A comparative analysis of green sukuk and green bonds

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International Journal of Islamic and Middle Eastern Finance and Management

1353

Received 17 December 2024
Revised 20 March 2025
Accepted 4 April 2025

Abstract

Purpose – The purpose of this study is to examine whether green sukuk and green bonds exhibit distinct performance in the market, assessing whether they function as separate financial assets. Additionally, it analyses their market dynamics to determine the extent of their connectedness within Malaysia's green finance sector.

Design/methodology/approach – The data include yield to maturity for each working day over an 8-year period, from 1 January 2017 to 2 April 2024, for both green sukuk and green bonds. This study investigates the difference between the two instruments and measures their performance using statistical approaches, such as a paired sample *t*-test and the Granger causality test.

Findings – This study reveals a significant difference in mean returns between green sukuk and green bonds, indicating distinct return profiles. Additionally, it finds that green sukuk offers higher returns than green bonds. Finally, this study finds no causal relationship between the two markets in Malaysia, demonstrating that green sukuk and green bonds are distinct financial assets.

Originality/value – To the best of the authors' knowledge, this is the first empirical analysis to examine the performance of green sukuk and green bonds using an extensive green sukuk data set.

Keywords Green finance, Green sukuk, Green bonds, Bond performance, Yield to maturity, Causality

Paper type Research paper

1. Introduction

The crisis induced by climate change has further intensified the need for sustainable development. Addressing this issue and achieving sustainable economic growth requires substantial capital. For instance, the Asian Development Bank estimates that developing countries will require an annual investment of US$210bn from 2016 to 2030 to sustain growth, reduce poverty and respond to climate change (Abdullah and Keshminder, 2022). This substantial funding demand has driven both the public and private sectors to explore new mechanisms for mobilising capital. In particular, as many companies increasingly

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2022S1A5C2A03093594).

International Journal of Islamic and Middle Eastern Finance and Management
Vol. 18 No. 6, 2025
pp. 1353-1373
Emerald Publishing Limited
1753-8394
DOI 10.1108/IMEFM-12-2024-0609

incorporate environmental protection into their core social responsibility activities, the demand for investment in eco-friendly projects has grown further (Iqbal *et al.*, 2024).

Governments and corporations are increasingly adopting green financing to fund initiatives aimed at mitigating environmental challenges. Among green financial instruments, green bonds have become essential for funding environmentally friendly projects, playing a vital role in promoting sustainable economic transitions. First issued by the European Investment Bank in 2007, green bonds are designed to finance projects that specifically aim to enhance environmental sustainability (Asl *et al.*, 2023). In addition to supporting eco-friendly initiatives, green bonds offer financial advantages such as positive stock price performance, improved stock liquidity and risk and return diversification, which have attracted widespread investor interest (Asl *et al.*, 2023; Maltais and Nykvist, 2020). With the global green bonds market reaching a valuation of US$2tn in 2022 and projected to grow to US$5tn by 2025, green bonds are positioned as essential tools for advancing global environmental and sustainability goals (Billah *et al.*, 2023b).

In contrast, within Islamic finance – where traditional interest-bearing bonds are prohibited under *Shariah* (Islamic law) principles – sukuk are widely used as *Shariah*-compliant debt instruments that facilitate liquidity in capital markets (Almaskati, 2022). Sukuk differs from conventional bonds by providing asset-based returns instead of interest-based income, allowing Islamic finance markets to access capital while adhering to *Shariah* principles. As the global green bonds market has expanded, green sukuk has similarly emerged as a novel tool within Islamic finance to support environmentally sustainable projects (Liu and Lai, 2021; Septiana and Dewi, 2008). Countries such as Indonesia and Malaysia have already issued green sukuk to finance renewable energy projects and sustainable infrastructure, highlighting its potential to address both environmental and economic development needs in the Islamic world.

Green bonds and green sukuk are green financial instruments designed to finance environmentally sustainable projects. However, they differ significantly in terms of structure, ownership matter and regulatory compliance. Green bonds are fixed-income securities in which the issuer raise capital from investors and commits to periodic interest payments along with the return of principal at maturity, following a standard debt-based financing structure. In contrast, green sukuk operates under an asset-backed or asset-based financing model (Billah and Adnan, 2024), thereby granting investors partial ownership of the underlying projects and entitling them to returns generated from the associated cash flows. Moreover, while green bonds comply with the green bonds principles (GBP) or the climate bonds initiative (CBI) standards (Liu and Lai, 2021), green sukuk must adhere to both environmental and *Shariah* compliance requirements (Billah and Adnan, 2024; Liu and Lai, 2021), aligning with Islamic ethical standards.

Given these fundamental differences, a clear comparison of green bonds and green sukuk in terms of financial performance and economic implications is essential. Currently, green bonds and green sukuk are the most widely used instruments for green financing, particularly in countries with an established Islamic finance system. However, their adoption is expected to expand beyond these regions as traditional financing faces limitations in financing green projects. While there is considerable comparative research on sukuk and conventional bonds, studies specifically comparing green sukuk and green bonds remain scarce. Although both instruments support environmentally sustainable projects, their structural differences – particularly the *Shariah*-compliant nature of green sukuk – may lead to variations in performance within the green economy. Despite the relatively small size of the green sukuk market, its role in sustainable finance is growing, making it essential to assess its viability and potential advantages over conventional green bonds. Given Malaysia's well-developed green finance market, which provides sufficient data on both instruments, analysing their performance is crucial for understanding their financial and economic implications. Such

research can offer valuable policy insights for investors, regulators and other stakeholders. With the rapid growth of green finance and increasing environmental concerns, a comprehensive comparative analysis is needed to bridge this research gap and contribute to the broader discourse on sustainable finance.

Therefore, this study compares the performance of green sukuk and green bonds, and their market relationships within the green economy. To the best of our knowledge, this is the first empirical study to comprehensively examine the performances of these two green finance instruments. This study contributes to the fields of green finance and Islamic finance by providing empirical evidence that offers valuable insights and policy implications for issuers, investors and policymakers. As green finance continues to play an increasingly important role in global sustainability efforts, this study provides valuable guidance for improving investment strategies and policy decisions, contributing to both the academic discourse and practical applications in sustainable finance.

This study uses a paired sample *t*-test to investigate performance differences between green sukuk and green bonds. The data set includes daily yield to maturity (YTM), which serves as an important indicator of bond performance for green sukuk and green bonds issued in Malaysia. As the pioneering country in green sukuk issuance in 2017, Malaysia continues to lead in private-sector issuance. Thus, its market provides a sufficient volume of private issuance, ensuring robust and reliable data for analysis. The data set spans the period from 1 January 2017 to 2 April 2024, covering the period following the inaugural green sukuk issuance. Additionally, this study uses the Granger causality test to examine the connectedness between their returns.

