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Institutional support, fintech innovation, and investor confidence in driving energy efficiency within Islamic green finance

Darmawan Darmawan
Department of Islamic Finance Management, Universitas Islam Negeri Sunan Kalijaga, Yogyakarta, Indonesia, and
Ifa Azzahra Farhatannisa
Department of Islamic Economics, Universitas Islam Negeri Sunan Kalijaga, Yogyakarta, Indonesia

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Abstract

Purpose – This study aims to examine how institutional support, as captured by regulatory compliance and access to financing, enhances energy efficiency outcomes in Islamic green finance. It examines the complementary roles of fintech innovation and investor confidence as the technological and behavioural mechanisms that translate institutional arrangements into measurable sustainability performance.

Design/methodology/approach – Using survey data from 302 Islamic fintech users, investors, and market stakeholders in Indonesia, the study tests a dual-pathway framework through partial least squares structural equation modelling. Institutional support is modelled as a second-order construct, and mediation effects are evaluated using a two-stage hierarchical component approach and predictive assessment via PLSpredict.

Findings – Institutional support does not directly improve energy efficiency. Instead, its influence is transmitted through two reinforcing channels: (1) fintech innovation, which enhances transparency, monitoring, and digital efficiency; and (2) investor confidence, which strengthens credibility and capital allocation toward efficiency-oriented projects. Fintech innovation also strengthens investor confidence, creating a complementary mechanism that amplifies efficiency outcomes. The model demonstrates strong explanatory power ($R^2 = 0.822$) and robust out-of-sample predictive accuracy.

Research limitations/implications – The study is based on cross-sectional survey data from Indonesia, whose regulatory, technological, and market characteristics may differ from those of other Islamic finance ecosystems. Accordingly, the findings should be interpreted within this institutional context. Future research could assess the framework through longitudinal and cross-country designs, objective measures of energy efficiency, and multi-source datasets. Comparative studies involving Malaysia, Gulf Cooperation Council countries, and conventional green-finance ecosystems could further examine the external validity and contextual boundaries of the proposed institutional–technological–behavioural relationships.

Practical implications – The findings offer differentiated implications for key stakeholders. Policymakers should align sustainable-finance strategies with technological development and market participation, while regulators should support digital monitoring, transparent reporting, and credible verification. Islamic financial institutions can embed digital capabilities into green-finance products, and fintech companies can develop technologies that strengthen both operational efficiency and market confidence. Investors should evaluate sustainability opportunities using verifiable performance information rather than relying solely on green labels.

Social implications – The results of this study highlight the importance of integrating digital monitoring, reporting, and verification (MRV) technologies into Islamic green finance to enhance transparency and investor trust. Such alignment between governance frameworks, technological capabilities, and behavioural trust can accelerate energy savings, strengthen market credibility, and support maqasid-oriented sustainability aspirations.

Originality/value – This study provides one of the first empirical validations of how institutional, technological, and behavioural mechanisms jointly shape energy efficiency within Islamic green finance. By framing fintech innovation and investor confidence as dual mediators, it offers a novel explanation of how regulatory design and digital transformation interact to produce real-economy sustainability gains.

Keywords Islamic green finance, Institutional support, Fintech innovation, Investor confidence, Energy efficiency, Sustainable finance

Paper type Research article

Introduction

Climate change mitigation increasingly depends on mobilising private capital toward technologies and projects that deliver measurable efficiency gains. Global energy investment

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exceeded USD 3 trillion in 2024, of which two-thirds was directed to clean energy (IEA, 2024a). However, despite being described as the "first fuel" for its cost-effectiveness in reducing demand and emissions, energy efficiency remains underfinanced and unevenly distributed across emerging markets (IEA, 2024b). Parallel to this challenge, sustainable debt markets have expanded rapidly, with cumulative issuance of green, social, sustainability, and sustainability-linked instruments surpassing USD 5 trillion by early 2025. This surge reflects robust investor appetite for assets linked to environmental outcomes, though concerns persist regarding transparency, verification, and the credibility of efficiency claims (Climate Bonds Initiative, 2024, 2025).

In this landscape, Islamic finance has emerged as a significant conduit for sustainability-oriented capital. Sukuk, in particular, has evolved beyond conventional issuance to incorporate environmental and social purposes, with cumulative sustainable sukuk exceeding USD 40 billion between 2017 and 2024 (ICMA, IsDB, & LSEG, 2024). Evidence suggests that these instruments can generate a "greenium" in primary markets, where verified environmental claims attract pricing advantages (Pirgaip and Arslan-Ayaydin, 2024). Such dynamics underscore the critical role of transparency and institutional frameworks in shaping investor behaviour. Notably, the trajectory of Islamic sustainable finance aligns with broader market trends while also introducing unique governance considerations tied to Shariah compliance, ethical screening, and maqāṣid al-sharī'ah, thereby offering a distinct setting for studying the interplay of finance, technology, and sustainability.

Concurrently, digital innovation is transforming the process of capital formation in climate finance. The emerging field of climate-fintech highlights how digital applications (ranging from tokenisation and data platforms to monitoring, reporting, and verification (MRV) tools can reduce transaction and verification costs, broaden participation, and mobilise new investment flows (Loukoianova *et al.*, 2024). These developments illustrate how digital transformation interacts with institutional design to address financing frictions in sustainable finance. Nevertheless, the effectiveness of fintech in sustainable finance remains contested. While digital technologies can improve transparency and reduce monitoring costs, concerns persist regarding cybersecurity vulnerabilities, privacy risks, technological readiness, and regulatory fragmentation, particularly in emerging markets (Aldboush and Ferdous, 2023; Loukoianova *et al.*, 2024). Furthermore, evidence suggests that fintech contributes to sustainable finance more effectively when supported by strong institutional environments and governance frameworks (Koranteng and You, 2024). Consequently, fintech innovation should not be viewed as an automatic driver of sustainability outcomes but rather as a mechanism whose effectiveness depends on broader institutional and governance conditions. This perspective is consistent with recent policy developments that emphasise transparency, accountability, and verification in sustainable-finance markets. Global guidance, such as the ICMA–IsDB–LSEG Green Sukuk Principles (2024), emphasises the importance of transparent use of proceeds, external reviews, and impact reporting.

Indonesia provides a particularly relevant context for examining these dynamics. Since pioneering the world's first sovereign green sukuk in 2018, Indonesia has consistently expanded its thematic debt instruments as part of a national sustainable finance strategy (ADB, 2022). Regulatory reforms led by the Financial Services Authority (OJK) include POJK 51/2017 on mandatory sustainability action plans, the Sustainable Finance Roadmap Phase II (2021–2025), and the Indonesian Taxonomy for Sustainable Finance (TKBI) updated 2024, which aligns domestic classification with global standards (OJK, 2017, 2021, 2024). These initiatives position Indonesia as a natural testbed where institutional support mechanisms intersect with the rise of Islamic fintech platforms. At the same time, debates over transitional classifications, disclosure quality, and investor signalling continue to highlight the importance of trust and technological innovation in sustaining market credibility.

Malaysia and several GCC countries have established mature Islamic finance ecosystems and have attracted substantial scholarly and policy attention in relation to green sukuk and sustainable investment (ICMA, IsDB, & LSEG, 2024; Lee *et al.*, 2025). Indonesia, however,

presents a distinctive setting characterised by rapid fintech expansion, active regulatory reforms, and a large retail investor base (ADB, 2022). Unlike many GCC markets, where sustainable finance initiatives are largely driven by established institutional and capital-market structures, Indonesia combines regulatory intervention with fintech-enabled financial inclusion strategies and digital financial innovation. These characteristics provide an opportunity to examine how institutional support, technological innovation, and investor confidence jointly shape sustainability outcomes within an emerging Islamic finance ecosystem.

