percentile confidence bands from the bootstrap distribution at each horizon using 300 replications. This approach follows standard VAR bootstrap inference for impulse responses (Lütkepohl, 2000).

4. Empirical results

4.1 Static spillovers and system-wide connectedness

Table 2 reports the Diebold–Yilmaz connectedness table based on the generalized FEVD. The diagonal elements dominate across all series, indicating that own-market shocks explain most of the forecast error variance. In particular, CPU is largely self-driven (95.40% of its forecast error variance is explained by its own shocks). Green sukuk series also exhibit strong idiosyncratic dynamics, with own shares of 91.18% for MY_GS and 88.20% for ID_GS. Equity markets reflect comparatively stronger cross-market dependence, with own contributions of 78.99% (ID_STOCK) and 76.47% (MY_STOCK). Consistent with these patterns, the TCI equals 13.95, implying that, on average, about 14% of system forecast

Table 2. Static connectedness based on generalized FEVD

Series	CPU	MY_GS	ID_GS	ID_STOCK	MY_STOCK	FROM
CPU	95.40	3.02	1.08	0.01	0.49	0.92
MY_GS	0.98	91.18	0.96	0.71	6.16	1.76
ID_GS	0.86	0.53	88.20	6.24	4.17	2.36
ID_STOCK	0.05	0.29	4.41	78.99	16.27	4.20
MY_STOCK	0.52	5.20	1.74	16.07	76.47	4.71
TO	0.48	1.81	1.64	4.60	5.42	TCI = 13.95

Note(s): Static Diebold and Yilmaz connectedness based on generalized forecast error variance decomposition ($H = 10$) for CPU, Malaysian and Indonesian green sukuk (MY_GS, ID_GS) and equity indices (ID_STOCK, MY_STOCK). Diagonal elements report own variance shares, off diagonal elements report spillovers across variables. FROM and TO summarize directional spillovers, and the bottom right entry reports the total connectedness index (TCI)

uncertainty is attributable to spillovers across CPU, sukuk and equities, while the remainder reflects idiosyncratic components.

The off-diagonal structure shows that spillovers are concentrated within and around equity markets. The largest bilateral transmissions occur between Malaysian and Indonesian equities: ID_STOCK receives 16.27% of its forecast error variance from MY_STOCK, and MY_STOCK receives 16.07% from ID_STOCK, indicating tight regional equity linkage. Spillovers from equities to sukuk markets are present but smaller than equity-to-equity effects. For example, Indonesian green sukuk (ID_GS) receives 6.24% from Indonesian equities (ID_STOCK) and 4.17% from Malaysian equities (MY_STOCK), while Malaysian green sukuk (MY_GS) receives 6.16% from MY_STOCK. These results suggest that green sukuk yield changes are partially exposed to broader equity-market repricing, particularly in Indonesia.

Similarly, the directional measures reinforce aforementioned patterns. The TO row indicates that MY_STOCK (5.42) and ID_STOCK (4.60) are the primary transmitters of shocks to the system, whereas CPU transmits very little ($TO = 0.48$). The FROM column shows that equities also absorb substantial spillovers ($FROM = 4.71$ for MY_STOCK and 4.20 for ID_STOCK), reflecting their central position in the connectedness network. Net spillovers ($NET = TO - FROM$) suggest that MY_STOCK (+0.71) and ID_STOCK (+0.40) are net transmitters, MY_GS is approximately neutral (+0.05), while ID_GS (−0.72) and CPU (−0.44) are net receivers. Overall, the static evidence implies an equity-led transmission mechanism, with CPU playing a comparatively reactive role in explaining return/yield-change dynamics once the joint system interactions are accounted for.

Table 3 further highlight the bilateral direction of spillovers in the system. The largest net pairwise effects indicate that Malaysia equities (MY_STOCK) are the most influential transmitter, exerting strong dominance over Indonesia green sukuk (ID_GS) ($NP_{ID_GS,MY_STOCK} = 2.43$) and also over Malaysia green sukuk (MY_GS) ($NP_{MY_GS,MY_STOCK} = 0.964$), while Indonesia equities (ID_STOCK) transmit strongly to Indonesia green sukuk ($NP_{ID_GS,ID_STOCK} = 1.835$). In contrast, CPU appears primarily on the receiving side in pairwise relations—most notably relative to Malaysia green sukuk ($NP_{CPU,MY_GS} = 2.035$) which confirm the earlier finding that spillovers are largely equity-led, whereas CPU plays a comparatively reactive role in the return connectedness network.