This study reveals several significant findings. Firstly, there is a significant difference in the mean returns between green sukuk and green bonds. This result indicates distinct return profiles for these two instruments. Secondly, this study shows that the return of green sukuk is higher than that of green bonds by suggesting that green sukuk provides greater economic benefits to investors. Finally, this study finds no causal relationship between green sukuk and green bonds market in Malaysia. This lack of interdependence highlights clear evidence that green sukuk is a different financial asset from green bonds and demonstrates their potential as valuable tools for portfolio diversification.

This study makes a valuable contribution to the fields of green finance and Islamic finance. Despite the growing importance and interest in green finance, there is a lack of empirical research analysing the two different green finance instruments. This study provides empirical findings that offer valuable insights and policy implications for issuers, investors and policymakers. These insights help guide the development of green finance and support informed investment decisions.

The remainder of this paper is organised as follows: Section 2 presents an overview of sukuk and green sukuk. Section 3 reviews the relevant literature. Section 4 describes the research methodology and data. Section 5 reports and analyses the study's empirical findings. Finally, Section 6 concludes the paper.

2. An overview of sukuk and green sukuk

2.1 Sukuk

Islamic finance, a rapidly growing alternative financial system, is based on Islamic economic principles derived from *Shariah* (Islamic law) (Farag *et al.*, 2018). Over the past two decades, Islamic finance has gained significant attention from governments, corporations and investors. Global Islamic financial assets have expanded by 69% in the past five years and by 163% in the past decade, reaching US$4.5tn (ICD and LSEG, 2023). Particularly, Islamic banks' resilience during the 2008 financial crisis sparked interest in Islamic financial

instruments worldwide, including non-Muslim countries (Ahmed, 2009; Asutay and Sidek, 2020; Asutay and Turkistani, 2015; Belal *et al.*, 2014).

Among Islamic finance instruments, sukuk (Islamic bonds) have emerged as the most popular, providing *Shariah*-compliant liquidity in debt capital markets (Almaskati, 2022). According to the Islamic Finance Service Board and the Auditing and Accounting Organisation of the Islamic Financial Institutions, sukuk is a certificate that represents holders' proportionate ownership in undivided shares of tangible assets, usufructs, services or assets of specific projects (IFSB, 2016; Umar *et al.*, 2023). The first sukuk was issued by Malaysia in 1990, and the country remains a leader in the global sukuk market (Asl *et al.*, 2023). The value of sukuk outstanding in 2022 was US$788.39bn, a threefold increase from US$260.03bn in 2012 (ICD and LSEG, 2023).

There are ongoing debates regarding the similarities and differences between sukuk and conventional bonds. Both instruments provide a stream of payments to holders, have fixed-term maturity and are traded on secondary markets (Samitas *et al.*, 2021; Umar *et al.*, 2023). Simultaneously, sukuk's unique characteristics lead to diverse perspectives on performance and sustainability as investment options. Unlike conventional bonds, which can finance a wider range of assets and projects, sukuk must adhere to *Shariah* principles, ensuring that the underlying assets and income flows are permissible by *Shariah*. This includes prohibiting activities such as interest (*riba*), excessive uncertainty (*gharar*) and gambling (*maisir*) (Billah *et al.*, 2023a; Samitas *et al.*, 2021; Naeem *et al.*, 2023). Sukuk represent ownership in tangible assets or projects, with sukuk holders sharing the earnings generated, whereas conventional bonds represent a debt obligation that relies on the issuer's creditworthiness (Hossain *et al.*, 2021). This asset-based structure provides sukuk with certain advantages, such as greater stability and the potential for higher revenue sharing (Fathurahman and Fitriati, 2013).

Empirical studies on the performance of sukuk and conventional bonds have produced mixed results. Some researchers have argued that sukuk are similar to conventional bonds, replicating the mechanism (Ayturk *et al.*, 2017; El-Mosaid and Boutti, 2014). They note that sukuk, like conventional bonds, have fixed-term maturities, predetermined profit rates and are traded in financial markets, showing a yield-price relationship. Consequently, these studies find no significant differences in returns or yields between sukuk and bonds. For example, El-Mosaid and Boutti (2014) found a positive correlation between the two instruments, indicating no difference in returns. Similarly, Ayturk *et al.* (2017) found that the main factors affecting primary market spreads for both sukuk and bonds are similar, suggesting that market participants view these instruments similarly.

In contrast, some studies have highlighted significant differences between sukuk and bonds, focusing on the unique features and compliance requirements of sukuk. These differences can affect their performance and risk characteristics (Afshar, 2013; Fathurahman and Fitriati, 2013; Hossain *et al.*, 2021). For instance, Balli *et al.* (2021) documented significant differences in how sukuk and bond yields are determined. Similarly, Asmuni and Tan (2021) confirmed significant yield differences between government-issued sukuk and bonds in the Malaysian market. These findings are further supported by Ariff *et al.* (2013), who demonstrate that yield curves for the same issuer, term and rating vary significantly between sukuk and bonds. Similarly, Saad *et al.* (2020) confirmed a noticeable gap in yield spreads between these instruments.

2.2 Green sukuk

Green sukuk, a combination of sukuk and green finance, is used to fund environmentally sustainable *Shariah*-compliant projects (Liu and Lai, 2021; Septiana and Dewi, 2008). Green

sukuk, while sharing many similarities with traditional sukuk, are distinct in their exclusive financing of projects that are both *Shariah*-compliant and environmentally focused. This aligns closely with Islamic principles of environmental stewardship and the ethical use of resources. The Quran, the holy book of Islam, particularly, emphasises the importance of preserving natural resources and avoiding harm to the environment. For instance, Surah Al-Baqarah (2:205) states:

> And when they leave, they strive throughout the land to cause corruption therein and destroy crops and animals. And Allah does not like corruption.

Additionally, Surah Al-A'raf (7:31) reminds believers to avoid wastefulness:

> Eat and drink, but be not excessive. Indeed, He likes not those who commit excess.

These two Quranic verses underscore the Islamic duty to protect natural resources and avoid waste. Furthermore, the Prophet Muhammad highlighted the importance of resource conservation, as illustrated in the Hadith, the recorded sayings and actions of the Prophet Muhammad:

> Do not waste water, even if performing ablution on the banks of a flowing river. (Sunnah Ibn Majah)

The Quranic verses and the Hadith reflect the goals of green sukuk, which aim to finance projects that mitigate environmental damage while ensuring compliance with *Shariah* principles. Through these investments, green sukuk contributes to the protection of both nature and the ethical use of resources, in line with Islamic teachings.

The first green sukuk was issued in Malaysia by Tadu Energy Sdn. Bhd in 2017, and since then, the market has experienced rapid growth (Azhgaliyeve, 2021; Raghim and Mohammad, 2018). Green sukuk issuance grew five-fold between 2017 and 2021, reaching US$12bn (Ulfah *et al.*, 2023). Indonesia currently holds the largest share of the green sukuk market, issuing 54% (US$5.5bn) of the total, predominantly through government issuance, while Malaysia leads in private-sector issuance, accounting for US$1bn (Azhgaliyeve, 2021).