Recent studies have examined fintech innovation as a driver of sustainable finance adoption and financial inclusion (Alsmadi, 2024; Idrees and Ullah, 2024), while others have focused on institutional quality and regulatory frameworks as determinants of green finance development (Koranteng and You, 2024; Yang and Huang, 2025). Separate streams of research have also explored investor confidence, trust formation, and signalling mechanisms in sustainable and Islamic financial markets (Pirgaip and Arslan-Ayaydin, 2024; Lee *et al.*, 2025; Zhang, 2025). Collectively, these studies have improved understanding of the institutional, technological, and behavioural dimensions of sustainable finance. However, they generally examine these factors independently, providing limited insight into how they interact within Islamic sustainable-finance ecosystems.

Despite the rapid growth of Islamic green finance and fintech research, empirical work rarely explains how institutional arrangements are translated into measurable sustainability outcomes. Much of the existing evidence focuses on financial outcomes, such as investment participation, market development, financial inclusion, adoption behaviour, or green innovation (Novák *et al.*, 2025; Lei *et al.*, 2025), with comparatively limited attention devoted to project-level energy-efficiency outcomes. This omission is important because energy efficiency often depends not only on regulatory support and financing availability but also on technological transparency and investor trust, particularly in emerging Islamic finance ecosystems. Consequently, the pathways through which institutional support contributes to efficiency performance through technological and behavioural channels remain insufficiently understood.

This study addresses these gaps by developing and empirically validating an integrated framework within the context of Islamic green finance. Specifically, it examines how institutional support is associated with energy-efficiency outcomes through two complementary pathways: fintech innovation and investor confidence. The study contributes to the literature in four ways. First, it develops an integrated framework by bringing together insights from institutional theory, signalling theory, and behavioural finance to clarify how institutional support is associated with energy-efficiency outcomes through technological and behavioural mechanisms. Second, it extends the Islamic green finance literature beyond adoption and financing issues by focusing on measurable energy-efficiency outcomes. Third, it provides empirical evidence from Indonesia, an emerging Islamic finance market that remains comparatively underexplored in the green sukuk and sustainable-finance literature relative to more established Islamic finance hubs such as Malaysia and several GCC countries. Fourth, the study offers policy-relevant insights regarding how regulatory frameworks, digital monitoring technologies, and investor-confidence mechanisms can be aligned to strengthen transparency, accountability, and energy-efficiency outcomes within Islamic sustainable-finance initiatives.

Literature review

Institutional support in Islamic green finance

Institutional support is a central determinant of how financial systems mobilise capital toward sustainability outcomes. In Islamic finance, policy and market architecture (encompassing regulation, disclosure regimes, and access to financing) create the conditions that shape incentives for green investment. In Indonesia, the Financial Services Authority (OJK) issued

POJK 51/2017, mandating sustainable finance action plans and disclosures for financial institutions, listed issuers, and public companies. This policy embeds environmental, social, and governance (ESG) considerations within the regulatory framework (OJK, 2017). The agenda was extended through the Sustainable Finance Roadmap Phase II (2021–2025), which prioritises ESG integration, enhanced risk management, and ecosystem development (OJK, 2021). More recently, the Indonesian Taxonomy for Sustainable Finance (TKBI) has been introduced to guide capital allocation with greater interoperability, though debates persist regarding transitional categories and investor clarity (OJK, 2024).

On the market side, the ICMA–IsDB–LSEG Guidance on Green, Social and Sustainability Sukuk (2024) highlights cumulative issuance of USD 42.7 billion since 2017, signalling strong investor appetite when use-of-proceeds and verification frameworks are credible. Indonesia's sovereign green sukuk program has been widely cited as a benchmark that links regulatory infrastructure with sustainable investment needs (Abubakar and Handayani, 2020). These arrangements constitute the Institutional Support construct in this study, modelled as a higher-order construct comprising regulatory compliance and access to financing.

Institutional theory emphasises that rules, norms, and shared beliefs collectively shape organisational behaviour (Scott, 2013). Regulatory and financing pressures can be viewed as coercive isomorphism (DiMaggio and Powell, 2000), compelling firms to align with sustainability practices. Empirical evidence supports this: technological innovation and green productivity are more likely to emerge when supported by strong institutional frameworks (Yang and Huang, 2025). In emerging markets, inclusive financing channels have been shown to catalyse systemic improvements in efficiency (Novák *et al.*, 2025). In Islamic fintech, coherent regulatory frameworks provide legitimacy and certainty, enabling innovation while ensuring Shariah alignment (Fidhayanti *et al.*, 2024). Similarly, cross-country analyses suggest that fintech enhances financial stability only when embedded in strong institutional foundations (Koranteng and You, 2024).

However, institutional support does not automatically lead to effective sustainability outcomes. Although regulatory frameworks and sustainable finance taxonomies enhance the legitimacy of sustainability-oriented investments, excessive regulatory complexity, fragmented standards, and policy uncertainty may discourage innovation and reduce market participation (Begemann *et al.*, 2025; Hilbrich, 2026). The growing body of literature on sustainable finance demonstrates that unclear sustainability classifications and inconsistent implementation across jurisdictions can generate compliance burdens and increase investment uncertainty, particularly in emerging economies where institutional capacities remain uneven (Silva and Awazu, 2025; Ahmad *et al.*, 2026). Furthermore, differences in taxonomy design and governance structures may undermine comparability and create challenges for investors seeking credible sustainability signals (Achterfeldt and Traverso, 2026). As a result, institutional arrangements may exert both enabling and constraining effects by simultaneously providing legitimacy while limiting adaptive capacity and innovation when regulatory requirements become overly prescriptive (Begemann *et al.*, 2025; Hilbrich, 2026). Therefore, institutional support is most effective when it combines clear and consistent governance mechanisms with sufficient flexibility to accommodate evolving technologies, market conditions, and transition pathways (Bagh and Iftikhar, 2024; Achterfeldt and Traverso, 2026).

Institutional support may also strengthen investor confidence by reducing information asymmetry and increasing the credibility of sustainability claims. Regulatory disclosure requirements, sustainability taxonomies, and external assurance mechanisms provide standardized and verifiable information that enables investors to better assess the environmental performance and sustainability quality of firms and projects (Boiral *et al.*, 2024; Venter and Krasodomska, 2024). By improving transparency and comparability, these institutional mechanisms reduce informational uncertainty and help investors distinguish credible sustainability initiatives from potential greenwashing practices, thereby enhancing market trust and investment confidence (Gaur *et al.*, 2025). Furthermore, external assurance of sustainability disclosures has been shown to improve the reliability and legitimacy of

non-financial information, strengthening stakeholders' confidence in reported sustainability performance and reducing information asymmetries between issuers and investors (Krasodomska *et al.*, 2025; Sánchez *et al.*, 2026). Recent evidence also suggests that transparent ESG reporting and credible verification processes positively influence investor perceptions, increase trust in sustainability-related disclosures, and support capital allocation toward environmentally responsible investments (Tucker *et al.*, 2026; Gao and Zhao, 2026). Consequently, institutional arrangements that promote transparency, standardized disclosure, and independent verification play a critical role in mobilizing sustainable finance by reinforcing investor confidence in both issuers and the underlying sustainability outcomes.

Drawing on institutional theory, we argue that such pressures encourage the adoption of new routines and digital tools consistent with policy goals.

H1. Institutional support positively influences Fintech Innovation.

H2. Institutional support positively influences Investor Confidence.