Table 3. Net pairwise spillovers based on generalized FEVD

Series	CPU	MY_GS	ID_GS	ID_STOCK	MY_STOCK
CPU	0.000	2.035	0.227	−0.041	−0.029
MY_GS	−2.035	0.000	0.431	0.418	0.964
ID_GS	−0.227	−0.431	0.000	1.835	2.433
ID_STOCK	0.041	−0.418	−1.835	0.000	0.208
MY_STOCK	0.029	−0.964	−2.433	−0.208	0.000

Note(s): Net pairwise directional connectedness matrix derived from the generalized forecast error variance decomposition ($H = 10$). Each entry measures bilateral net spillover asymmetry between variables, computed as the contribution of shocks from market j to market i minus the reverse contribution. Positive values indicate that the row variable is a net receiver from the column variable, while negative values indicate net transmission

4.2 Dynamic connectedness: time variation in spillovers

Figure 1 plots the rolling TCI (window = 252 trading days), capturing how spillover intensity evolves over time. The rolling TCI ranges roughly from 15.55–20.55, with a pronounced increase from late 2023 into early 2024 and peaks in mid–late April 2024 (maximum around 20.55). This pattern indicates that the system becomes more interconnected during that period: cross-market shocks explain a larger fraction of forecast uncertainty, consistent with heightened common risk factors and stronger transmission channels.

Figure 2 reports the rolling NET connectedness (TO – FROM) for each series and exhibit several observations. First, CPU remains persistently negative (net receiver) for most of the sample, with values frequently below −1 and reaching close to −3 at times. This indicates that, in variance-decomposition terms, CPU is predominantly absorbing spillovers rather than driving them. Second, MY_STOCK is consistently positive, highlighting a stable role as a net transmitter of shocks within the system. Third, ID_STOCK is mostly positive, indicating that its transmitter role strengthens particularly during periods of elevated system connectedness. Finally, the sukuk markets exhibit more mixed roles: MY_GS is a transmitter

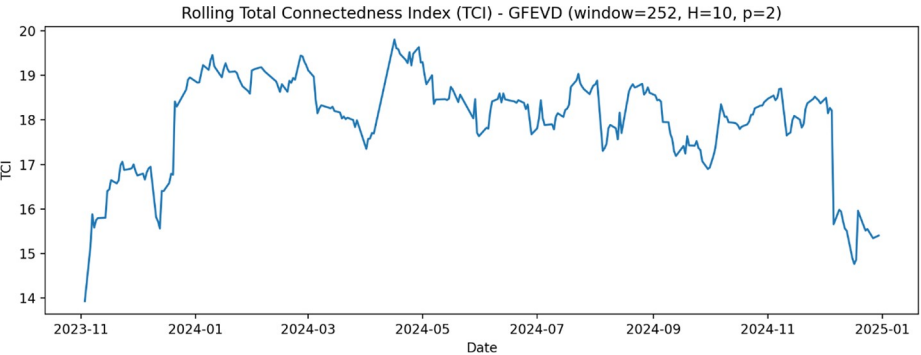


Figure 1. Time-varying total connectedness (rolling TCI) based on GFEVD

Note(s): The figure plots the rolling Total Connectedness Index (TCI) computed from a VAR(2) estimated over a 252-trading-day window and a generalized FEVD horizon of $H = 10$ trading days. Higher values indicate stronger system-wide spillovers (greater share of forecast uncertainty explained by cross-variable shocks) among CPU, green sukuk returns and equity returns