While green sukuk shares many characteristics with traditional sukuk, their main distinction lies in the fact that green sukuk exclusively fund projects that are both *Shariah*-compliant and environmentally focused, such as renewable energy, energy efficiency and climate change mitigation (El-Amri *et al.*, 2021; Musari and Hidayat, 2023; World Bank, 2020). Green sukuk have been recognised as an important instrument for tackling climate change and supporting sustainable development. The rapid growth in green sukuk issuance, especially with large investments in renewable energy projects, highlights their role as a critical tool for addressing sustainability problems (Ulfah *et al.*, 2023).

2.3 Green bonds vs green sukuk

Green bonds and green sukuk are both financial instruments designed to fund environmentally sustainable projects. However, they differ significantly in terms of structure, ownership and regulatory compliance.

Green bonds are fixed-income securities where issuers raise capital from investors and commit to periodic interest payments (coupons) along with a return of principal at maturity. These bonds follow the standard debt-based financing structure used in global bond markets. In contrast, green sukuk complies with *Shariah* and operates under an asset-backed or asset-based financing model (Billah and Adnan, 2024). Instead of interest payments, green sukuk provides returns to investors through profit–loss sharing contracts and underlying assets such

as *Ijarah* (leasing), *Murabahah* (cost-plus sale) or *Mudarabah* (profit and loss sharing agreements) (Pirgaip and Arslan-Ayaydin, 2024). This ensures that investments are tied to tangible assets rather than conventional debt instruments.

Another key difference differences between green bonds and green sukuk lies in ownership and investor rights. In a green bond, investors act as creditors where they lend money to the issuer and receive fixed interest payments. If the issuer defaults, bondholders have legal claims based on debt obligations, but they do not hold ownership of any underlying assets. Green sukuk investors, however, are considered asset holders or beneficiaries rather than creditors (Alam *et al.*, 2013). Since sukuk must be linked to a tangible asset, investors share ownership of the underlying project and receive returns from the generated cash flows. This means that, in the event of default, sukuk holders may have direct rights to the project's assets, depending on the sukuk structure (Pirgaip and Arslan-Ayaydin, 2024). This fundamental difference results in distinct risk and return profiles between these two instruments.

Regarding the regulatory standards, green bonds must comply with the GBP issued by the International Capital Market Association or the CBI standards (Liu and Lai, 2021), ensuring that proceeds are allocated to sustainable projects with transparent reporting. These frameworks provide globally recognised guidelines for green bond issuance. Green sukuk, however, requires both environmental and Shariah compliance. In addition to meeting GBP or CBI standards, issuers must obtain Shariah certification to confirm that the structure aligns with Islamic ethical standards (Billah and Adnan, 2024; Liu and Lai, 2021). This dual certification process makes green sukuk issuance more complex and often more costly than green bonds. While both instruments promote green financing, green sukuk is distinct in requiring dual-layered verification to ensure both environmental and religious compliance.

3. Literature review

There is extensive research on the performance comparison between sukuk and conventional bonds; however, the results remain inconclusive. For instance, Fathurahman and Fitriati (2013) found that the mean YTM of sukuk is generally higher than that of conventional bonds, a finding that is supported by Ariff *et al.* (2017). These higher yields may be due to sukuk's liquidity premium and asset backing, which provide investors with the potential for asset appreciation (Haque *et al.*, 2017; Afshar, 2013; Alam *et al.*, 2013). Additionally, sukuk's close connection to the real economy offers long-term stability, potentially leading to higher returns (Haque *et al.*, 2017). The profit- and loss-sharing model of sukuk also offers the possibility of generating higher revenues than conventional bonds (Fathurahman and Fitriati, 2013). In contrast, Almaskati (2022) found that sukuk have lower returns than bonds, indicating a higher cost of holding sukuk than bonds. This result might be due to the high demand for sukuk investments and limited investment opportunities compared to conventional bonds (Djelassi and Boukhatem, 2020; Godlewski *et al.*, 2013). Almaskati (2022) suggested that issuers can take advantage of this pricing disparity by issuing more sukuk than bonds, benefiting from lower issuance expenses.

The literature has also explored the relationship between sukuk and conventional bonds. Haque *et al.* (2017) used the Granger causality test and wavelet coherence approach to find a significant causal relationship between sukuk and bonds across different maturities. Their findings align with those of Samitas *et al.* (2021), who identified a strong interconnectedness between sukuk and bond markets, particularly during external shocks. However, other studies have suggested that sukuk and conventional bonds are not closely related. For instance, Naifar and Hammoudeh (2016) found no significant relationship between uncertainty in conventional markets and sukuk returns, suggesting that sukuk may offer

diversification benefits. Similarly, Ariff *et al.* (2013) documented no causality between sukuk and bonds. Hossain *et al.* (2021) also found no long-term relationship between sukuk and bonds, reinforcing the notion that sukuk and bonds are not inherently interconnected.

The relationship between green bonds and sukuk has been examined in the context of green finance. Billah *et al.* (2023b) empirically examined the asymmetric relationship and spillover effects between sukuk and green bonds. They found that these two classes are interconnected. Similarly, Billah *et al.* (2023a) investigated the return connectedness between sukuk and green bonds, revealing that while the connectedness is relatively low during average market conditions, it becomes significantly stronger during extreme market conditions. Karim and Naeem (2022) confirmed this, noting that although sukuk and green bonds exhibit low connectedness during stable periods, their correlation increases significantly in volatile market environments. These findings emphasise the complex and dynamic nature of the relationship between sukuk and green bonds.

Several studies have examined the pricing and yield behaviours of green sukuk. Pirgaip and Arslan-Ayaydin (2024) found that green sukuk tend to be issued at lower yields than non-green sukuk, suggesting that investors may accept lower returns in exchange for supporting environmentally sustainable projects – a concept known as the "greenium". This contrasts with the findings of Roslen *et al.* (2021), who reported that the median and long-term yields of green sukuk in Malaysia were significantly higher than those of non-green sukuk, highlighting regional differences and market-specific factors.

However, empirical studies on green sukuk are limited. A systematic literature review on green sukuk by Ulfah *et al.* (2023) showed that most existing research is predominantly theoretical or qualitative, accounting for 50%, whereas less than 30% used quantitative or empirical approaches. Given the significant differences in operating principles and contractual structures between sukuk and bonds and the lack of empirical studies comparing green sukuk and green bonds, there is a notable research gap in this area. This study aims to fill this gap by providing a comprehensive empirical comparison of green sukuk and green bonds, which will contribute to a better understanding of the current green finance performance.