Fintech innovation as capability and signal

Digital finance has been increasingly recognised as a mechanism to reduce frictions that constrain climate-aligned investment. Climate-fintech tools, including digital MRV, tokenisation, crowdfunding platforms, and regulatory technology (regtech), expand access to climate data, reduce verification costs, and enhance disclosure mechanisms (Loukoianova *et al.*, 2024). Policy guidance similarly stresses that blockchain-enabled monitoring enhances transparency, mitigates greenwashing, and complements institutional safeguards (ICMA, IsDB, & LSEG, 2024).

From a theoretical perspective, fintech innovation can be understood through two complementary lenses. First, as a capability, digital technologies enhance operational performance by improving measurement, reporting, and monitoring. For example, transparent dashboards and automated compliance tools can strengthen the credibility of sukuk-funded energy retrofits. This perspective draws on the capability view of organisations, where resources and routines drive performance outcomes. Second, fintech innovation functions as a signal. According to Signalling Theory (Spence, 1973; Connelly *et al.*, 2010), actors use observable signals to reduce information asymmetries. In financial markets, digital transparency signals reliability and accountability, thereby enhancing investor confidence (Zhang, 2025; Chien *et al.*, 2025).

Empirical studies support this dual role. Fintech adoption in banking has been shown to improve efficiency only when it aligns with enabling regulation (Li *et al.*, 2025). In Islamic finance, legitimacy is further shaped by religious orientation, with Shariah alignment reinforcing trust (Alsmadi, 2024). Trust in fintech also depends on ethical safeguards, privacy protection, and brand credibility (Aldboush and Ferdous, 2023; Marhadi *et al.*, 2024). Furthermore, education level and digital inclusion significantly influence fintech adoption, underscoring the need for fintech innovation to address both technological and social dimensions (Idrees and Ullah, 2024). Applied to energy efficiency, the International Energy Agency (2024b) emphasises that efficiency is the "first fuel", implying that technologies enabling control and optimisation are central to achieving measurable outcomes. Fintech innovation thus operates both as a capability pathway, improving efficiency through digital optimisation, and as a signal pathway, enhancing investor trust through transparency.

Beyond its financial intermediation role, fintech innovation can improve energy-efficiency outcomes by facilitating real-time monitoring, performance verification, and data-driven resource allocation. Through the integration of digital technologies such as artificial intelligence, big data analytics, blockchain, and Internet-of-Things (IoT)-enabled monitoring systems, fintech platforms enable continuous tracking of energy consumption, operational performance, and environmental indicators, thereby improving project oversight and reducing resource inefficiencies (Ahmad *et al.*, 2026; Mertzanis *et al.*, 2026). These technologies

generate timely and verifiable information that supports evidence-based decision making, allowing project managers and investors to identify performance gaps, implement corrective actions, and optimize resource allocation throughout the project lifecycle (Offiong *et al.*, 2025; Shen *et al.*, 2026). Moreover, digital monitoring and reporting systems enhance transparency and accountability by providing reliable sustainability data that can be used for performance assessment, impact measurement, and compliance with environmental reporting requirements (Tanchangya *et al.*, 2025; Teixeira, 2026). Such capabilities are particularly important in green-finance projects, where investors increasingly require measurable and verifiable sustainability outcomes to ensure that financed activities deliver genuine environmental benefits rather than merely symbolic commitments (Ahmad *et al.*, 2026; Shen *et al.*, 2026). Consequently, fintech-driven monitoring and verification mechanisms strengthen both the operational efficiency and accountability of green investments by linking financial flows with observable sustainability performance.

H3. Fintech Innovation positively influences Investor Confidence.

H4. Fintech Innovation positively influences Energy Efficiency in Green Projects.

Investor confidence as a behavioural channel

Investor confidence serves as a behavioural channel that links institutional frameworks and technological signals to real-economy outcomes. In sustainable debt markets, transparency and credible verification consistently attract oversubscription and pricing advantages, known as the "greenium" (Pirgaip and Arslan-Ayaydin, 2024; ICMA, IsDB, & LSEG, 2024). This combination highlights the crucial role of investor trust in mobilising capital for green projects.

From a theoretical standpoint, this channel aligns with Behavioural Finance, which highlights how perceptions of risk, credibility, and norms influence investment decisions (Shiller, 2015; Barberis, 2018). In Islamic finance, investor confidence is further reinforced by Shariah governance, ethical screening, and social legitimacy (Lee *et al.*, 2025). Comparative studies have shown that higher investor confidence in sukuk markets enhances capital flows, strengthens project oversight, and leads to more efficient implementation (Riaz *et al.*, 2024; Wang and Xu, 2025; Zhou *et al.*, 2024).

Indonesia's regulatory frameworks are explicitly designed to reinforce this confidence. POJK 51/2017, the Sustainable Finance Roadmap II, and TKBI (2024) provide standardised disclosure and taxonomy signals to guide investment (OJK, 2017, 2021, 2024). In this sense, institutional arrangements not only shape compliance but also create the conditions for confidence, stewardship, and sustained oversight.

Nevertheless, investor confidence may not always lead to efficient sustainability outcomes. Excessive optimism and overreliance on ESG ratings, sustainability labels, or green-finance certifications may reduce investors' incentives to conduct independent assessments of environmental performance, thereby increasing the risk of capital misallocation and greenwashing (Berg *et al.*, 2022; Christensen *et al.*, 2022). Furthermore, sustainable investment markets are not immune to herding behaviour, whereby investors follow prevailing sustainability trends rather than evaluating the substantive environmental impacts of individual projects (Gillan *et al.*, 2021). As a result, sustainability signals may create legitimacy without necessarily guaranteeing genuine environmental performance when disclosure quality and monitoring mechanisms are weak (Raghunandan and Rajgopal, 2022). Therefore, investor confidence contributes most effectively to sustainability outcomes when accompanied by credible sustainability disclosures, independent verification processes, and transparent governance structures that strengthen accountability and enable rigorous evaluation of sustainability claims (Boiral *et al.*, 2024).

H5. Investor Confidence positively influences Energy Efficiency in Green Projects.

Dual-mediation logic

Synthesising these strands, we propose a dual-mediation framework that connects institutional support to efficiency outcomes via two complementary pathways.

(1) Capability pathway: Institutional support fosters fintech innovation, thereby enhancing project-level efficiency through improved monitoring, reporting, and optimisation (Loukoianova *et al.*, 2024; IEA, 2024b).

(2) Behavioural pathway: Institutional rules and technological signals enhance investor confidence, catalysing capital mobilisation and stewardship that reinforce efficiency outcomes (Pirgaip and Arslan-Ayaydin, 2024).

The two pathways are conceptually distinct yet mutually reinforcing. Institutional support provides the regulatory legitimacy, policy stability, and governance mechanisms necessary to encourage innovation and reduce uncertainty surrounding sustainable investments (Begemann *et al.*, 2025; Achterfeldt and Traverso, 2026). These institutional conditions facilitate the adoption of technological innovations that improve information transparency, performance verification, and sustainability reporting, thereby reducing information asymmetry and enhancing the credibility of environmental claims (Boiral *et al.*, 2024; Ahmad *et al.*, 2026). Improved transparency and credibility subsequently strengthen investor confidence by enabling more informed investment decisions and increasing trust in sustainability-related disclosures (Christensen *et al.*, 2022; Balaskas, 2026). Higher levels of investor confidence, in turn, facilitate capital mobilisation toward sustainability-oriented projects and reinforce monitoring and accountability mechanisms that support the achievement of measurable environmental and efficiency outcomes (Tanchangya *et al.*, 2025; Teixeira, 2026). Accordingly, sustainability outcomes emerge not from isolated institutional, technological, or behavioural factors but from the dynamic interaction among these mechanisms. This integrated perspective extends prior research that has largely examined institutional arrangements, technological innovation, or investor behaviour independently, while paying limited attention to their sequential and mutually reinforcing relationships (Gillan *et al.*, 2021; Offiong *et al.*, 2025).

