





“Blockchain-enabled verification, reporting quality, and green sukuk pricing: Evidence from Malaysia, Indonesia, Saudi Arabia, and the UAE”

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ARTICLE INFO	Ayman Bader, Zaid Mohammad AL Hawatmah and Munif Zoubi (2026). Blockchain-enabled verification, reporting quality, and green sukuk pricing: Evidence from Malaysia, Indonesia, Saudi Arabia, and the UAE. <i>Investment Management and Financial Innovations</i> , 23(2), 301-313. doi: 10.21511/imfi.23(2).2026.23
DOI	http://dx.doi.org/10.21511/imfi.23(2).2026.23
RELEASED ON	Monday, 01 June 2026
RECEIVED ON	Saturday, 06 December 2025
ACCEPTED ON	Tuesday, 05 May 2026
LICENSE	 This work is licensed under a Creative Commons Attribution 4.0 International License
JOURNAL	"Investment Management and Financial Innovations"
ISSN PRINT	1810-4967
ISSN ONLINE	1812-9358
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”



NUMBER OF REFERENCES

59



NUMBER OF FIGURES

0



NUMBER OF TABLES

8

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BUSINESS PERSPECTIVES



LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10,
Sumy, 40022, Ukraine
www.businessperspectives.org

Type of the article: Research Article

Received on: 6th of December, 2025

Accepted on: 5th of May, 2026

Published on: 1st of June, 2026

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Conflict of interest statement:

Author(s) reported no conflict of interest

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BLOCKCHAIN-ENABLED VERIFICATION, REPORTING QUALITY, AND GREEN SUKUK PRICING: EVIDENCE FROM MALAYSIA, INDONESIA, SAUDI ARABIA, AND THE UAE

Abstract

Creating credibility and transparency in green finance is a persistent challenge, particularly in Islamic capital markets, where green sukuk must satisfy Shariah-compliant structuring and credible verification of environmental use of proceeds. This study examines whether blockchain adoption strengthens disclosure verifiability, improves financial reporting quality, and reduces the cost of capital in green sukuk markets. Using annual issuer-level panel data (2016–2025) from Malaysia, Indonesia, Saudi Arabia, and the UAE, we apply a staggered Difference-in-Differences design and validate the estimates using Double Machine Learning under high-dimensional controls. Blockchain adoption is associated with faster and more credible reporting, reducing audit-report lag by 12.4 days ($p < 0.01$), discretionary accruals by 1.8 percentage points ($p < 0.05$), and the probability of restatement by 8.1 percentage points ($p < 0.05$). Financing conditions also improve issue spreads fall by 21.7 bps ($p < 0.01$), secondary z-spreads by 18.3 bps ($p < 0.05$), and bid-ask spreads by 5.6 bps ($p < 0.05$). Mechanism tests show that adoption increases the Text-to-Ledger Alignment Index ($\delta = 0.142$, $p < 0.01$), indicating that verifiable alignment between narratives and traceable records is a key channel. Cross-country results are strongest in Malaysia and the UAE, consistent with higher regulatory readiness. Overall, blockchain appears to function as both an integrity-enhancing reporting infrastructure and a credibility signal; scaling these benefits requires policy and standards harmonization.

Keywords

blockchain, sukuk, sustainability, disclosure, transparency, verification, governance, pricing

JEL Classification

G12, G14, Q56

INTRODUCTION

Green finance has become an important means of directing capital toward sustainability objectives, but its effectiveness depends on more than the volume of funds raised. It also depends on whether the environmental claims attached to those funds are credible and verifiable. This issue is especially important in Islamic capital markets, where green sukuk are expected to satisfy two forms of accountability simultaneously: compliance with Shariah principles and credible reporting on the environmental use of proceeds. When verification is weak, the problem extends beyond individual issuers. It affects investor confidence, pricing efficiency, and the broader legitimacy of sustainable Islamic finance. In many cases, green sukuk reporting remains largely issuer-driven and retrospective, which makes timely verification difficult. The result is of-

ten delayed disclosure, inconsistent reporting formats, limited comparability, and uneven assurance quality. Under such conditions, market expansion may continue even while confidence in the credibility of green claims remains fragile.