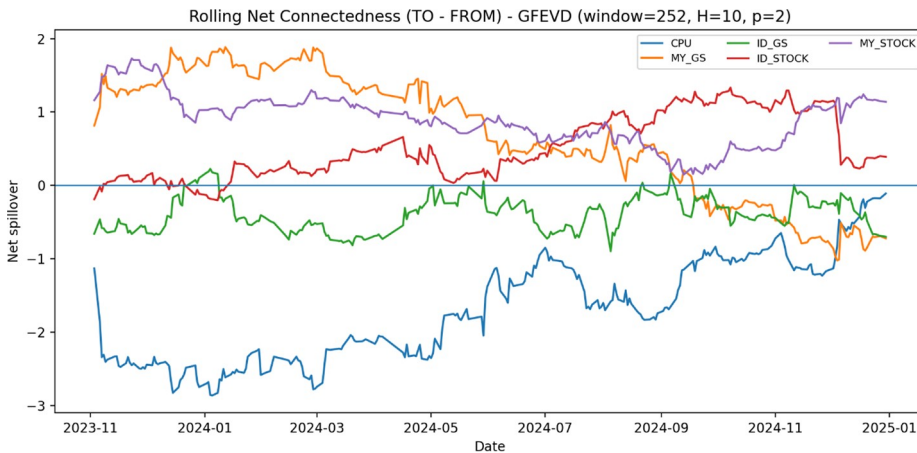


Figure 2. Rolling net directional connectedness based on GFEVD

Note(s): This figure shows rolling net spillovers $NET_i = TO_i - FROM_i$ for each variable using a 252-trading-day window, VAR(2), and $H = 10$ -day generalized FEVD. Positive (negative) values indicate that a variable is a net transmitter (net receiver) of shocks to the system. The figure highlights time variation in transmitter/receiver roles across CPU, green sukuk markets and equity markets

early in the sample but drifts toward weaker or negative net positions later, while ID_GS is mostly a net receiver. Overall, the dynamic evidence points to a system where equity markets dominate the transmission of shocks, while CPU plays a more reactive role in the return connectedness network.

4.3 Impulse responses to CPU shocks

To directly quantify the economic transmission of uncertainty, we also compute generalized impulse responses to a one-standard-deviation CPU innovation, with 95% bootstrap confidence bands. Figure 3 shows that across all four markets, the point responses are small in magnitude and mean-reverting, converging quickly toward zero within a few trading days. Importantly, the 95% confidence bands consistently include zero at all horizons for each response series, indicating that CPU shocks do not generate statistically distinguishable mean-return effects on either green sukuk or equity returns over the 20-day horizon. Economically, this suggests that while uncertainty may comove with market conditions, its incremental predictive effect on average returns is weak once the joint dynamics of the system are taken into account. A plausible reason is that uncertainty shocks may transmit more strongly through risk premia channels reflected in volatility or higher moments, rather than through sustained shifts in mean returns, or that markets incorporate such information rapidly, leaving limited persistent return impacts.

5. Additional analysis

To check the robustness of our findings, we also examine the comovements between CPU green sukuk (Malaysia and Indonesia), and the corresponding equity markets in the time–frequency domain using wavelet coherence based on the continuous wavelet transform (Grinsted *et al.*, 2004).

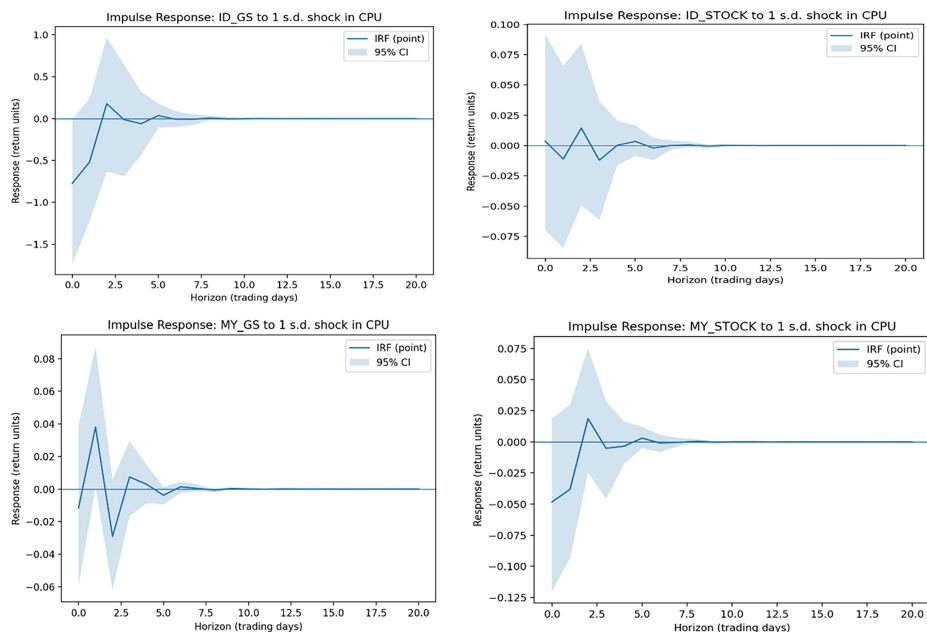


Figure 3. Generalized impulse response functions (GIRFs) to a one-standard-deviation CPU shock
Note(s): This figure reports the generalized impulse response of each market return series (MY_GS, ID_GS, ID_STOCK, MY_STOCK) to a one-standard-deviation innovation in CPU over 20 trading days, based on the estimated VAR(2). Shaded areas represent 95% bootstrap percentile confidence bands (residual bootstrap, $B = 300$). Responses are expressed in return units