This model integrates institutional, technological, and behavioural perspectives, addressing calls for frameworks that are both theoretically grounded and predictive, linking financial-system design to measurable energy savings (OJK, 2021, 2024).

H6a. Institutional support has a positive indirect effect on Energy Efficiency through Fintech Innovation.

H6b. Institutional support has a positive indirect effect on Energy Efficiency through Investor Confidence.

H6c. Fintech Innovation has a positive indirect effect on Energy Efficiency through Investor Confidence.

Conceptual framework

Building on institutional theory, signalling theory, and behavioural finance, the conceptual framework posits Institutional Support (encompassing regulatory compliance and access to financing) as a higher-order construct that indirectly drives energy efficiency in green projects. This framework operates through two pathways: (1) a capability pathway, in which fintech innovation enhances operational efficiency, and (2) a behavioural pathway, in which investor confidence translates institutional and technological signals into sustained capital allocation. Fintech innovation not only directly enhances efficiency but also indirectly fosters investor trust, resulting in a dual-mediation structure (Figure 1).

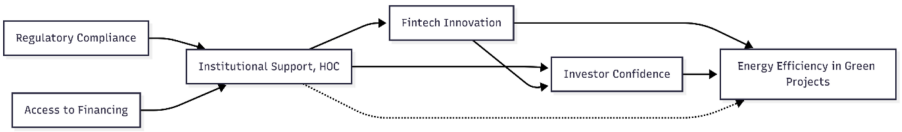

Figure 1. Conceptual framework. Source: Authors' own work

Methodology

Research design

This study applies a quantitative, cross-sectional survey design and tests the proposed framework using partial least squares structural equation modelling (PLS-SEM). PLS-SEM was selected for three reasons: (1) its suitability for prediction-oriented models, (2) its ability to handle complex models with multiple mediators and higher-order constructs, and (3) its relaxed distributional assumptions (Hair *et al.*, 2022). The two-stage higher-order construct (HOC) approach was employed to model Institutional Support (IS) as a second-order construct.

Sample and data collection

Data were collected through an online questionnaire distributed between January and July 2025 using purposive sampling. The sampling strategy targeted individuals who were actively involved in, or possessed professional knowledge of, Islamic fintech, sustainable finance, green investment, and related regulatory activities in Indonesia. To capture perspectives from multiple stakeholders within the Islamic green-finance ecosystem, the survey was disseminated through professional networks, industry associations, academic institutions, fintech communities, and regulatory forums.

The final dataset comprised 302 valid responses. Respondents represented diverse stakeholder groups, including regulators (30.8%), academics (23.2%), entrepreneurs (18.9%), investors (17.2%), and fintech professionals (9.9%). Although regulators and academics constituted a substantial proportion of the sample, their inclusion was intentional because the study examines institutional support, fintech innovation, investor confidence, and energy-efficiency outcomes at the ecosystem level rather than focusing exclusively on individual fintech adoption behaviour. Regulators provide insights into policy implementation and governance mechanisms, academics contribute expert knowledge regarding sustainable-finance practices, entrepreneurs represent recipients and users of green-finance facilities and sustainable-investment funding, investors represent capital providers, and fintech professionals contribute perspectives regarding technological implementation and financial intermediation. Consequently, the sample reflects the multi-stakeholder nature of Islamic green-finance ecosystems (see Table 1).

Although a substantial proportion of respondents reported less than one year of experience, they were actively involved in Islamic fintech, sustainable-finance activities, or related professional functions at the time of the survey. Consequently, they were considered capable of evaluating the institutional, technological, and behavioural dimensions examined in this study.

Measures and instruments

All constructs were measured using multi-item reflective scales adapted from prior studies and aligned with established sustainability and fintech frameworks (see Table 2).

All items were measured using a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The questionnaire was pretested with academics and practitioners to ensure clarity and content validity.

Table 1. Respondent demographic profile

Variable	Category	Frequency	Percentage (%)
Gender	Male	145	48.0
	Female	157	52.0
Age	<25 years	61	20.2
	25–34 years	133	44.0
	35–44 years	72	23.8
	45–54 years	36	11.9
Education	High School/Equivalent	9	3.0
	Pre Graduate	6	2.0
	Graduate (Bachelor)	235	77.8
	Postgraduate	52	17.2
Experience	<1 year	186	61.6
	1–3 years	110	36.4
	3–5 years	3	1.0
	5–10 years	3	1.0
Respondent type	Regulator	93	30.8
	Scholar/Academic	70	23.2
	Entrepreneur	57	18.9
	Investor	52	17.2
	Fintech Staff	30	9.9
Total	–	302	100

Source(s): Authors' own work

Higher-order construct (HOC) specification

Institutional Support (IS) was modelled as a second-order reflective construct, composed of RC and AF. Following the two-stage approach recommended for higher-order constructs (Hair *et al.*, 2022).

(1) Stage 1: First-order constructs (RC and AF) were estimated separately, and their latent variable scores were saved.

(2) Stage 2: The latent scores were used as indicators of IS in the second-order model, which was then linked to other constructs.

This approach helps minimise multicollinearity concerns and improves robustness when combining conceptually distinct but complementary dimensions.

Analytical procedure

Data analysis was conducted using SmartPLS 4. The assessment proceeded in two steps.

(1) The assessment followed established criteria for convergent and discriminant validity, using factor loadings (>0.70), composite reliability (>0.70), average variance extracted (>0.50), and HTMT ratios (<0.90) as recommended by Hair *et al.* (2022).

(2) Structural paths, explanatory power (R^2), effect size (f^2), and predictive relevance (Q^2) were evaluated according to the guidelines provided by Hair *et al.* (2022), and mediation was tested using a bootstrapping procedure with 5,000 resamples.

Mediation analysis was performed using bootstrapping (5,000 resamples) to test indirect effects.

Robustness and predictive assessment

Several robustness checks were conducted:

Table 2. Operational definitions of variables

Construct	Operational definition	Item	Sources
Regulatory compliance (RC)	The extent to which Islamic green-finance activities comply with sustainability regulations, disclosure requirements, and governance standards	Compliance with sustainable-finance regulations; Implementation of sustainability reporting; Adherence to ESG and green-finance standards	OJK (2017, 2021, 2024)
Access to financing (AF)	The degree to which individuals and organisations can access financing facilities for sustainable and green projects through Islamic financial institutions and fintech platforms	Availability of green-finance funding; Ease of obtaining financing; Inclusiveness of financing mechanisms	OJK (2021), Novák *et al.* (2025), Koranteng and You (2024)
Institutional support (IS) (higher-order construct)	Institutional Support (IS) was operationalised as a higher-order construct comprising Regulatory Compliance and Access to Financing	Regulatory support; Financing accessibility	Scott (2013), DiMaggio and Powell (2000), Yang and Huang (2025)
Fintech innovation (TI)	The extent to which digital technologies improve transparency, monitoring, efficiency, and information management in Islamic green-finance activities	Digital transparency; Monitoring and reporting capability; Efficiency of digital financial services; Technological innovation in green-finance processes	Loukoianova *et al.* (2024), Chien *et al.* (2025), Li *et al.* (2025)
Investor confidence (IC)	The degree of investor trust in the credibility, transparency, and reliability of Islamic green-finance projects and institutions	Trust in green-finance institutions; Credibility of sustainability claims; Confidence in risk management and disclosure practices	Pirgaip and Arslan-Ayaydin (2024), Lee *et al.* (2025), Aldboush and Ferdous (2023)
Energy efficiency in green projects (EFG)	The extent to which green-finance projects contribute to reducing energy consumption and improving resource utilisation efficiency	Reduction in energy consumption; Improvement in resource utilisation; Achievement of energy-efficiency objectives; Sustainability performance outcomes	IEA (2024b), Wang and Xu (2025), Zhou *et al.* (2024)

Source(s): Authors' own work

(1) Standard method bias: assessed via full collinearity VIF values (<3.3 threshold).