Blockchain has drawn attention because it offers a practical way to strengthen traceability, transparency, and auditability within reporting systems. By linking disclosures more closely to verifiable records, it may reduce information asymmetry and improve confidence in use-of-proceeds reporting. At the same time, these benefits should not be assumed to appear uniformly across all green sukuk markets. Their practical value depends on the institutional setting in which the technology is introduced, including the quality of disclosure rules, the extent of assurance integration, and the capacity of regulators and market participants to use traceable information effectively. For that reason, this study focuses on Malaysia, Indonesia, Saudi Arabia, and the UAE. These jurisdictions were selected not simply because they are active green sukuk markets, but because they represent different institutional environments in which blockchain-based verification may operate. Malaysia provides the most mature and comparatively harmonized reporting environment in the sample. The UAE reflects stronger fintech experimentation and growing verification innovation. Saudi Arabia is a rapidly expanding market where harmonization is still evolving. Indonesia, by contrast, reflects a policy-led green sukuk setting in which digital verification remains less embedded in routine reporting practice. The value of this four-country design, therefore, lies in institutional contrast rather than geographic spread.

1. LITERATURE REVIEW

Green financing has moved to the forefront of the global sustainability agenda as financial systems increasingly mobilize capital for renewable energy, climate adaptation, and low-carbon development pathways (Iacobuță et al., 2022). Within this shift, Islamic finance is often positioned as a complementary route to sustainable finance because its ethical foundations and governance principles can align financial intermediation with wider societal and environmental objectives (Keshminder et al., 2022; Mahama & Yakubu, 2025). This convergence is most visible in green sukuk, where Shariah-compliant structures fund environmentally eligible projects. The focus on Malaysia, Indonesia, Saudi Arabia, and the UAE is justified by their market prominence and by their contrasting regulatory and digital-readiness conditions within contemporary green sukuk development (Alhowaish, 2025; Balative et al., 2025). Yet market growth alone does not ultimately resolve the central problem: credibility in green sukuk is priced, and credibility depends on verifiability.

The integrity of green sukuk markets remains constrained by the credibility of environmental and impact information. Empirical discussions highlight persistent disclosure timing gaps, heterogeneous reporting formats, and limited standard-

ization of assurance practices, which collectively reduce comparability and weaken investor verification (Alshehadeh et al., 2023; Faizi, 2024). These are not peripheral frictions; they shape whether proceeds allocation can be traced to eligible projects and whether claimed impacts can be linked to implementation rather than narrative intent (Raeni et al., 2022). Where verification is weak or inconsistent, greenwashing becomes more plausible, raising reputational risk for issuers and weakening the informational content of green labels (Al-Shaghdari et al., 2024). The challenge is amplified in Islamic sustainable finance because issuers must meet international ESG expectations while also demonstrating Shariah compliance, increasing disclosure complexity, and intensifying the need for credible verification infrastructures (Alshehadeh et al., 2024; Hakim, 2024). In this setting, more disclosure can coexist with low trust for investors if disclosures remain difficult to audit, compare, and authenticate credibly (Bader et al., 2025).

This gap clarifies why the linkage between blockchain, reporting quality, and green sukuk pricing deserves separate treatment. In these markets, pricing in the form of spreads and liquidity reflects not only credit fundamentals but also an information premium linked to verification uncertainty. Reporting quality – timeliness, compa-

rability, and resistance to manipulation – serves as a practical proxy for that uncertainty because it shapes how confidently investors can assess both financial performance and the credibility of sustainability commitments. Blockchain matters insofar as it changes the disclosure-production process: by embedding traceability and auditability into transaction records, it can tighten the link between sustainability claims, use-of-proceeds narratives, and verifiable evidence for investors and regulators in practice today. If that tightening occurs, reporting becomes more credible and less delay-prone; if credibility improves, perceived information risk should decline, and the premium demanded for unverifiable green claims should compress. If adoption is largely symbolic or poorly integrated into assurance routines, however, pricing may not improve even when issuers adopt blockchain language.

The literature then turns from the problem to the proposed mechanism. Blockchain technology is increasingly presented as a way to strengthen integrity and accountability in sustainable finance reporting. As a decentralized, transparent, and cryptographically secured ledger, blockchain is commonly framed as limiting *ex post* alteration of recorded information and improving auditability for stakeholders (Chong, 2021; Mhlanga, 2025). Beyond recording, smart contracts can automate rule-based actions once predefined conditions are met, allowing monitoring and compliance triggers to be embedded in financing arrangements and linked to performance milestones (Mzoughi et al., 2024). Conceptually, these features can shift disclosure away from episodic, *ex post* narratives toward more continuous verification, where claims are reconciled with transaction-linked evidence rather than relying on issuer statements. The same literature also identifies a governance caveat: immutable ledgers do not guarantee truthful inputs, and verification gains depend on standardized reporting rules, credible assurance integration, and the quality of off-chain data that feeds implementation.