4. Methodology

4.1 Comparison and statistical significance

To compare the market performance of green sukuk and green bonds, this study uses a paired sample *t*-test, focusing on the YTM, to identify any statistically significant differences in their returns. This method is selected because of the unbalanced nature of the samples, making it necessary to match them one-to-one for a more accurate comparison. A paired sample *t*-test ensures comparability by matching instruments based on specific criteria, controlling for confounding variables and enhancing the reliability of the results (Ross and Willson, 2017). It also allows for a direct comparison of mean returns over the same period (Field, 2013). Other methods, such as an independent *t*-test or the Mann–Whitney U test, were considered; however, they were found to be less appropriate for this analysis. An independent *t*-test does not account for the imbalance between the two samples, and the Mann–Whitney U test, which is suitable for non-parametric data, does not effectively handle paired data. A paired sample *t*-test is widely used in the existing literature to compare the performance of sukuk and bonds (see: Ariff and Safari, 2012; Haque *et al.*, 2017; Hossain *et al.*, 2021).

In this study, the matching criteria include the same tenure, rating, period and market to ensure the comparability of the paired samples. A paired sample *t*-test compares the mean

difference between two related groups; in this case, the returns of green sukuk and green bonds. The *t*-value is calculated using the following equation:

$$t = \frac{\overline{d}}{s_d/\sqrt{n}}$$

where:

- $\overline{d}$ is the mean of the differences between paired observations.
- s_d is the standard deviation of the differences.
- is the number of paired observations.

This study applies the Granger causality test to examine the relationship between green sukuk and green bonds. As each pair is issued in the same market and period, their yields are expected to correlate. The test identifies whether the past returns of one instrument can predict the future returns of the other, offering insights for investors and policymakers on the dynamics between these financial instruments (Hossain *et al.*, 2021). This test is widely used to compare the relationship between sukuk and bonds (see: Ariff and Safari, 2012; Haque *et al.*, 2017; Hossain *et al.*, 2021). We use a vector autoregression (VAR) model to perform the Granger causality test. The VAR model captures the linear interdependencies among multiple time series by analysing the impact of past values of green sukuk on the current value of green bonds and vice versa. The VAR model is represented by the following equations:

$$Y_t = \alpha_1 + \sum_{i=1}^{p} \beta_i Y_{t-1} + \sum_{i=1}^{p} \delta_i X_{t-1} + \epsilon_{1t}$$

$$X_t = \alpha_2 + \sum_{i=1}^{p} \gamma_i Y_{t-1} + \sum_{i=1}^{p} \theta_i X_{t-1} + \epsilon_{2t}$$

where:

- Y_t and X_t represent the returns of green sukuk and green bonds, respectively, at time *t*.
- is the number of lags.
- β_i, γ_i, δ_i, θ_i are the coefficients to be estimated.
- ϵ_{1t} and ϵ_{2t} are the error terms.
- α_1 and α_2 are the constants.

In this study, the appropriate number of lags for the VAR model is determined using the Schwarz Bayesian Information Criterion (SBIC), and a lag length of two is selected accordingly. SBIC is chosen as the primary criterion because it is more conservative and less prone to overfitting, which is particularly important when sample sizes are smaller or moderate (Bruns and Stern, 2019). This lag length ensures that the model appropriately captures the dynamic interactions between green sukuk and green bonds over time, thus providing robust results for the Granger causality test.

Two additional tests are conducted to ensure robustness. The Welch *t*-test is used to check the robustness of a paired sample *t*-test between the yields of green sukuk and green bonds. The Welch *t*-test is robust and reliable when dealing with unequal sample sizes and variances because it adjusts the degrees of freedom and provides a more accurate estimate of the

significance level (Greene, 2000). Moreover, the Granger causality test is performed with different lag lengths. For robustness, the Hannan–Quinn Information Criterion (HQIC) with a lag order of three is applied, as HQIC balances the risk of both overfitting and underfitting, making it ideal for robustness checks (Mainassara and Kokonendji, 2016). HQIC's effectiveness in minimising these risks has been widely recognised in the literature (Agiakloglou and Tsimpanos, 2021).

4.2 Data

This study examines the performance of green sukuk and green bonds using their YTM. The sample comprises daily YTM data as an important indicator of bond performance and returns for green sukuk and green bonds issued in Malaysia from 1 January 2017 to 2 April 2024. Corporate bonds and fixed-income securities are selected. The sample period begins in 2017, as this is the earliest available data for green sukuk and green bonds in Malaysia and extends to 2 April 2024, which was the most recent data available at the time of collection for this study.

Malaysia is a leading country, with the most sukuk value outstanding of US$300bn (ICD and LSEG, 2023). In terms of the green sukuk market, Tadu Energy Sdn. Bhd issued the first green sukuk in Malaysia (Raghim and Mohammad, 2018). Although a large amount of green sukuk comes from Indonesia owing to government issuance, Malaysia has the largest number of corporate issuers (Azhgaliyeve, 2021). Therefore, we choose the Malaysian market to compare corporate bonds between green sukuk and green bonds.

Data for this study are obtained from the Thomson Reuters Eikon and Datastream databases, ensuring a comprehensive and reliable data set. The total number of observations includes 13,398 data points for green sukuk and 13,398 data points for green bonds. This extensive data set allows for a robust analysis of the YTM of these instruments.

4.2.1 Descriptive statistics. Table 1 presents the descriptive statistics for the YTM of green sukuk and green bonds, providing an overview of their performance during the study period.

Green sukuk range from a minimum of 1.621 to a maximum of 8.551 with a standard deviation of 1.784. In contrast, green bonds range from a minimum of 3.667 to a maximum of 5.900, with a standard deviation of 0.689, suggesting a narrower distribution. The standard deviation of green sukuk is higher than that of green bonds, regardless of the maturity. This means that green sukuk have more variable returns than green bonds. Fathurahman and

Table 1. Descriptive statistics

Types	Mean	Median	Max.	Min.	SD	Skew.	Kurt.	N
Green sukuk	5.288	5.209	8.551	1.621	1.784	0.296	2.834	13,398
Green bonds	4.609	4.458	5.900	3.667	0.689	0.418	1.927	13,398
Short-term green sukuk	3.762	3.774	6.191	0.895	1.271	−0.505	3.575	4,253
Short-term green bonds	4.094	4.049	4.871	3.555	0.347	0.613	2.650	4,253
Long-term green sukuk	6.035	5.480	8.636	4.215	1.495	0.765	2.043	9,145
Long-term green bonds	4.854	4.822	6.086	3.707	0.700	0.061	1.877	9,145

Note(s): Mean denotes the average YTM of each variable. Median indicates the middle value of the YTM when the data is arranged in ascending order. *Max.* denotes the maximum YTM observed. *Min*. indicates the minimum YTM observed. *SD* represents the standard deviation, a measure of the dispersion or variability in the YTM values. Skew. denotes a skewness and *Kurt*. denotes a Kurtosis, respectively. *N* denotes the number of observations in the data set

Source(s): Authors' own work

Fitriati (2013) and Hossain *et al.* (2021) also found that sukuk portfolios have higher standard deviations than conventional bond portfolios, indicating greater volatility and risk.