(2) Predictive validity: evaluated using PLSpredict, which compares PLS-SEM predictions with linear model (LM) benchmarks to assess out-of-sample accuracy.

(3) Blindfolding: applied to calculate cross-validated redundancy (Q^2) for endogenous constructs.

(4) Common method bias and endogeneity control: Several procedural remedies were implemented to mitigate common method bias and endogeneity concerns. These included assuring respondent anonymity, separating construct sections within the questionnaire, and using previously validated measurement scales. In addition, full-collinearity VIF values were examined to assess potential common method variance. Although these procedures cannot completely eliminate endogeneity risks inherent in cross-sectional survey designs, they reduce the likelihood that the observed relationships are driven by systematic measurement bias.

Results and discussion

Overview of the structural model

The structural model was estimated using SmartPLS 4 with a two-stage higher-order construct (HOC) specification for Institutional Support (IS). Figure 2 presents the standardised path coefficients and explained variances (R^2) for the endogenous constructs. Consistent with our theoretical framework, Institutional Support (operationalised through Regulatory Compliance (RC) and Access to Financing (AF)) significantly predicts both Fintech Innovation (TI) and Investor Confidence (IC). However, its direct effect on Energy Efficiency in Green Projects (EFG) is not significant. Instead, efficiency gains materialise primarily through dual mediation: (1) Institutional Support fosters Fintech Innovation, which in turn enhances efficiency, and (2) both Institutional Support and Fintech Innovation strengthen Investor Confidence, which further channels resources toward efficiency outcomes.

The high R^2 values across endogenous constructs (TI = 0.806, IC = 0.935, and EFG = 0.822) confirm that the model possesses strong explanatory power. In line with institutional theory, this suggests that regulatory frameworks and financing availability provide necessary conditions, but they also require technological and behavioural mechanisms to produce tangible efficiency improvements.

The exceptionally high explanatory power observed for Investor Confidence ($R^2 = 0.935$) warrants careful interpretation. Theoretically, this result is plausible because Investor Confidence is positioned as a behavioural response to two closely relevant but conceptually distinct antecedents: Institutional Support, which provides regulatory legitimacy and financing certainty, and Fintech Innovation, which enhances transparency, monitoring, and the credibility of sustainability-related information. Within an emerging Islamic green-finance ecosystem, these institutional and technological mechanisms can jointly reduce uncertainty and information asymmetry, thereby explaining a substantial proportion of variation in investor confidence. Importantly, the high R^2 should not, by itself, be interpreted as evidence of model overfitting or construct redundancy. The measurement model demonstrates satisfactory discriminant validity, with HTMT ratios remaining below the recommended threshold, while the collinearity diagnostics and predictive assessment reported in subsequent sections provide additional evidence that the constructs remain empirically distinguishable and that the model retains predictive relevance beyond the estimation sample. Nevertheless, the magnitude of the R^2 calls for appropriate caution, and future studies employing longitudinal, multi-source, or

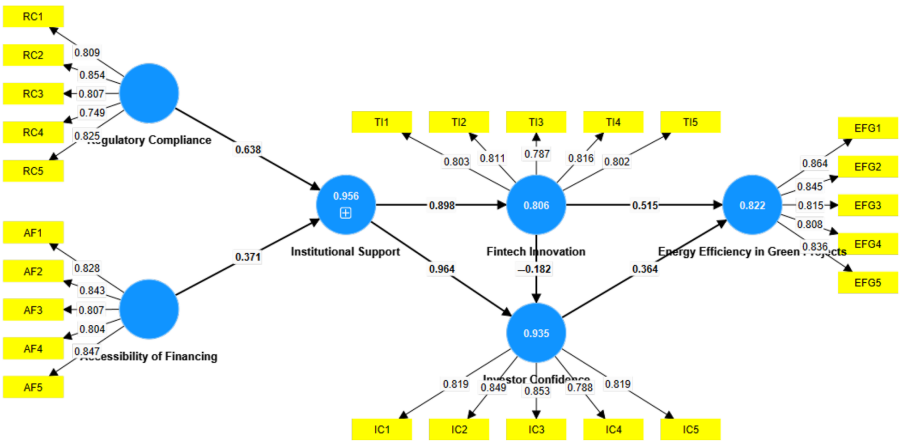

Figure 2. Structural model results of the PLS-SEM analysis (two-stage HOC approach). Source: Authors' own work

cross-country data may provide further evidence regarding the stability of these relationships across different institutional contexts.

Measurement model

The quality of the measurement model was first assessed. Convergent validity was established, as all indicator loadings exceeded the recommended threshold of 0.70, with minor variations still above 0.74. Composite reliability (CR) values were consistently greater than 0.90, and average variance extracted (AVE) values exceeded 0.65 across constructs. This finding confirms strong internal consistency and convergent validity.

Discriminant validity was evaluated using both the HTMT criterion and the Fornell–Larcker criterion. HTMT ratios were comfortably below 0.90, supporting the distinctiveness of the constructs despite high correlations. Table 3 summarises these results.

Overall, the measurement model demonstrates satisfactory psychometric properties. This finding provides a strong foundation for evaluating the structural model and interpreting the hypothesised relationships.

Structural model

The inner model in Table 4 was examined through collinearity, path coefficients, explanatory power, and model fit. All VIF values were below 5, indicating no collinearity issues. The R^2 values indicate substantial explanatory power: 0.806 for TI, 0.935 for IC, and 0.822 for EFG. The SRMR value, below 0.08, further confirms a satisfactory global model fit.

The structural model estimated in SmartPLS 4 (two-stage HOC for Institutional Support) indicates that Institutional Support has significant predictive effects on Fintech Innovation ($\beta = 0.638$, $p < 0.001$) and Investor Confidence ($\beta = 0.371$, $p < 0.001$). In contrast, its direct path to Energy Efficiency is not significant ($\beta = -0.182$, $p = 0.231$). Fintech Innovation, in

Table 3. Measurement model assessment

Construct	Indicator loading range	AVE	CR	Cronbach's α	HTMT (max)
Regulatory compliance (RC)	0.749–0.854	0.74	0.91	0.88	<0.85
Access to financing (AF)	0.804–0.847	0.76	0.92	0.89	<0.85
Fintech innovation (TI)	0.787–0.816	0.81	0.94	0.91	<0.90
Investor confidence (IC)	0.789–0.854	0.82	0.94	0.92	<0.85
Energy efficiency (EFG)	0.808–0.864	0.83	0.95	0.93	<0.85

Source(s): Authors' own work

Table 4. Structural model path coefficients

Path	β	*t*-value	*p*-value	Result
IS → TI	0.638	12.3	0.000	Supported
IS → IC	0.371	5.7	0.000	Supported
TI → IC	0.964	31.5	0.000	Supported
TI → EFG	0.515	9.8	0.000	Supported
IC → EFG	0.364	6.1	0.000	Supported
IS → EFG	−0.182	1.2	0.231	Not supported

Note(s): R^2: TI = 0.806; IC = 0.935; EFG = 0.822
Q^2 (blindfolding): all >0, confirming predictive relevance

Source(s): Authors' own work

turn, strongly predicts Investor Confidence ($\beta = 0.964$, $p < 0.001$) and directly improves Energy Efficiency ($\beta = 0.515$, $p < 0.001$); Investor Confidence also contributes positively to Energy Efficiency ($\beta = 0.364$, $p < 0.001$). The model attains substantial explanatory power (R^2: TI = 0.806; IC = 0.935; EFG = 0.822) and acceptable global fit (SRMR <0.08), with positive Q^2 values indicating predictive relevance.