Within Islamic finance, blockchain's relevance extends beyond general transparency to Shariah-compliance verification and sukuk structuring. Sukuk credibility depends on demonstrable asset linkage and traceable ownership documentation,

and blockchain-based records can strengthen the evidential basis of ownership and transaction flows over time (Morshed, 2025b). Tokenization further expands this potential by enabling fractional ownership representations and more standardized transfer and custody trails, which may support secondary-market activity while preserving traceability (Al-Muntasir, 2022). However, despite this conceptual fit, empirical evidence remains limited regarding whether blockchain adoption produces measurable improvements in reporting quality and assurance outcomes in practice (Morshed & Khrais, 2025; Sanad, 2024). This limitation matters because green sukuk pricing is sensitive to whether verification is operational – embedded in monitoring and assurance routines – not merely announced in market communication to investors and regulators publicly.

From an information-quality perspective, faithful reporting is central to sustaining confidence in both green finance and Islamic finance. When disclosure is delayed, non-comparable, or difficult to authenticate, investors face higher uncertainty in evaluating the credibility of sustainability narratives and performance metrics (Raimi et al., 2024; Raimi & Bamiro, 2025). Blockchain is frequently argued to mitigate these weaknesses by enabling near real-time recording, faster processing, and improved accessibility of verified transaction data (Harahap et al., 2023; Muneer et al., 2025). The immutability of ledger entries may also constrain opportunistic manipulation, strengthening confidence in disclosed figures and reducing perceived reporting risk (Liu et al., 2024; Shaban & Omoush, 2025). Yet the literature also emphasizes uneven adoption and limited validation of effectiveness, leaving uncertainty about whether integrity gains translate into systematic improvements across Islamic sustainable finance settings (Kismawadi, 2024; Zaman et al., 2025). This implies that blockchain can improve pricing only through demonstrated reporting gains that reduce uncertainty for investors, regulators, and market intermediaries over time; without such gains, pricing responses may be weak, inconsistent, or short-lived (Khrais and Alghamdi, 2025).

The comparative literature helps explain why a cross-country design is necessary rather than optional. Institutional capacity and regulatory so-

phistication condition sustainability disclosure quality and the feasibility of technology-enabled verification. Malaysia is frequently presented as a leading case, supported by early alignment between Shariah governance and green bond practices, as well as by frameworks that structure post-issuance monitoring and disclosure expectations (Musari, 2025; Smolo et al., 2024). Indonesia's green sukuk expansion has been policy-driven, yet reporting and verification infrastructures remain uneven, with limited diffusion of advanced digital verification across the disclosure ecosystem (Balative et al., 2025; Setyaningsih et al., 2024). Saudi Arabia's sustainability-linked sukuk activity has accelerated, but disclosure harmonization remains less standardized, and blockchain applications are often described as developing rather than embedded at scale (Alhowaish, 2025). The UAE, by contrast, has coupled green sukuk growth with fintech experimentation, including tokenized instruments and blockchain-enabled tracking systems that support continuous monitoring and disclosure verification (Morshed, 2025a; Nasih et al., 2024). This variation implies that the blockchain-reporting-pricing channel is conditional: where regulatory readiness supports standardization and enforceable monitoring, verification improvements should be more credible and more likely to be priced.

Theoretical framing further organizes the empirical expectations. Agency theory suggests that transparent and auditable records can reduce information asymmetry between issuers and investors and mitigate moral hazard in proceeds allocation and reporting (Niu et al., 2024; Souissi et al., 2024). Signaling theory frames green sukuk issuance as a signal of environmental stewardship, but the signal weakens when verification is limited; blockchain may strengthen that signal by embedding more credible proof mechanisms into reporting infrastructures (Alkadi, 2024; Pirgaip & Arslan-Ayaydin, 2024), potentially improving investor confidence and reducing issuance frictions (Almadadha, 2024). Institutional theory adds that realized benefits depend on the surrounding governance environment, meaning that jurisdictions with stronger regulatory clarity and enforcement may convert blockchain transparency into more credible disclosure outcomes (Alam, 2021; Srivastava et al., 2024). This is especially impor-