The higher risk may be due to structural differences, such as asset ownership and earnings dependency on the underlying asset. Sukuk performance is directly linked to the operational success and profitability of these assets (Hossain *et al.*, 2021). Additionally, various sukuk structures (e.g. *Ijarah*, *Murabahah*, *Mudarabah* and *Musharakah*) introduce complexities and risks not present in the lender-borrower relationship of conventional bonds (Hossain *et al.*, 2021). Lower market liquidity also contributes to higher risk, leading to greater price volatility (Hossain *et al.*, 2021). Finally, additional regulatory requirements by *Shariah*, along with the need to adhere to environmental standards, may introduce operations risks and compliance costs (Hossain *et al.*, 2021).

Moreover, green sukuk shows a relatively high mean of 5.288 compared to green bonds, with a mean of 4.609. This indicates that, on average, green sukuk offers higher returns than green bonds. Regarding maturity levels, short-term green bonds have a higher mean value of 4.094 than short-term green sukuk, which have a mean value of 3.762. This suggests that, in the short term, green bonds tend to provide higher returns than green sukuk. Conversely, long-term green sukuk have a higher mean value of 6.035 than long-term green bonds with a mean value of 4.854. This indicates that, over the long term, green sukuk tend to offer higher returns than green bonds.

4.2.2 Regression analysis of green sukuk characteristics. To further examine the yield characteristics of green sukuk, this study uses an ordinary least squares (OLS) regression model with year-fixed effects to account for time-specific variations. The model specifies YTM as the dependent variable and includes a green sukuk dummy as the main independent variables, along with several control variables such as amount issued, credit rating, spread to treasury and bid yield.

Table 2 presents the result, indicating that green sukuk exhibit significantly higher YTM compared to green bonds, even after controlling for these factors. This finding is consistent with the descriptive statistics in Table 1, which show that the mean YTM of green sukuk is higher than that of green bonds.

In addition, this study investigates the key determinants of green sukuk issuance using a logit regression model, where the dependent variable is a dummy indicating whether a bond is a green

Table 2. Regression analysis of YTM

Variable	Yield to maturity
Green sukuk dummy	0.060*** (0.0057)
Amount issued	−0.148*** (0.0024)
Rating	−0.063*** (0.0033)
Spread to treasury	0.050*** (0.0017)
Bid yield	0.401*** (0.0044)
Intercept	5.574*** (0.1688)
R^2	0.606
Observations	192,078

Note(s): Yield to maturity (YTM) is the dependent variable. *Green sukuk dummy* represents the type of bond, where 1 indicates a green sukuk and 0 indicates a green bond. *Amount issued* refers to the total bond issuance size. *Rating* denotes the bond's credit rating. *Spread to treasury* measures the difference between the bond's yield and the corresponding treasury yield. *Bid yield* represents the yield at which the bond is bid in the market. Standard error is reported in parentheses. Statistical significance levels are denoted as follows: *$p < 0.10$, **$p < 0.05$ and ***$p < 0.01$

Source(s): Authors' own work

sukuk (1) or a green bond (0). The primary independent variables include credit rating, amount issued and tenure, while additional control variables account for market and financial factors.

Table 3 presents the results, demonstrating how credit rating, issuance amount and tenure influence the likelihood of green sukuk issuance. The findings indicate that credit rating has a negative and significant effect on green sukuk issuance, suggesting that bonds with higher credit ratings are less likely to be issued as green sukuk. Similarly, issuance amount also exhibits a negative and significant relationship, implying that larger bond issuances are less likely to be structured as green sukuk. In contrast, tenure has a positive and significant effect, indicating that bonds with longer maturities are more likely to be issued as green sukuk.

In summary, green bonds tend to have higher credit ratings and larger issuance sizes compared to green sukuk, whereas green sukuk are more commonly issued with longer maturities.

5. Results and discussion

5.1 Mean difference

Table 4 shows the results of the paired sample *t*-test between the YTM of green sukuk and green bonds. The mean difference is 0.67, which is statistically significant. This result rejects the null hypothesis of no difference between green sukuk and green bonds. The result indicates that the YTM of green sukuk differs significantly from that of green bonds, highlighting the significant divergence in the performance of these two types of green financial instruments. This result contradicts the common belief that sukuk can serve as a substitute for conventional bonds in debt financing (Ayturk *et al.*, 2017; El-Mosaid and Boutti, 2014).

The significant difference might be due to the fundamental distinction between sukuk and bond features, which stems from their contractual arrangements, in which sukuk operate on different principles and structures, impacting their performance and risk characteristics

Table 3. Logit model for green sukuk issuance

Variable	Coefficient	Std. error	z-value	$p > \|z\|$	95% CI lower	95% CI upper
Rating	−3.780	0.045	−83.25	0.000	−3.869	−3.690
Amount issued	−3.225	0.034	−96.06	0.000	−3.291	−3.159
Tenure	0.370	0.009	39.28	0.000	0.352	0.389
z-spread	0.002	0.002	0.81	0.418	−0.002	0.005
Mid yield	1.091	0.051	21.59	0.000	0.992	1.190
Clean price	1.071	0.403	25.20	0.000	0.988	1.155
FX rate	−138.661	4.976	−27.87	0.000	−148.414	−128.908
Intercept	60.215	0.709	84.88	0.000	58.824	61.605
Pseudo R^2	0.638					
Observations	189,098					

Note(s): The dependent variable is a binary indicator, where 1 represents a green sukuk and 0 represents a green bond. *Coefficient* indicates the change in the log-odds of green sukuk issuance relative to green bonds for a one-unit increase in the corresponding independent variable. *Std. error* measures the precision of the coefficient estimate. *z-value* is the test statistic, calculated as the coefficient divided by its standard error. $p > |z|$ denotes the p-value, which tests whether the coefficient is significantly different from zero. The *95% CI lower* and *95% CI Upper* are the bounds of the 95% confidence interval. *Rating* refers to the bond's credit rating. *Amount issued* represents the total bond issuance size. *Tenure* indicates the bond's maturity period. *z-spread* measures the yield difference between the bond and a benchmark risk-free rate. *Mid Yield* is the midpoint yield between the bid and ask prices. *Clean Price* represents the bond price excluding accrued interest. *FX rate* captures the impact of foreign exchange fluctuations

Source(s): Authors' own work

Table 4. Paired t-test results for YTM differences

Instrument	N	Mean	Diff.	*t*-value	*p*-value
Green sukuk	13,398	5.28	0.67	58.45	0.000***
Green bond	13,398	4.60			