The absence of a significant direct relationship between Institutional Support and Energy Efficiency suggests that regulatory and financing arrangements alone may be insufficient to generate measurable sustainability outcomes. Instead, their influence appears to operate through technological and behavioural mechanisms, supporting the theoretical proposition that institutional conditions require complementary implementation channels before they are translated into operational performance improvements.

Mediation analysis

Bootstrapping results confirm that multiple indirect effects are statistically significant, supporting the proposed framework.

Bootstrapping results confirm three significant indirect effects consistent with the proposed dual-mediation structure (Table 5). Institutional support affects Energy Efficiency indirectly through both Fintech Innovation (IS → TI → EFG, $\beta = 0.329$, $p < 0.001$) and Investor Confidence (IS → IC → EFG, $\beta = 0.135$, $p < 0.001$), while Fintech Innovation further enhances efficiency indirectly via Investor Confidence (TI → IC → EFG, $\beta = 0.351$, $p < 0.001$). These results indicate that institutional mechanisms are associated with energy-efficiency outcomes through technological and behavioural pathways. In this configuration, Fintech Innovation operates as both a capability that improves project performance and a signal that strengthens investor confidence, validating the interdependence between technological and behavioural pathways.

Predictive assessment (PLSpredict)

The predictive relevance of the model was assessed using the PLSpredict procedure in Table 6. All Q^2predict values exceeded zero (ranging from 0.48 to 0.71), confirming predictive capability.

For Energy Efficiency (EFG), the PLS-SEM model consistently achieved lower RMSE values compared to the linear benchmark (LM), indicating superior predictive performance. For Investor Confidence (IC), results were mixed: PLS-SEM outperformed LM on some indicators (IC1, IC4), while LM slightly outperformed on others (IC2, IC3, IC5). Overall, the PLSpredict results indicate moderate-to-high predictive power, as the PLS-SEM model outperformed or matched the benchmark linear model across most indicators.

These results reinforce that the framework is not only theoretically grounded but also predictive, with an emphasis on models that inform practice.

Robustness checks

A series of robustness tests was conducted to ensure the model's validity and stability. Collinearity diagnostics confirmed that all inner and full VIF values were well below accepted

Table 5. Mediation results

Mediation path	Indirect effect	*t*-value	*p*-value	Result
IS → TI → EFG	0.329	7.4	0.000	Supported
IS → IC → EFG	0.135	4.2	0.000	Supported
TI → IC → EFG	0.351	8.9	0.000	Supported

Source(s): Authors' own work

Table 6. PLSpredict results

Indicator	Q^2predict	PLS-SEM RMSE	LM RMSE	Better model
EFG1	0.530	0.639	0.658	PLS-SEM
EFG2	0.602	0.625	0.632	PLS-SEM
EFG3	0.513	0.636	0.644	PLS-SEM
EFG4	0.511	0.683	0.700	PLS-SEM
EFG5	0.552	0.622	0.633	PLS-SEM
IC1	0.534	0.620	0.620	Tie
IC2	0.612	0.611	0.607	LM (slightly)
IC3	0.588	0.608	0.596	LM (slightly)
IC4	0.482	0.704	0.710	PLS-SEM
IC5	0.506	0.664	0.648	LM (slightly)

Source(s): Authors' own work

thresholds (5 and 3.3, respectively), indicating the absence of multicollinearity. The blindfolding procedure yielded positive cross-validated redundancy values (Q^2) for all endogenous constructs, confirming strong predictive relevance. Common-method variance was also assessed, with all full collinearity VIFs comfortably below 3.3, suggesting no significant bias arising from self-reported data.

Potential endogeneity concerns were mitigated through the careful specification of a theoretical model and the use of validated measurement items. Although diagnostic indicators did not suggest severe endogeneity, future studies could further strengthen causal inference using techniques such as the Gaussian copula or two-stage least squares in PLS. Collectively, these checks affirm that the proposed model is both statistically robust and methodologically sound, enhancing confidence in the reliability of its theoretical and empirical contributions.

Discussion

Institutional support as an enabling rather than direct mechanism

A central finding of this study is that institutional support does not exhibit a significant direct association with energy-efficiency outcomes. Although institutional support significantly influences both fintech innovation and investor confidence, its direct path to energy efficiency is not statistically significant. This finding suggests that regulatory frameworks, sustainability policies, and financing mechanisms alone may be insufficient to generate measurable operational improvements. Instead, institutional arrangements appear to function primarily as enabling conditions that create the environment within which technological and behavioural mechanisms can operate effectively. In this respect, the findings challenge the assumption that stronger regulation or greater financing availability automatically translates into improved sustainability performance.

This result is consistent with institutional theory, which views institutions as systems of rules, norms, and resources that shape organisational behaviour by creating incentives and constraints rather than directly determining outcomes (Scott, 2013). Regulatory requirements and financing structures may encourage organisations to adopt sustainability-oriented practices, but the translation of these institutional pressures into measurable performance improvements depends on how organisations respond to them. The findings therefore support the argument that institutional arrangements primarily provide legitimacy, policy direction, and resource access, while actual performance improvements emerge through organisational adaptation and implementation processes. This interpretation is also consistent with the notion of coercive isomorphism proposed by DiMaggio and Powell (2000), whereby regulatory

pressures encourage conformity to sustainability expectations without necessarily guaranteeing operational effectiveness.

The findings also resonate with recent debates in the sustainable-finance literature that emphasise the dual nature of institutional arrangements. While regulatory frameworks, sustainability taxonomies, and disclosure requirements enhance transparency and legitimacy, excessive complexity, fragmented standards, and implementation inconsistencies may simultaneously constrain innovation and reduce market responsiveness (Begemann *et al.*, 2025; Hilbrich, 2026). Similarly, Silva and Awazu (2025) argue that sustainability regulations can generate substantial compliance burdens when institutional capacities remain uneven, while Achterfeldt and Traverso (2026) highlight that differences in taxonomy design may create uncertainty regarding the credibility and comparability of sustainability classifications. Viewed from this perspective, the non-significant direct effect observed in this study suggests that institutional support alone does not guarantee efficiency gains. Rather, its effectiveness depends on the extent to which institutional arrangements are translated into practical capabilities and credible market signals.

The Indonesian context provides a useful illustration of this mechanism. Regulatory initiatives such as POJK 51/2017, the Sustainable Finance Roadmap Phase II, and the Indonesian Taxonomy for Sustainable Finance have established an important institutional foundation for sustainable-finance development. These policies provide guidance, disclosure requirements, and financing incentives that encourage market participation and sustainability-oriented investment. However, the present findings indicate that their contribution to energy-efficiency outcomes is realised primarily when they facilitate technological innovation and strengthen investor confidence. Consequently, institutional support should be understood not as a direct driver of sustainability outcomes but as a foundational governance mechanism that enables technological and behavioural processes through which measurable efficiency improvements are ultimately achieved.

Fintech innovation as both capability and signal

The second major finding concerns the central role of fintech innovation as both an operational capability and a signalling mechanism within Islamic green-finance ecosystems. The results demonstrate that fintech innovation is positively associated with both energy efficiency and investor confidence, suggesting that digital technologies contribute not only to operational improvements but also to the credibility and legitimacy of sustainability-oriented financial activities. This finding extends previous studies that have primarily examined fintech from the perspectives of financial inclusion, user adoption, or digital financial services by demonstrating its broader role in translating institutional support into measurable sustainability outcomes.