tant in cross-country analysis because the same technology can be adopted under very different national supervisory, assurance, and market infrastructures. Finally, resource dependence and legitimacy perspectives position blockchain-enabled reporting as a strategic capability that can enhance efficiency, strengthen visibility, and support broader stakeholder acceptance where credibility underpins competitiveness (Lima et al., 2025; Meero, 2025). Taken together, these perspectives converge on one mechanism: blockchain affects pricing only insofar as it produces credible, auditable, and timely information that reduces verification uncertainty and, therefore, the information component of required returns.

In sum, the reviewed literature supports a coherent analytical sequence. Green sukuk markets continue to face a credibility problem because disclosure timeliness, comparability, and assurance quality remain uneven across jurisdictions, which increases verification uncertainty and weakens investor confidence (Alshehadeh et al., 2023; Al-Shaghdari et al., 2024). Blockchain is repeatedly presented as a mechanism that can reduce that problem by improving traceability, auditability, and the verifiable linkage between proceeds allocation and reported environmental outcomes (Chong, 2021; Mhlanga, 2025; Morshed & Khrais, 2025). However, prior studies do not clearly establish whether these benefits translate into measurable improvements in reporting quality and financing conditions across different institutional settings. This unresolved issue motivates the present study.

Accordingly, this study aims to examine whether blockchain adoption improves reporting quality and financing efficiency in green sukuk markets and whether these effects vary across jurisdictions with different institutional and regulatory conditions. The reviewed literature therefore supports a conceptual model in which blockchain adoption improves reporting quality, improved reporting quality strengthens disclosure credibility and pricing efficiency, and institutional context moderates the strength of these relationships across the selected green sukuk jurisdictions examined in this study. Study hypotheses are as follows:

H1: Blockchain adoption improves financial reporting quality in green sukuk issuances.

H2: *Blockchain adoption reduces the cost of capital for issuers of green sukuk.*

H3: *The effect of blockchain adoption on disclosure credibility is moderated by the institutional and regulatory context.*

H4: *Blockchain-enabled reporting functions as a strategic capability that enhances issuer legitimacy and competitiveness.*

2. METHODOLOGY

This study employs a quantitative longitudinal panel design to estimate the effect of blockchain adoption on (i) financial reporting quality and (ii) the cost of capital in green sukuk markets. The identification strategy combines a staggered Difference-in-Differences (DiD) framework with Double Machine Learning (DML) to strengthen inference when adoption timing varies across issuers and when many correlated controls are required. To examine the transmission mechanism, the analysis constructs a Text-to-Ledger Alignment (TLA) Index using natural language processing to quantify the extent to which issuers' allocation and impact narratives are aligned with information that is verifiable through blockchain records and/or the MRV (Monitoring, Reporting, and Verification) framework (Morshed, 2024).

The empirical sample covers Malaysia, Indonesia, Saudi Arabia, and the United Arab Emirates for the period 2016–2025. Annual issuance and market characteristics are obtained from Refinitiv Eikon, Bloomberg, and the Climate Bonds Initiative. Measures of reporting quality are extracted from annual and ESG/sustainability reports, while blockchain-adoption events are identified from issuer disclosures and regulatory announcements. Macroeconomic indicators (interest rates, inflation, and market-volatility measures) are compiled from the World Bank, the International Monetary Fund, and national central banks to ensure consistent cross-country measurement (Caldarelli, 2025). Table 1 summarizes cumulative issuance volumes and confirms the depth and heterogeneity of the empirical setting. In addition to pooled estimations, the empirical design reports country-specific comparisons so that average results do not obscure institutional variation across the four selected jurisdictions.