Figure 4 of wavelet map indicates episodic coherence between CPU and MY_GS. The most visible coherence island appears around June 2023 in the 3–6-day band, with CPU leading and the series moving out of phase, suggesting a short-horizon inverse association during that episode. A second coherence island emerges around November 2023 in the 1–7-day band, where the series are largely in phase and CPU leads, pointing to a more synchronized short-horizon response at that time. A further coherence island is observed around May 2024 in the 2–6-day band, again with CPU leading but with an out-of-phase pattern, consistent with a renewed short-horizon divergence. Overall, the evidence for MY_GS indicates time-varying and episodic dependence with CPU rather than a persistent relationship. In contrast, the coherence plot suggests weak and largely sporadic dependence between CPU and ID_GS across horizons, implying that Indonesian green sukuk returns remain comparatively less sensitive to CPU over the sample period.

Similarly, For Malaysian stock market (MY_STOCK), a prominent coherence island appears from November 2022 to February 2023 in the 6–12-day band, with CPU leading and an in-phase pattern. This episode points to a sustained positive association at medium horizons during late 2022–early 2023. Outside this period, coherence is mostly scattered and intermittent, indicating that CPU does not exert a stable influence on Malaysian equity returns throughout the remainder of the sample.

The coherence map for ID_STOCK shows several recurring islands, particularly in the 6–9-day band, suggesting repeated medium-horizon sensitivity to CPU. The intermittent nature of

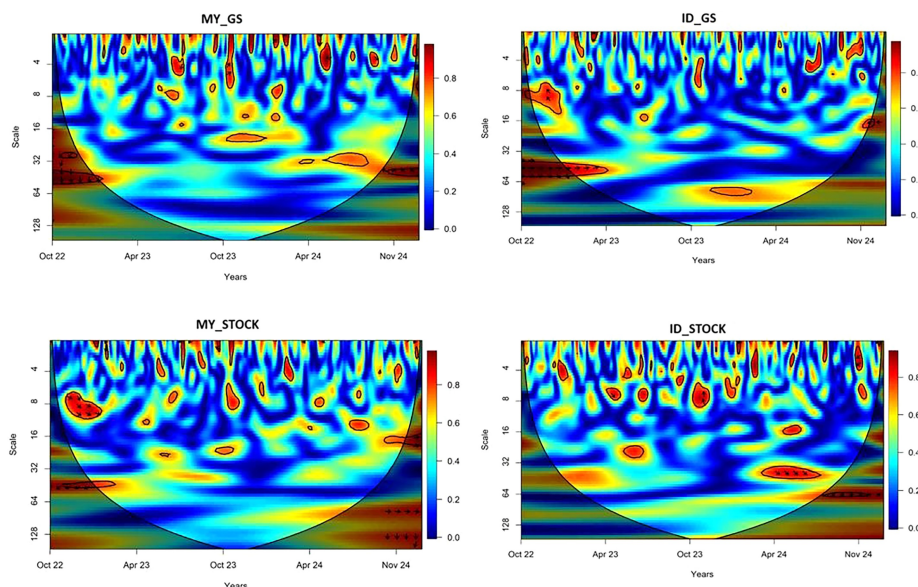


Figure 4. Comovement of asset classes with climate policy uncertainty

Note(s): The figures below show the intensity of the comovement between Climate Policy Uncertainty and asset classes (MY_GS, ID_GS, ID_STOCK, MY_STOCK). The comovement ranges from red (high) to blue (low). The statistical significance at 5%-level is represented by the black contours. Frequency-scale is on the left vertical axis, ranging from high-frequency (2–8 days), medium-frequency (8–32 days), to low-frequency (32–256 days), whereas the timescale is on the horizontal axis. The U-shaped solid black line marks the region influenced by edge effects. Phase differences, represented by black arrows, reveal both the lead-lag relationships and the causality type among variables. When arrows are horizontal (indicating a phase difference of zero), there is no lead-lag relationship. Arrows pointing to the left (right) suggest a negative (positive) association between asset classes, showing an out-of-phase (in-phase) relationship. If arrows are angled upward-left or downward-right, it indicates that the first variable leads the second. Conversely, arrows pointing upward-right or downward-left signify that the second variable leads, with the first one following