From a capability perspective, fintech innovation enhances the ability of organisations to monitor, verify, and optimise project performance. Climate-fintech applications such as digital monitoring, reporting, and verification (MRV) systems, blockchain-enabled transaction records, artificial intelligence, and data analytics improve information quality and reduce the operational inefficiencies that often hinder sustainability initiatives. These technologies facilitate real-time tracking of energy consumption, environmental performance, and project implementation, enabling managers and investors to identify inefficiencies and undertake corrective actions more effectively. The significant positive relationship between fintech innovation and energy efficiency observed in this study is therefore consistent with recent evidence suggesting that digital technologies improve sustainability performance by strengthening transparency, accountability, and resource optimisation (Offiong *et al.*, 2025; Ahmad *et al.*, 2026; Shen *et al.*, 2026). The findings also align with the International Energy Agency's characterisation of energy efficiency as the "first fuel", highlighting the importance of technologies that support measurement, control, and optimisation in achieving measurable environmental outcomes.

Beyond its operational role, fintech innovation also functions as a powerful market signal. Drawing on Signalling Theory (Spence, 1973; Connelly *et al.*, 2010), digital technologies generate observable indicators of transparency, accountability, and governance quality that reduce information asymmetry between issuers and investors. In sustainable-finance markets, where information regarding environmental performance is often difficult to verify, technologies such as blockchain verification systems, digital sustainability dashboards, and automated reporting tools provide credible signals regarding the quality and legitimacy of financed projects. The exceptionally strong relationship between fintech innovation and investor confidence observed in this study suggests that investors place substantial value on technological transparency when evaluating sustainability-oriented investment opportunities. This finding supports recent climate-fintech research indicating that digital transparency functions not only as an operational tool but also as a trust-building mechanism that enhances market confidence and facilitates capital mobilisation (Loukoianova *et al.*, 2024; Chien *et al.*, 2025).

At the same time, the findings should not be interpreted as suggesting that fintech innovation automatically generates sustainability benefits. Recent studies increasingly emphasise implementation challenges associated with cybersecurity vulnerabilities, data-governance risks, technological readiness, and unequal access to digital infrastructure, particularly in emerging economies (Aldboush and Ferdous, 2023; Loukoianova *et al.*, 2024). Moreover, digital technologies may improve information availability without necessarily guaranteeing effective utilisation or meaningful sustainability outcomes when institutional oversight remains weak. Consequently, the effectiveness of fintech innovation depends not only on technological sophistication but also on the quality of governance structures, regulatory support, and organisational capabilities surrounding its implementation. This observation reinforces the broader argument of this study that technological innovation produces the greatest sustainability benefits when embedded within supportive institutional environments that provide legitimacy, standards, and accountability mechanisms.

Investor confidence as the behavioural transmission mechanism

The third major finding highlights the importance of investor confidence as the behavioural mechanism through which institutional credibility and technological transparency are translated into sustainability outcomes. The positive association between investor confidence and energy efficiency indicates that sustainability performance is influenced not only by regulatory frameworks or technological capabilities but also by how investors perceive, evaluate, and respond to sustainability-related information. This finding suggests that the effectiveness of Islamic green-finance initiatives depends on the willingness of investors to trust the institutions, technologies, and governance mechanisms that underpin sustainable-investment activities.

From a behavioural-finance perspective, investor confidence reduces uncertainty and facilitates capital allocation toward projects perceived as credible and legitimate (Shiller, 2015; Barberis, 2018). In sustainable-finance markets, investors often face significant information asymmetries because environmental outcomes are difficult to observe directly and may only materialise over extended periods. Under such conditions, confidence functions as a behavioural shortcut that enables investors to commit resources despite uncertainty. The findings therefore support previous research showing that transparency, credible disclosure, and verification mechanisms increase investor trust and encourage participation in sustainability-oriented financial markets (Pirgaip and Arslan-Ayaydin, 2024; Lee *et al.*, 2025).

The results are particularly relevant in the context of Islamic finance, where confidence is reinforced not only by financial considerations but also by ethical legitimacy and Shariah compliance. Islamic financial institutions operate within a governance framework that incorporates religious principles, ethical screening, and accountability mechanisms designed to strengthen trust among stakeholders. Consequently, investor confidence reflects more than

perceptions of financial performance; it also embodies confidence in the integrity, transparency, and social legitimacy of the underlying financing activities. This interpretation is consistent with studies suggesting that trust in Islamic financial services is shaped by transparency, ethical safeguards, privacy protection, brand credibility, and perceived compliance with Islamic principles (Aldboush and Ferdous, 2023; Alsmadi, 2024; Marhadi *et al.*, 2024).

The findings further suggest that investor confidence contributes to sustainability outcomes by strengthening both capital mobilisation and project oversight. Higher levels of confidence increase the willingness of investors to allocate funds to sustainability-oriented projects, thereby improving access to capital for initiatives that require long-term financing. At the same time, confident investors are more likely to remain engaged with funded projects and to support accountability mechanisms that encourage effective implementation and performance monitoring. This interpretation aligns with evidence showing that investor participation enhances the effectiveness of green-finance initiatives when supported by credible governance structures and transparent sustainability disclosures (Zhou *et al.*, 2024; Wang and Xu, 2025).

Nevertheless, confidence should not be viewed as an unconditionally positive force. The sustainable-finance literature increasingly warns that excessive reliance on sustainability labels, ESG ratings, or green-finance certifications may create a false sense of assurance and reduce incentives for independent evaluation (Berg *et al.*, 2022; Christensen *et al.*, 2022). Similarly, herding behaviour may encourage investors to follow prevailing sustainability trends without critically assessing the environmental performance of individual projects (Gillan *et al.*, 2021). Under such circumstances, confidence may reinforce legitimacy without necessarily improving actual sustainability outcomes. Therefore, investor confidence contributes most effectively to energy-efficiency performance when supported by transparent disclosure systems, independent verification processes, and robust monitoring mechanisms that enable investors to distinguish substantive sustainability achievements from symbolic sustainability claims. This observation reinforces the importance of integrating behavioural trust with technological transparency and institutional accountability within Islamic green-finance ecosystems.

Dual-mediation mechanism and integrated sustainability governance

The mediation results provide the most important theoretical contribution of this study by demonstrating that institutional support is associated with energy-efficiency outcomes through two complementary and mutually reinforcing pathways. The first pathway operates through fintech innovation, while the second operates through investor confidence. In addition, fintech innovation indirectly contributes to energy efficiency by strengthening investor confidence. Taken together, these findings suggest that sustainability outcomes emerge not from isolated institutional, technological, or behavioural factors but from their interaction within a broader governance ecosystem. This observation responds to recent calls for more integrated frameworks capable of linking institutional arrangements, technological transformation, and stakeholder behaviour within sustainable-finance systems (Koranteng and You, 2024; Loukoianova *et al.*, 2024).

The capability pathway highlights how institutional support creates conditions that facilitate technological innovation. Consistent with institutional theory, regulatory frameworks, financing accessibility, disclosure requirements, and sustainability standards provide legitimacy and incentives that encourage the adoption of digital technologies (DiMaggio and Powell, 2000; Scott, 2013). These technologies subsequently improve monitoring, reporting, verification, and resource optimisation, thereby contributing to measurable energy-efficiency outcomes. This finding is consistent with recent evidence suggesting that technological innovation functions as a critical mechanism through which institutional conditions are translated into sustainability performance and green productivity improvements (Yang and Huang, 2025; Ahmad *et al.*, 2026; Shen *et al.*, 2026).