Note(s): *N* indicates the total number of observations, *Mean* represents the mean YTM values of green sukuk and green bonds and *Diff.* denotes the difference in mean YTM values between green sukuk and green bonds. The *t-values* represent the ratio of the difference between the paired observations to the standard error of the difference. The *p-value* indicates the probability that the observed differences occurred by chance, with significance levels denoted as $*p < 0.10$, $**p < 0.05$ and $***p < 0.01$
Source(s): Authors' own work

(Afshar, 2013; Ariff and Safari, 2012; Fathurahman and Fitriati, 2013; Hossain *et al.*, 2021). For example, sukuk are based on underlying assets, and sukuk holders own those assets and share earnings with issuers rather than having a lender-borrower relationship (Hossain *et al.*, 2021). By contrast, bonds are simply promissory notes or debt papers (Hossain *et al.*, 2021). These differences make sukuk and bonds distinct products, leading investors to expect different returns from green sukuk and green bonds. This result confirms the differing performance of green sukuk and green bonds and aligns with empirical studies that find significant differences between sukuk and bonds, such as Asmuni and Tan (2021) and Ariff and Safari (2012).

Moreover, Table 4 shows that the YTM for green sukuk (5.28) is significantly higher than that of green bonds (4.60), indicating that investing in green sukuk currently offers higher yields for investors. The results of this study align with those of Fathurahman and Fitriati (2013), who found that the average yield of sukuk is higher than that of conventional bonds. Several factors explain the higher returns of green sukuk. Firstly, the higher return may be due to the risk premium for green sukuk. As shown in the descriptive statistics in Table 1, the standard deviation of green sukuk is higher than that of green bonds. Fathurahman and Fitriati (2013) found that risk, measured by the standard deviation, is greater for sukuk than for conventional bonds. This suggests that the higher risk level of sukuk may lead to higher returns, consistent with the risk-return trade off theory, which suggests that higher risk leads to higher expected returns (Ramírez *et al.*, 2022). Additionally, green sukuk must comply with both environmental and *Shariah* principles. Dual compliance increases complexity and volatility, making green sukuk riskier than conventional green bonds.

Secondly, the liquidity premium of sukuk may also contribute to the higher returns of green sukuk. The sukuk market is generally less liquid than the conventional bonds market (Haque *et al.*, 2017). Consequently, investors may demand higher returns to compensate for the difficulty in buying and selling sukuk quickly.

Thirdly, the higher returns may come from basic differences in sukuk's operational principles and contractual structure. The cash flow for sukuk comes from the earnings of the underlying assets; therefore, investors can benefit from asset appreciation and the success of these assets. Sukuk can offer better returns when the underlying assets generate high profits (Afshar, 2013; Alam *et al.*, 2013; Fathurahman and Fitriati, 2013). Additionally, owing to the profit- and loss-sharing mechanisms, it is possible to obtain higher revenue sharing compared to conventional bonds (Fathurahman and Fitriati, 2013; Haque *et al.*, 2017).

As a sub-sample analysis, the YTM of green sukuk and green bonds is further analysed by dividing the sample into two groups based on maturity: short-term and long-term. Short-term maturity is defined as less than five years, whereas long-term maturity is defined as more than five years. The *t*-test results for these groups are summarised in Table 5. Table 5 shows

Table 5. YTM paired *t*-test results by maturity

Maturity	N	Mean		Diff.	*t*-value	*p*-value
		Green sukuk	Green bond			
Short term	4,253	3.76	4.09	−0.33	−19.70	0.000***
Long term	9,145	6.03	4.85	1.18	108.48	0.000***

Note(s): *Short-term* maturity is defined as less than five years, while *long-term* maturity is defined as more than five years. The results show the mean differences in YTM between green sukuk and green bonds for each maturity category. The causality tests are conducted considering a lag of two periods. *N* indicates the total number of observations, *Mean* represents the mean YTM values of green sukuk and green bonds and *Diff.* denotes the difference in mean YTM values between green sukuk and green bonds. The *t*-values represent the ratio of the difference between the paired observations to the standard error of the difference. The *p-value* indicates the probability that the observed differences occurred by chance, with significance levels denoted as *$p < 0.10$, **$p < 0.05$ and ***$p < 0.01$
Source(s): Authors' own work

that for short-term maturity, the mean YTM for green sukuk is 3.76, whereas the mean YTM for green bonds is 4.09. The mean difference in YTM between green sukuk and green bonds for this group is −0.33, which is statistically significant. This indicates that, for short-term tenure, green bonds offer a higher yield than green sukuk.

Conversely, for bonds with a long-term tenure, the mean YTM for green sukuk is 6.03, whereas the mean YTM for green bonds is 4.85. This means that the difference in YTM between green sukuk and green bonds is 1.18, which is statistically significant. This indicates that, for long-term maturity, green sukuk offers a significantly higher yield than green bonds. This result aligns with that of Haque *et al.* (2017), who found that sukuk's average yield is generally higher than that of bonds over the long term. It suggests that green sukuk could be a good investment option for investors seeking long-term debt financing.

This study's sample shows that long-term green sukuk are more common than short-term ones, contributing to their higher returns. Green sukuk are typically issued for periods longer than five years, as indicated by the greater number of long-term issuances. This extended holding period and lower liquidity in the secondary market may result in less correlation with other assets, leading to higher returns owing to market illiquidity (Almaskati, 2022).

5.2 Granger causality

The previous section demonstrated that the mean yields of green sukuk are statistically different from those of green bonds in the same market. This suggests that green sukuk and green bonds are distinct types of securities. However, because each pair of securities is issued in the same market and period, their yields are expected to be highly correlated. Therefore, this study examines the Granger causality. The pairwise Granger causality tests are conducted to investigate the predictive relationships between green sukuk and green bonds. The results are summarised in Table 6. The null hypotheses are as follows:

H1. Green bond does not Granger-cause green sukuk yield.

H2. Green sukuk does not Granger-cause green bonds yield.

Given the insignificant *p*-value level, this study cannot reject the null hypothesis for both tests at any reasonable level of significance. These findings suggest that the price movements or returns of green sukuk do not provide predictive information about the future price movements or

Table 6. Pair-wise Granger causality tests

Null	Chi-squared	Degrees of freedom	*p*-value	Conclusion
Green bond does not Granger-cause green sukuk	0.2211	2	0.895	Do not reject
Green sukuk does not Granger-cause green bond	1.1679	2	0.558	Do not reject

Note(s): The first panel provides the test results for the hypothesis that changes in the yields of green bond do no not affect changes in the yields of green sukuk. The second panel presents the test statistics for the hypothesis that changes in the yields of green sukuk do not affect changes in the yields of green bond. The *Chi-squared* denotes the Chi-squared statistic value obtained from the test. *Degree of Freedom* represents the degrees of freedom associated with the Chi-squared test. *Conclusion* indicates the results of the hypothesis test based on the *p*-value, specifying whether the null hypothesis is rejected or not. *p-value* indicates the probability that the observed results occurred by chance, with significance levels denoted as $*p < 0.10$, $**p < 0.05$, $***p < 0.01$
Source(s): Authors' own work

returns of green bonds, and vice versa. In other words, there is no causality relationship between the yields of green sukuk and green bonds. This lack of causal relationship implies that, despite both securities being categorised under green finance and sharing similar features and environmental objectives, they operate independently in the market.