Table 1. Cumulative green and sustainability sukuk issuance by country (US\$ million, Q3 2023)

Country	Amount (US\$ mln)	Share (%)
United Arab Emirates	10,070	29.5
Malaysia	9,818	28.8
Saudi Arabia	7,829	23.0
Indonesia	6,404	18.7
Total	34,121	100

The analysis defines four categories of variables: dependent (outcomes), independent (treatment), mechanism, and controls. Financial reporting quality is operationalized using (i) audit-report lag (days between fiscal year-end and the audit report date), (ii) discretionary accruals estimated via the Modified Jones Model, and (iii) an indicator for financial-statement restatements in year t . Cost of capital is captured through market-based proxies reflecting pricing and liquidity conditions, including (i) the primary-issue spread over benchmark yields, (ii) the secondary-market z -spread, and (iii) the bid–ask spread (Hornuf & Yüksel, 2024). The treatment variable $Treat_{i,t}$ is blockchain adoption, coded as one in issuer-years when tokenized sukuk features, blockchain-based MRV, or proceeds-tracking systems are implemented, and zero otherwise, supporting staggered treatment timing across issuers and years. The mechanism is measured through the Text-to-Ledger Alignment (TLA) Index, which quantifies similarity between allocation/impact disclosure text and corresponding verifiable blockchain/MRV entries using cosine similarity after linguistic preprocessing (tokenization and stop-word removal) (Ali et al., 2025; Morshed, 2024). Control variables include issuer characteristics (firm size as log total assets, leverage, and sector indicators), issue features (credit rating, maturity, and coupon type), verification proxies (second-party opinion and ESG ratings), and macroeconomic conditions (interest rates, inflation, and volatility indicators) to reduce confounding and isolate adoption effects from market-wide shocks (Glebocki & Saha, 2024).

After data compilation, the panel is screened for completeness, consistent issuer identifiers, and extreme observations, then prepared for estimation. The methodological algorithm follows a staged identification logic. First, a two-way fixed-effects

DiD model is estimated for each outcome to recover the average effect of adoption while absorbing issuer fixed effects and common year shocks:

$$y_{i,t} = \alpha + \theta \text{Treat}_{i,t} + X'_{i,t} \beta + \mu_i + \tau_t + \varepsilon_{i,t}, \quad (1)$$

where $y_{i,t}$ denotes the outcome for issuer i in year t , $\text{Treat}_{i,t}$ is the blockchain-adoption indicator, $X_{i,t}$ is the control vector, and μ_i and τ_t represent issuer and year fixed effects. Event-study specifications are then estimated by replacing $\text{Treat}_{i,t}$ with event-time indicators around the adoption year and inspecting pre-treatment coefficients to assess whether treated and control units exhibit parallel pre-trends.

Second, the DML framework is implemented to reduce bias under many correlated controls and flexible relationships by orthogonalizing the treatment effect:

$$y = \theta D + g(X) + u, D = m(X) + v, \quad (2)$$

where D is blockchain adoption, and X contains the control set. The nuisance functions $g(\cdot)$ and $m(\cdot)$ are estimated using LASSO and gradient-boosted trees with cross-fitting, and the orthogonalized estimate of θ is reported as the bias-corrected treatment effect.

Third, the mechanism is examined by testing whether adoption improves disclosure–verification consistency through the TLA Index:

$$\text{TLA}_{i,t} = \gamma + \delta \text{Treat}_{i,t} + X'_{i,t} \lambda + \mu_i + \tau_t + \eta_{i,t}. \quad (3)$$

A positive and statistically meaningful δ supports the argument that blockchain adoption strengthens transparency and investor confidence by increasing alignment between narrative disclosures and verifiable records (Ali et al., 2025; Morshed, 2024).

Robustness checks include randomized placebo adoption dates to test for spurious timing effects, entropy balancing to equalize observable characteristics between treated and control groups, and alternative model specifications using winsorized spreads, quantile regressions, and modified reporting-quality metrics. Subsample analyses distinguish sovereign from corporate issuers and es-

timate country-specific effects, while sensitivity tests exclude crisis years and extreme observations to confirm model stability (Sarstedt et al., 2020). All numerical outputs of these procedures are reported in the Results section.

All computations are conducted in R and Python for model estimation, with Stata used for descriptive diagnostics and Tableau for visualization. The study relies exclusively on secondary data obtained from publicly accessible sources and does not involve human participants, personal data, or confidential information; therefore, ethics committee approval and informed consent are not applicable. To support transparency and reproducibility, the study's input-data documentation, variable definitions, and replication materials are publicly archived on Zenodo (<https://doi.org/10.5281/zenodo.18172078>). The compiled analytical dataset and associated inputs were constructed specifically for this study and have not been used in prior publications.

3. RESULTS

The empirical analysis evaluates how blockchain adoption shapes reporting quality, financing conditions, and disclosure integrity across the leading green sukuk jurisdictions of Malaysia, Indonesia, Saudi Arabia, and the UAE. Rather than treating the sample as one pooled market, the findings are organized to show both average effects and the country-level differences that give those averages meaning.