these islands indicates that Indonesian equities respond episodically, with dependence strengthening around specific periods rather than remaining continuous. In addition, a further coherence island appears around March 2024 to June 2024 at longer horizons, where CPU leads, implying a discernible medium-term adjustment of the equity market during that episode.

The findings from wavelet coherence points to heterogeneous and horizon-dependent linkages between CPU and financial markets. MY_GS exhibits episodic comovement with CPU, whereas ID_GS appears largely detached. For equities, MY_STOCK shows a pronounced coherence episode in late 2022–early 2023, while ID_STOCK displays more frequent but intermittent coherence islands. Therefore, these results support the view that the influence of CPU is time-varying, differs across asset classes and is concentrated in specific investment horizons.

6. Conclusion

This study examines the interaction between CPU, green sukuk markets and equity markets using the Diebold and Yilmaz connectedness framework based on generalized forecast error

variance decomposition and generalized impulse response functions. Using daily data for CPU, Malaysian and Indonesian green sukuk and Malaysian and Indonesian equity indices, the findings point to a system with moderate spillovers and clear differences in shock transmission roles across asset classes and over time.

The static connectedness results show a moderate level of system wide spillovers, with a Total Connectedness Index of 13.95. Spillovers are concentrated in the equity segment, where cross country equity linkages are the dominant transmission channel. Equity shocks account for a nontrivial share of variance in both sukuk series, particularly Indonesian green sukuk, indicating that stock market conditions are an important conduit through which shocks propagate into green debt markets. CPU is largely self-driven in variance terms and contributes only marginally to the forecast error variance of sukuk and equity returns, implying that uncertainty shocks are not a major source of return spillovers within this system.

The dynamic analysis confirms that connectedness is time varying. The rolling TCI fluctuates between 15.55 and 20.55, with the highest connectedness occurring in early 2024, consistent with periods in which common shocks and repricing strengthen cross market linkages. Rolling net connectedness measures further indicate that CPU remains a net receiver of shocks through most of the sample, whereas equity markets, especially Malaysian equities, more often serve as net transmitters. Green sukuk markets exhibit asymmetric and time varying roles, with Indonesian green sukuk generally absorbing shocks and Malaysian green sukuk shifting from net transmission early in 2024 to net reception later in the sample. These patterns suggest that increases in system wide connectedness reflect stronger financial market spillovers rather than CPU-led transmission.

Impulse response evidence aligns with these findings. Responses of green sukuk and equity returns to a one standard deviation CPU shock are small, short lived and typically not statistically distinguishable from zero once bootstrap confidence bands are considered. CPU therefore appears to be part of the broader information environment that moves with market conditions, but it does not generate persistent effects on daily mean returns in green sukuk and equity markets over the horizons examined.

These results carry implications for investors and policymakers. For investors, the limited mean return response to CPU shocks suggests that CPU is unlikely to substantially alter short horizon return dynamics in these markets, though it may still matter for risk through volatility and tail behavior. For policymakers, equity markets appear to be the primary conduit for spillover transmission, indicating that monitoring equity driven channels is important for financial stability assessments during periods of elevated uncertainty.

This paper has used ChatGPT (OpenAI) solely for copyediting support to improve the language clarity, grammar and overall structure. All the intellectual contributions, data analyses and interpretations are entirely the authors' own, and the authors take full responsibility for the accuracy and integrity of the paper.

Acknowledgements

This manuscript has used ChatGPT (OpenAI) solely for copyediting support to improve the language clarity, grammar, and overall structure. All the intellectual contributions, data analyses, and interpretations are entirely the authors' own, and the authors take full responsibility for the accuracy and integrity of the manuscript.