This result is consistent with Hossain *et al.* (2021), who found that the performance of bonds does not significantly impact the performance of sukuk, further validating that sukuk are fundamentally distinct from conventional bonds. Additionally, Ariff and Safari's (2012) findings showed no causal relationship between sukuk and bond yields. Naifar and Hammoudeh (2016) argued that sukuk and bonds are complementary markets and do not substitute for their distinct roles and features.

The absence of a causal relationship can be attributed to several factors. Firstly, green sukuk and green bonds may attract investors with distinct strategies and risk preferences. For example, green sukuk investors may prioritise *Shariah* compliance and ethical investing, whereas green bond investors may focus more on the environmental impact on financial returns. Secondly, the underlying assets and issuance mechanisms differ between sukuk and bonds, potentially leading to differences in market dynamics. Sukuk are asset-backed and involve shared ownership in tangible assets, projects or investments, whereas bonds are debt instruments that represent loans (Hossain *et al.*, 2021). This fundamental difference means that sukuk returns depend on the performance of the underlying assets, whereas bond returns are primarily influenced by interest rates and the issuer's creditworthiness. These differences can result in different risk profiles, investor behaviours and market responses to sukuk and bonds. Finally, as green financial instruments are still relatively new, their market behaviours may not yet be well integrated (Bachelet *et al.*, 2019; Karpf and Mandel, 2018).

The results of the Granger causality test confirm the findings of the paired sample *t*-test, showing a significant difference in the mean YTM between green sukuk and green bonds. These results indicate that the yields of green sukuk and green bonds are not only different but also do not influence each other, highlighting the lack of connectedness between these two green financial instruments. Therefore, this study clearly demonstrates that green sukuk are distinct financial assets from green bonds.

5.3 Robustness test

5.3.1 Welch t-test. As shown in Table 7, the Welch *t*-test is conducted to support the initial paired sample *t*-test results. Given the imbalance in the sample size between green sukuk and green bonds, the Welch *t*-test is appropriate because it addresses the sample imbalance and

Table 7. Welch *t*-test for YTM differences

Instrument	N	Mean	Diff.	*t*-value	*p*-value
Green sukuk	178,904	5.104	0.053	7.1817	0.000***
Green bond	13,620	5.050			

Note(s): *N* indicates the total number of observations, *Mean* represents the mean YTM values of green sukuk and green bonds and *Diff.* denotes the difference in mean YTM values between green sukuk and green bonds. The *t*-values represent the ratio of the difference between the paired observations to the standard error of the difference. The *p-value* indicates the probability that the observed differences occurred by chance, with significance levels denoted as *$p < 0.10$, **$p < 0.05$ and ***$p < 0.01$
Source(s): Authors' own work

differences in variance between the groups (Greene, 2000). Given the significant *p*-value level (0.000), it is concluded that the mean difference of YTM between green sukuk and green bonds is significantly different and the mean of YTM of green sukuk is higher than that of green bonds. This result supports the initial findings of this study by using the paired sample *t*-test.

5.3.2 Pair-wise Granger causality test with a lag 3. Table 8 summarises the results of the Granger causality test with a lag of three periods. This study could not reject the first null hypothesis, with a *p*-value of 0.989. In other words, there is no significant evidence that changes in green bond yields can predict changes in green sukuk yields. This result supports the initial result of the Granger causality test with a lag of two periods.

However, with a *p*-value of 0.090, the second null hypothesis is rejected at the 10% significance level. This suggests that changes in green sukuk yields can weakly predict changes in green bond yields by indicating a potential unidirectional causality from green sukuk to green bonds but not vice versa. This result is consistent with Haque *et al.* (2017), who found that bonds are influenced by sukuk in the long term.

These results may be attributed to the significance of Malaysia's sukuk market. In Malaysia's green finance market, the issuance of green sukuk outweighs that of green bonds. The Malaysian Government actively supports the sukuk market, including green sukuk, through various measures such as tax incentives and favourable regulations (SCM, 2019).

Table 8. Pair-wise Granger causality tests lag 3

Null	Chi-squared	Degrees of freedom	*p*-value	Conclusion
Green bond does not Granger-cause green sukuk	0.122	3	0.989	Do not reject
Green sukuk does not Granger-cause green bond	6.502	3	0.090*	Reject at 10% significance

Note(s): The first panel provides the test results for the hypothesis that changes in the yields of green bond do no not affect changes in the yields of green sukuk. The second panel presents the test statistics for the hypothesis that changes in the yields of green sukuk do not affect changes in the yields of green bond. The *Chi-squared* denotes the Chi-squared statistic value obtained from the test. *Degree of Freedom* represents the degrees of freedom associated with the Chi-squared test. *Conclusion* indicates the results of the hypothesis test based on the *p*-value, specifying whether the null hypothesis is rejected or not. *p-value* indicates the probability that the observed results occurred by chance, with significance levels denoted as *$p < 0.10$, **$p < 0.05$ and ***$p < 0.01$
Source(s): Authors' own work

This robust support promotes the issuance and use of sukuk, further increasing their attractiveness to issuers and investors. The large sukuk market in Malaysia contributes to the Granger causality results, showing that the green sukuk market influences the green bonds market in the country. For example, price movements in the green sukuk can provide valuable information for green bond investors, influencing green bond yields and overall market dynamics (Balli *et al.*, 2021; Bhuiyan *et al.*, 2019).

This finding suggests that if the Malaysian Government and regulatory bodies implement policies to encourage the green sukuk market, it can positively impact the overall green finance market in Malaysia by influencing the green bonds market.

5.3.3 Risk comparison between green bonds and green sukuk. To further assess the differences between green sukuk and green bonds, a paired sample *t*-test is conducted using duration as a measure of risk. Since the primary analysis identified significant differences in YTM between green sukuk and green bonds, this test examines whether these instruments also exhibit differences in risk profiles.

Table 9 presents that green sukuk have a significantly higher mean duration (1.40) compared to green bonds (1.01). The difference in duration (0.39) is statistically significant, confirming that the duration of green sukuk and green bonds differs meaningfully. Given that duration is a key measure of interest rate risk, the longer duration of green sukuk suggests that they may be more sensitive to interest rate fluctuations and, consequently, subject to higher interest rate risk.