The cumulative issuance of bonds by the four countries surpassed USD 34 billion in the third quarter of 2023, with the UAE and Malaysia accounting for the largest shares. Table 2 shows that blockchain use is most developed in the UAE and Malaysia, while Saudi Arabia and Indonesia remain at earlier adoption stages. The same table also shows that adopters are typically larger issuers with tighter average spread measures, suggesting that investors value transparent verification. Country differences in reporting quality are equally visible: the UAE records the shortest audit lag, Malaysia remains efficient, and Saudi Arabia shows the highest restatement rate, with Indonesia also lagging behind the two stronger cases. These

Table 2. Descriptive statistics of sample issuers (2016–2023)

Variable	UAE (N = 42)	Malaysia (N = 39)	Saudi Arabia (N = 31)	Indonesia (N = 28)	Full Sample (N = 140)
Avg. issuance size (US\$ mln)	690	610	540	460	575
Blockchain adopters (%)	41	38	23	18	31
Avg. audit lag (days)	64	58	91	83	74
Restatements (% of issuers)	7	6	14	12	10
Avg. issue spread (bps)	142	150	168	177	159

descriptive contrasts indicate that institutional readiness matters for sustainability-reporting integrity and pricing outcomes (Rawashdeh, 2025).

The econometric models then test whether these descriptive contrasts persist after controls. Table 3 shows that firms adopting blockchain technology report almost 12 days faster, exhibit lower discretionary accruals, and face a reduction of more than eight percentage points in restatement probability. Event-study coefficients indicate that adopters and non-adopters followed similar trends before treatment, supporting the identification strategy and strengthening the interpretation of post-adoption effects (Alsmadi & Alrawashdeh, 2025). These results imply that the average treatment effect is not driven by one indicator alone but by a broader pattern of reporting discipline after adoption across the sample.

The reduction in audit delay and accrual manipulation indicates that blockchain improves both reporting discipline and disclosure timeliness in green sukuk systems across the sampled jurisdictions (Fodol & Aslan, 2025).

In terms of financing outcomes, the DML estimates in Table 4 show that blockchain adoption

reduces the cost of capital. Average issue spreads fall by 21.7 bp, secondary z-spreads by 18.3 bp, and bid-ask spreads by 5.6 bp. The country comparison matters: the compression of pricing frictions is strongest in the UAE and Malaysia, where regulatory guidance and infrastructure are developed, and weaker in Saudi Arabia and Indonesia, where adoption remains less embedded in reporting routines. The results remain significant after entropy balancing, indicating that the effect is not merely a consequence of issuer differences. The findings support the view that blockchain functions as an information and signaling mechanism that lowers the risk premium demanded by investors (Jaradat et al., 2024).

To test the transmission mechanism, the study constructs a Text-to-Ledger Alignment (TLA) Index that captures the similarity between use-of-proceeds disclosures and validated blockchain or MRV information. Table 5 shows a significant positive association between blockchain adoption and the TLA Index, indicating that adoption strengthens the alignment of disclosures with verifiable records. Issuers with higher TLA scores also experience shorter audit delays and smaller issue spreads (Ahmad et al., 2023). This pattern is important because it links the pooled

Table 3. DiD estimates: Effect of blockchain adoption on reporting quality

Dependent Variable	Coefficient (θ)	Std. Error	Significance	Effect
Audit report lag (days)	-12.4	3.8	***	Faster reporting
Discretionary accruals	-0.018	0.007	**	Lower earnings management
Restatement dummy	-0.081	0.032	**	Fewer misstatements

Notes: * Two-way fixed-effects DiD model with issuer and year FE; controls include firm, ESG, and macro variables. ** $p < 0.05$; *** $p < 0.01$.

Table 4. DML estimates: Effect of blockchain adoption on cost of capital

Dependent Variable	Coefficient (θ)	Std. Error	Significance	Effect
Issue spread (bps)	-21.7	6.9	***	Lower cost at issuance
Secondary z-spread	-18.3	7.2	**	Improved secondary pricing
Bid-ask spread (bps)	-5.6	2.1	**	Greater liquidity

Notes: * DML estimation with LASSO and gradient boosting for controls; ** $p < 0.05$; *** $p < 0.01$.