Notes

- [1.] See the following report for details. <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/586751546962364924>

- [2.] See the following report for detail. www.undp.org/stories/pioneering-green-sukuk-indonesia#:~:text=Further%20to%20investing%20in%20projects,low%2Dcarbon%2C%20sustainable%20future

References

- Alam, N., Duygun, M., and Ariss, R.T. (2016), "Green sukuk: an innovation in islamic capital markets", *Energy and Finance*, Springer, Cham, doi: [10.1007/978-3-319-32268-1_10](https://doi.org/10.1007/978-3-319-32268-1_10).
- Belkhir, N., Boujelbène, M. and Mezghani, T. (2025), "Exploring asymmetric effects of uncertainties on the time-varying nexus of green sukuk, clean and dirty energy markets under various market conditions", *Journal of Islamic Accounting and Business Research*.
- Billah, S.M. and Adnan, N. (2024), "Navigating environmental concerns and geopolitical risks: a study on green sukuk and Islamic equities amid climate crisis and the Russia-Ukraine conflict", *Energy Strategy Reviews*, Vol. 53, p. 101372.
- Chowdhury, T., Datta, R. and Mohajan, H. (2013), "Green finance is essential for economic development and sustainability. Published in", *International Journal of Research In Commerce, Economics and Management*, Vol. 3 No. 10, pp. 104-108.
- Demski, J., Dong, Y., McGuire, P. and Mojon, B. (2025), "Growth of the green bond market and greenhouse gas emissions", *BIS Quarterly Review*.
- Dervi, U.D., Khan, A., Saba, I., Hassan, M.K. and Paltrinieri, A. (2022), "Green and socially responsible finance: past, present and future", *Managerial Finance*, Vol. 48 No. 8, pp. 1250-1278.
- Diebold, F.X. and Yilmaz, K. (2009), "Measuring financial asset return and volatility spillovers, with application to global equity markets", *The Economic Journal*, Vol. 119 No. 534, pp. 158-171.
- Diebold, F.X. and Yilmaz, K. (2012), "Better to give than to receive: predictive directional measurement of volatility spillovers", *International Journal of Forecasting*, Vol. 28 No. 1, pp. 57-66.
- Dong, X. and Yu, M. (2024), "Green bond issuance and green innovation: evidence from China's energy industry", *International Review of Financial Analysis*, Vol. 94, p. 103281.
- Dusuki, A.W. (2008), "What does Islam say about corporate social responsibility", *Review of Islamic Economics*, Vol. 12 No. 1, pp. 5-28.
- Dusuki, A.W. and Abdullah, N.I. (2007), "Why do Malaysian customers patronise Islamic banks?", *International Journal of Bank Marketing*, Vol. 25 No. 3, pp. 142-160.
- Grinsted, A., Moore, J.C. and Jevrejeva, S. (2004), "Application of the cross wavelet transform and wavelet coherence to geophysical time series", *Nonlinear Processes in Geophysics*, Vol. 11 Nos 5-6, pp. 561-566.
- Hariz, F., Mezghani, T. and Abbes, M.B. (2025), "Modeling dependence structure between green sukuk spread in Malaysia and the uncertainty factors before and during the COVID-19 pandemic", *Journal of Islamic Accounting and Business Research*, Vol. 16 No. 5, pp. 950-975.
- ICMA (2025), "Green bond principles: voluntary process guidelines for issuing green bonds. Guidelines, June".
- Ji, Q., Ma, D., Zhai, P., Fan, Y. and Zhang, D. (2024), "Global climate policy uncertainty and financial markets", *Journal of International Financial Markets, Institutions and Money*, Vol. 95, p. 102047.
- Khairisma, K., Yoesoef, Y.M. and Syarif, M.F. (2025), "Green sukuk impact: stock market reactions and SDG contributions of pioneering issuers", *Journal of Islamic Marketing*.
- Koop, G., Pesaran, M.H. and Potter, S.M. (1996), "Impulse response analysis in nonlinear multivariate models", *Journal of Econometrics*, Vol. 74 No. 1, pp. 119-147.