The findings align with the main analysis, which demonstrated that the YTM of green sukuk differs significantly from that of green bonds. This reinforces the notion that these two financial instruments exhibit substantial differences not only in terms of return (YTM) but also in risk exposure.

5.3.4 Regression analysis of green sukuk yield to maturity and risk. To further validate the findings from the Granger causality test, a regression analysis is conducted to examine whether green bonds YTM and risk influence green sukuk YTM and risk. The primary analysis using Granger causality revealed no significant relationship between green sukuk and green bonds. However, given that Malaysia's green bonds market is larger, there remained a possibility that the green bonds market dynamics could still impact green sukuk performance, even if direct causality was not detected.

To address this concern, this regression model serves as a robustness check, testing whether green bonds YTM and risk have any explanatory power over green sukuk YTM and risk. The analysis uses an OLS model with year-fixed effects to control for time-specific variations. The analysis consists of two models. Model (1) examines the determinants of green sukuk YTM, with green bonds YTM as the main independent variable, while

Table 9. Paired *t*-test results for risk differences

Instrument	N	Mean	Diff.	*t*-value	*p*-value
Green sukuk	13,398	1.40	0.39	46.3981	0.000***
Green bond	13,398	1.01			

Note(s): *N* indicates the total number of observations, *Mean* represents the mean *duration* values of green sukuk and green bonds and *Diff.* denotes the difference in mean *duration* values between green sukuk and green bonds. The *t*-values represent the ratio of the difference between the paired observations to the standard error of the difference. The *p-value* indicates the probability that the observed differences occurred by chance, with significance levels denoted as $*p < 0.10$, $**p < 0.05$ and $***p < 0.01$
Source(s): Authors' own work

Model (2) investigates the determinants of green sukuk risk, using green bonds risk as the main independent variable. In Model (2), risk is measured by duration, which reflects the sensitivity of the bond to interest rate fluctuations. Several control variables are included.

Model (1) in Table 10 shows that green bond YTM has an insignificant effect on green sukuk YTM, indicating that green bond yields do not significantly influence green sukuk yields. Despite potential market spillover effects, green bonds YTM does not serve as a determinant for green sukuk YTM, reinforcing the idea that these instruments function as distinct asset classes.

Model (2) demonstrates that green bonds risk also has an insignificant effect on green sukuk risk, suggesting that the risk structure of conventional green bonds does not carry over to green sukuk. This further confirms that the green sukuk market is not driven by risk dynamics in the green bonds market.

Overall, this regression analysis supports the Granger causality findings that green sukuk and green bonds markets operate independently, even though the green bonds market in Malaysia is larger.

6. Conclusion

The increasing number of environmental problems has highlighted the importance of environmental conservation and sustainable development. Consequently, numerous industries are now adopting green practices as part of their business models. Green finance plays a significant role in supporting environmentally friendly projects and investments. Green bonds and green sukuk, as major instruments in green finance, have grown rapidly in recent years owing to increasing global interest.

This study examines and compares the performance of green sukuk and green bonds issued in Malaysia using a paired sample *t*-test with daily YTM data. Additionally, we investigate the connectedness between the yields of green sukuk and green bonds using the Granger causality test.

Table 10. Regression analysis of green sukuk yield and risk

Variable	(1) Sukuk YTM	(2) Sukuk risk
Bond YTM	0.174 (0.0988)	
Bond risk		0.152 (0.1879)
Amount issued	−0.035 (0.0207)	0.171* (0.0811)
Rating	−0.455*** (0.0958)	−0.122 –(0.1217)
Duration	0.187*** (0.0136)	
Bid yield change	0.287 (0.2398)	0.056 (0.0559)
z-spread		0.032*** (0.0322)
Intercept	2.086*** (0.5472)	−2.893** (−2.8931)
R^2	0.599	0.869
Observations	13,179	13,398

Note(s): *Bond YTM* represents the yield to maturity of green bond. *Bond risk* is measured using duration. *Amount issued* refers to the total bond issuance size. *Rating* denotes the bond's credit rating. *Duration* captures the sensitivity of bond to interest rate changes. *Bid yield change* represents fluctuations in the bid yield. *z-spread* measures the yield difference between the bond and a benchmark risk-free rate. Standard error is reported in parentheses. Statistical significance levels are denoted as follows: *$p < 0.10$, **$p < 0.05$ and ***$p < 0.01$

Source(s): Authors' own work

This study finds a significant difference in the mean yields between green sukuk and green bonds, indicating distinct return profiles for these two instruments. Specifically, the return on green sukuk is significantly higher than that on green bonds. This finding suggests that green sukuk are a more attractive investment option for those seeking higher yields in the green finance market. Additionally, this study finds no causal relationship between green sukuk and green bonds, implying that the performance of green sukuk does not predict or directly impact the performance of green bonds and vice versa. This suggests that the two green financial instruments operate independently.

Although this study focuses on the Malaysian market owing to limited data availability, its findings are not confined to Malaysia. Given Malaysia's significant role in the global sukuk market and increasing global interest in green and Islamic finance, these results provide valuable policy insights for countries beyond Malaysia, regardless of whether they use Islamic finance. The findings suggest that green sukuk, which offers higher returns than green bonds, presents a compelling investment option, particularly for long-term investors. Furthermore, green sukuk can enhance portfolio diversification as they are not closely linked to the green bonds market, providing a safeguard against market downturns. This diversification may be especially beneficial for investors seeking ethical or religious investments and for those in non-Islamic finance countries, as green sukuk offers better returns and risk management.

From the issuer's perspective, green sukuk's higher yields compared to green bonds can attract a wider range of investors, especially those who need *Shariah*-compliant options. Issuers can also benefit from risk diversification by balancing their portfolios with both green sukuk and green bonds. Moreover, issuers in non-Islamic finance countries can explore issuing green sukuk in the global market to raise funds for environmental projects, thereby expanding their investor base.

The results highlight the need for policymakers to develop distinct strategies to support both green sukuk and green bonds. The performance differences and lack of correlation between the two instruments suggest the need for tailored policies, particularly in Islamic finance countries. A balanced approach to green finance can help manage risks while promoting a country's sustainable development.

In countries not using Islamic finance, policymakers can encourage domestic investors seeking higher returns and risk diversification to invest in foreign green sukuk markets. This can be achieved by supporting domestic channels for green sukuk investments, such as mutual funds or exchange-traded funds, providing tax incentives and implementing educational initiatives in Islamic finance. Additionally, domestic companies can be encouraged to issue green sukuk in foreign markets to fund their environmental projects, taking advantage of the high international demand. Government-backed issuance programmes, regulatory support and the provision of local market information can facilitate this process, fostering the growth of sustainable and environmentally friendly projects.

Future research could expand to include a larger sample size and more countries as the issuance of green sukuk expands globally. Additionally, incorporating various performance and risk indicators will enhance understanding the behaviour of green sukuk and green bonds.

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