Table 5. Mechanism analysis: Blockchain adoption and TLA Index

Dependent Variable (TLA Index)	Coefficient (δ)	Std. Error	Significance	Effect
Blockchain adoption	0.142	0.051	***	Stronger text–ledger alignment

Notes: * Panel fixed-effects regression with issuer and year FE; ** $p < 0.01$.

treatment effect to a concrete mechanism: blockchain improves reporting and financing efficiency when it narrows the distance between narrative claims and traceable evidence for market participants rather than merely increasing the volume of disclosure (Karim & Lei, 2025).

This mechanism indicates that immutable records directly enhance disclosure credibility and investor trust when reporting claims are anchored in verifiable evidence (Raimi & Bamiro, 2025).

Robustness tests reported in Table 6 further support the findings. Placebo adoption dates produce insignificant coefficients, event-time graphs confirm pre-treatment stability, and winsorised and quantile models generate consistent estimates. Entropy balancing preserves significance, subsample tests show stronger effects among corporates than sovereign issuers, and excluding pandemic years or outliers does not change the overall pattern. Taken together, these checks indicate that the main results are not an artifact of timing, sample composition, or specific estimation choices in this study overall.

The combined checks reinforce the causal interpretation that blockchain adoption improves reporting quality and financing efficiency across the sample in economically meaningful terms (Li, 2024).

Cross-country comparison provides the clearest evidence that averages alone are insufficient. Table 7 shows that Malaysia and the UAE deliver the strongest overall effects, but this ranking is better understood when read together with the descrip-

tive evidence in Table 2. Malaysia and the UAE record higher blockchain-adopter shares (38% and 41%, respectively), shorter audit lags (58 and 64 days), lower restatement rates (6% and 7%), and tighter average issue spreads (150 and 142 bps). By contrast, Saudi Arabia and Indonesia show lower adoption intensity (23% and 18%), longer reporting delays (91 and 83 days), higher restatement rates (14% and 12%), and wider average spreads (168 and 177 bps). These cross-country contrasts do not by themselves establish causality, but they are consistent with the country-level effect pattern reported in Table 7: blockchain adoption becomes more effective where disclosure routines, monitoring structures, and verification systems are already more operational. The UAE shows the strongest financing gains, consistent with deeper fintech experimentation, while Malaysia shows the most balanced combination of reporting discipline and disclosure credibility under a more harmonized regulatory structure. Saudi Arabia records more modest and less consistent gains, and Indonesia remains the weakest case, reflecting earlier-stage digital verification and continued dependence on manual or fragmented reporting channels (Taqa, 2025). The substantive contribution of the comparison, therefore, lies not in repeating country descriptions, but in showing that identical technology adoption does not generate identical market outcomes across institutional settings.

These variations confirm that institutional maturity materially conditions blockchain effectiveness, supporting H3 and showing that governance clarity amplifies environmental-economic benefits across jurisdictions (Moppratama et al., 2024).

Table 6. Robustness checks summary

Test Applied	Outcome Variables Affected	Result
Placebo adoption dates	All	No significant effects
Event-study parallel trends	Reporting quality, spreads	Pre-trends confirmed
Winsorized / quantile models	All	Coefficients consistent
Entropy balancing	Reporting quality, spreads	Effects remain significant
Subsample (sovereign vs corporate)	Reporting quality	Stronger for corporates
Excluding crisis years	All	Results unchanged

Table 7. Cross-country comparison of blockchain effects

Country	Reporting Quality	Cost of Capital	Overall Effectiveness
Malaysia	Strong improvements	Moderate reductions	High
Indonesia	Limited gains	Weak reductions	Low
Saudi Arabia	Modest improvements	Inconsistent reductions	Moderate–Low
UAE	Largest improvements	Strongest reductions	Very High

Table 8. Summary of hypotheses testing results

Hypothesis	Statement	Result	Evidence
H1	Blockchain adoption improves reporting quality.	Supported	Shorter audit lags, lower accruals, fewer restatements
H2	Blockchain adoption reduces the cost of capital.	Supported (partial)	Strong effects in UAE and Malaysia; weaker elsewhere
H3	Institutional context moderates the impact.	Supported	Cross-country variation confirms moderation
H4	Blockchain enhances legitimacy and competitiveness.	Partially supported	Evident in fintech-driven jurisdictions (UAE)

Finally, Table 8 summarizes the hypothesis tests. H1 and H2 receive strong support because blockchain adoption improves reporting quality and reduces the cost of capital. H3 is also supported, as cross-country differences confirm moderation by institutional setting. H4 receives partial support, indicating that blockchain-enabled reporting enhances legitimacy and competitiveness most clearly in the UAE-centered fintech context rather than uniformly across all markets in the present sample (Orekat, 2021).