- Lee, E., Kim, J.Y. and Lee, Y. (2025), "A comparative analysis of green sukuk and green bonds", *International Journal of Islamic and Middle Eastern Finance and Management*, Vol. 18 No. 6.
- Li, C., Xu, Y., Gill, A., Haider, Z.A. and Wang, Y. (2019), "Religious beliefs, socially responsible investment, and cost of debt: evidence from entrepreneurial firms in India", *Emerging Markets Review*, Vol. 38, pp. 102-114, doi: [10.1016/j.ememar.2018.12.001](https://doi.org/10.1016/j.ememar.2018.12.001).
- Louche, C. (2004), *Ethical Investment: Processes and Mechanisms of Institutionalisation in the Netherlands, 1990–2002*, Erasmus University, Rotterdam.
- Lütkepohl, H. (2000), "Bootstrapping impulse responses in VAR analyses", in *COMPSTAT: Proceedings in Computational Statistics 14th Symposium Held in Utrecht, The Netherlands, 2000*, Physica-Verlag HD, Heidelberg, pp. 109-119.
- Ma, D., Zhang, D., Guo, K. and Ji, Q. (2024), "Coupling between global climate policy uncertainty and economic policy uncertainty", *Finance Research Letters*, Vol. 69, p. 106180.
- Mehta, P., Singh, M. and Mittal, M. (2020), "It is not an investment if it is destroying the planet: a literature review of socially responsible investments and proposed conceptual framework", *Management of Environmental Quality: An International Journal*, Vol. 31 No. 2, pp. 307-329.
- Mohd Zain, F.A., Muhamad, S.F., Abdullah, H., Sheikh Ahmad Tajuddin, S.A.F. and Wan Abdullah, W.A. (2024), "Integrating environmental, social and governance (ESG) principles with maqasid al-shariah: a blueprint for sustainable takaful operations", *International Journal of Islamic and Middle Eastern Finance and Management*, Vol. 17 No. 3, pp. 461-484.
- Mounir, A.M. (2021), "Prudence and temperance in portfolio selection with shariah-compliant investments", *International Journal of Islamic and Middle Eastern Finance and Management*, Vol. 14 No. 4, pp. 753-766.
- Muhammad, S.N., Cheema, S., Mohamad Ariff, A., Nik Him, N.F. and Muhmad, S.N. (2024), "Systematic literature review and bibliometric analysis of green finance and renewable energy development", *Sustainable Development*, Vol. 32 No. 6, pp. 7342-7355.
- Paltrinieri, A., Hassan, M.K., Bahoo, S. and Khan, A. (2023), "A bibliometric review of sukuk literature", *International Review of Economics and Finance*, Vol. 86, pp. 897-918.
- Pesaran, H.H. and Shin, Y. (1998), "Generalized impulse response analysis in linear multivariate models", *Economics Letters*, Vol. 58 No. 1, pp. 17-29.
- Pirgaip, B. and Arslan-Ayaydin, O. (2024), "Exploring the greenium in the green sukuk universe: evidence from the primary market", *International Journal of Islamic and Middle Eastern Finance and Management*, Vol. 17 No. 3, pp. 423-440.
- Rahim, S.R.M. and Mohamad, Z.Z. (2018), "Green sukuk for financing renewable energy projects", *TUJISE*, Vol. 5 No. 2, p. 129.
- Santoso, I.R. (2020), "Green sukuk and sustainable economic development goals: mitigating climate change in Indonesia", *Global Journal Al-Thaqafah*, Vol. 10 No. 1, pp. 18-26.
- Schueth, S. (2003), "Socially responsible investing in the United States", *Journal of Business Ethics*, Vol. 43 No. 3, pp. 189-194.
- Siswanto, D. (2018), "Performance of Indonesian green sukuk (Islamic bond): a sovereign bond comparison analysis, climate change concerns?", In *IOP Conference Series: Earth and Environmental Science*, Vol. 200 No. 1, p. 012056.
- Tang, D.Y. and Zhang, Y. (2020), "Do shareholders benefit from green bonds?", *Journal of Corporate Finance*, Vol. 61, p. 101427.
- Ulfah, I.F., Sukmana, R., Laila, N. and Sulaeman, S. (2024), "A structured literature review on green sukuk (Islamic bonds): implications for government policy and future studies", *Journal of Islamic Accounting and Business Research*, Vol. 15 No. 7, pp. 1118-1133.

Ullah, S., Jamali, D. and Harwood, I.A. (2014), "Socially responsible investment: insights from Shari'a departments in Islamic financial institutions", *Business Ethics: A European Review*, Vol. 23 No. 2, pp. 218-233.

Wilson, R. (1997), "Islamic finance and ethical investment", *International Journal of Social Economics*, Vol. 24 No. 11, pp. 1325-1342.

Corresponding author

Ashraf Khan can be contacted at: ashraf.khan@unive.it

International
Journal of Islamic
and Middle
Eastern Finance
and Management

1401