The behavioural pathway reveals a complementary process. Institutional arrangements and technological transparency jointly enhance investor confidence by reducing uncertainty and strengthening the credibility of sustainability claims. Increased confidence subsequently facilitates capital mobilisation, stakeholder engagement, and project oversight, all of which support the achievement of sustainability objectives. This finding aligns with signalling theory, which suggests that credible signals reduce information asymmetry and influence stakeholder behaviour (Spence, 1973; Connelly *et al.*, 2010). It also supports growing evidence from sustainable-finance research indicating that investor confidence plays a crucial role in determining whether sustainability-oriented initiatives attract sufficient resources and long-term commitment (Pirgaip and Arslan-Ayaydin, 2024; Lee *et al.*, 2025; Wang and Xu, 2025).

Importantly, the findings indicate that the two pathways are not independent but mutually reinforcing. Institutional support facilitates technological innovation, while technological innovation enhances transparency and credibility, which in turn strengthen investor confidence. Higher levels of investor confidence subsequently reinforce both capital allocation and project oversight, increasing the likelihood that sustainability objectives are translated into measurable efficiency outcomes. This sequential relationship is consistent with emerging ecosystem perspectives that emphasise the interdependence of governance quality, technological capability, and stakeholder trust in generating sustainability outcomes (Loukoianova *et al.*, 2024; Koranteng and You, 2024; Teixeira, 2026).

These findings extend the Islamic green-finance literature in several ways. Previous studies have often focused on individual dimensions of sustainable-finance ecosystems, such as regulatory quality, fintech adoption, financial inclusion, or investor behaviour (Alsmadi, 2024; Idrees and Ullah, 2024; Koranteng and You, 2024). By integrating institutional theory, signalling theory, and behavioural finance within a unified framework, this study demonstrates how institutional arrangements are translated into measurable sustainability outcomes through interconnected technological and behavioural channels. The findings therefore contribute to a growing body of research seeking to explain not only how sustainable-finance systems mobilise capital but also how they generate real-economy impacts such as energy-efficiency improvements (Novák *et al.*, 2025; Lei *et al.*, 2025).

Theoretical contributions

This study contributes to theory by demonstrating that institutional support influences sustainability outcomes indirectly through technological and behavioural mechanisms. The findings extend institutional theory by showing that regulatory frameworks and financing accessibility function primarily as enabling conditions rather than direct drivers of performance (DiMaggio and Powell, 2000; Scott, 2013). The study also advances the fintech literature by conceptualising fintech innovation as both an operational capability that enhances efficiency and a signalling mechanism that strengthens investor confidence. More broadly, the findings integrate institutional theory, signalling theory, and behavioural finance into a unified framework, illustrating how governance structures, technological innovation, and investor trust jointly contribute to energy-efficiency outcomes within Islamic green-finance ecosystems.

Practical and policy implications

The findings offer distinct implications for key stakeholders within Islamic green-finance ecosystems. For policymakers, the results suggest that sustainable-finance strategies should integrate institutional support with technological development and market participation rather than relying solely on financing programmes or regulatory mandates. Policy initiatives that encourage digital infrastructure, sustainability-oriented financial innovation, and credible mechanisms for evaluating environmental outcomes may strengthen the translation of green-finance initiatives into measurable energy-efficiency improvements.

For regulators, the findings highlight the importance of complementing disclosure requirements and sustainability taxonomies with frameworks that encourage digital monitoring, transparent reporting, and credible verification. Regulatory support can create enabling conditions for sustainability outcomes, but its effectiveness depends on whether institutional requirements are translated into technological capabilities and trusted market signals. Regulators should therefore promote interoperable digital monitoring, reporting, and verification (MRV) mechanisms while maintaining appropriate safeguards for transparency, accountability, and investor protection.

For Islamic financial institutions, the findings emphasise the strategic value of embedding technological capabilities into the design and management of green-finance products. Digital reporting systems, automated compliance tools, and transparent performance-monitoring mechanisms can improve project oversight while strengthening the credibility of sustainability claims. Integrating such capabilities with Shariah governance may further reinforce the ethical legitimacy and accountability of Islamic green-finance initiatives.

For fintech companies, the results indicate that technological innovation can contribute to sustainability outcomes both as an operational capability and as a mechanism for building market confidence. Fintech providers can strengthen their role within the green-finance ecosystem by developing solutions that improve data transparency, facilitate real-time monitoring, and support reliable verification of energy-efficiency performance. Such technologies should be designed not merely to digitalise financial transactions but also to enhance the observability and credibility of sustainability outcomes.

For investors, the findings underscore the importance of evaluating green-finance opportunities through credible institutional and technological signals. Digital transparency and verification mechanisms can reduce information asymmetry and strengthen confidence, but investment decisions should remain grounded in verifiable sustainability performance rather than relying solely on green labels or market sentiment. Active investor attention to disclosure quality, monitoring mechanisms, and measurable energy-efficiency outcomes can also strengthen accountability within Islamic green-finance projects.

Conclusion

This study examined how institutional support, operationalised through regulatory compliance and access to financing, is associated with energy-efficiency outcomes in Islamic green finance. The findings indicate that institutional support does not directly translate into efficiency performance but operates through two complementary pathways: fintech innovation and investor confidence. Fintech innovation enhances transparency, monitoring, and operational capabilities, while investor confidence facilitates capital mobilisation and project oversight. Together, these technological and behavioural mechanisms help explain how institutional arrangements are associated with measurable sustainability outcomes.

The study contributes to the literature by integrating institutional theory, signalling theory, and behavioural finance into a unified framework that links governance structures, digital innovation, and stakeholder trust. The findings extend existing research in Islamic green finance by moving beyond adoption and financing issues to explain how institutional arrangements are translated into operational sustainability outcomes. More broadly, the results suggest that effective sustainability governance depends on the alignment of institutional support, technological capability, and investor confidence rather than on any single mechanism operating in isolation.

From a practical perspective, the findings imply that regulatory initiatives and financing programmes are likely to be more effective when accompanied by digital monitoring systems, transparent disclosure mechanisms, and initiatives that strengthen investor trust. Such alignment may enhance the effectiveness of sustainable-finance programmes and support energy-efficiency objectives within Islamic finance ecosystems.

This study should be interpreted in light of its contextual boundaries. The empirical evidence is drawn exclusively from Indonesia, whose Islamic finance ecosystem is characterised by a distinctive combination of regulatory development, sovereign green sukuk initiatives, rapid fintech expansion, and a large retail-oriented market. These institutional characteristics differ from those of more established Islamic finance markets, including Malaysia and the Gulf Cooperation Council (GCC) countries, where regulatory architectures, capital-market structures, investor profiles, and the maturity of Islamic financial institutions may shape the relationships examined in this study differently. Consequently, the findings should not be assumed to generalise automatically across Islamic finance jurisdictions. Rather, they provide context-specific evidence from an emerging Islamic green-finance ecosystem, and the external validity of the proposed framework should be assessed through replication in institutional settings with different regulatory, technological, and market characteristics.

Future research can extend the present study in several directions. Longitudinal designs could examine whether the relationships among institutional support, fintech innovation, investor confidence, and energy-efficiency outcomes remain stable as regulatory frameworks and digital technologies evolve. Cross-country studies, particularly comparisons involving Indonesia, Malaysia, and GCC countries, could assess how differences in institutional and market environments shape the proposed relationships. Future studies could also complement perceptual survey measures with objective indicators of energy efficiency, such as verified reductions in energy consumption or project-level performance data, and employ multi-source datasets that combine information from investors, financial institutions, fintech providers, and project operators. Finally, comparative research between Islamic and conventional green-finance ecosystems could clarify whether Shariah governance and the ethical foundations of Islamic finance generate distinctive institutional, technological, or behavioural mechanisms in the pursuit of sustainability outcomes.

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Corresponding author
Darmawan Darmawan can be contacted at: Darmawan@uin-suka.ac.id