Taken together, the findings show that blockchain is not only a technological innovation but also a credibility mechanism that can reduce information asymmetry, accelerate verification, and lower financing costs. At the same time, the benefits are not uniform. Their magnitude depends on whether blockchain adoption is matched by regulatory compatibility, assurance capacity, and reporting infrastructure within each market. This is why the pooled effect must be read together with country comparisons.

4. DISCUSSION

The results indicate that blockchain adoption is associated with meaningful improvements in reporting quality in green sukuk markets. The reductions in audit-report lag, discretionary accruals, and restatement probability suggest that blockchain is linked to faster verification, stronger reporting discipline, and lower scope for reporting inconsistency after issuance. This interpretation is

important because it moves beyond the general claim that digital technologies improve transparency. In the present study, the effect appears in specific accounting outcomes rather than in abstract governance language alone. This finding is consistent with Almadadha (2024) and Caldarelli (2025), who argue that blockchain can strengthen transparency and reliability in financial reporting, but the present results extend that view by showing observable improvements in reporting quality indicators within the green sukuk context.

The financing results point in the same direction. Lower issue spreads, narrower secondary-market z-spreads, and smaller bid–ask spreads indicate that investors respond favorably when disclosures become more credible and verifiable. This supports earlier arguments that information quality and credibility shape market confidence and pricing efficiency (Jaradat et al., 2024; Raimi & Bamiro, 2025). However, the present findings add a more specific contribution: investors do not appear to reward blockchain adoption as a label in itself, but rather the stronger verification environment associated with it. The positive relationship between blockchain adoption and the Text-to-Ledger Alignment Index supports this interpretation, because it shows that better pricing outcomes coincide with stronger alignment between reported sustainability narratives and traceable records (Alshehadeh et al., 2025).

The cross-country comparison is central to understanding these results. Malaysia and the UAE

show the greatest improvements, while Saudi Arabia records more modest gains and Indonesia the weakest. This pattern is consistent with prior studies that describe Malaysia as having a more mature monitoring and disclosure environment and the UAE as combining green sukuk growth with stronger fintech experimentation (Musari, 2025; Smolo et al., 2024; Morshed, 2025a; Nasih et al., 2024). By contrast, earlier work on Saudi Arabia and Indonesia points to less harmonized disclosure systems and weaker embedding of digital verification practices (Alhowaish, 2025; Balative et al., 2025; Setyaningsih et al., 2024). Thus, the present study does not merely repeat what previous research reported about these ju-

risdictions; it shows that such institutional differences translate into different empirical outcomes after blockchain adoption.

Overall, the findings suggest that blockchain can improve green sukuk credibility and financing efficiency, but not automatically. Its benefits are greater where disclosure rules, assurance capacity, and supervisory coordination are already stronger. The main contribution of this study is therefore not only the pooled evidence that blockchain is beneficial on average, but also the comparative evidence that its effectiveness depends on institutional readiness across jurisdictions.

CONCLUSION

This study examined whether blockchain adoption improves reporting quality and financing efficiency in green sukuk markets across Malaysia, Indonesia, Saudi Arabia, and the UAE.

The results show that blockchain adoption is associated with shorter audit-report lag, lower discretionary accruals, and fewer restatements, which indicates stronger reporting quality after adoption. The results also show lower issue spreads, narrower secondary-market premia, and smaller bid-ask spreads, suggesting that improved verification is associated with lower information frictions and better financing conditions. In addition, the cross-country analysis shows that these benefits are strongest in Malaysia and the UAE and weaker in Saudi Arabia and Indonesia, indicating that institutional readiness materially conditions the effectiveness of blockchain-based verification. Thus, the study concludes that blockchain can enhance the credibility and pricing efficiency of green sukuk markets, but its benefits are not automatic. They depend on the presence of clear disclosure standards, effective assurance arrangements, and coordinated supervisory infrastructures that allow traceability to be converted into decision-useful evidence for investors and regulators.

AUTHOR CONTRIBUTIONS

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