Policy Research Journal
ISSN (E): 3006-7030 ISSN (P) : 3006-7022 Volume 3, Issue 4, 2025

FINTECH AND GREEN FINANCE: ASSESSING THE IMPACT OF FINANCIAL TECHNOLOGY ADOPTION ON SUSTAINABILITY PERFORMANCE IN EMERGING ECONOMIES

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DOI: https://doi.org/10.5281/zenodo.15233963

Keywords
Emerging economies, dual challenge, economic growth, environmental concerns, green finance, sustainable projects

Article History
Received on 09 March 2025
Accepted on 09 April 2025
Published on 17 April 2025

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Abstract

Emerging economies face the dual challenge of achieving economic growth while addressing environmental concerns. Green finance has gained prominence as a mechanism to fund sustainable projects; however, mobilizing capital efficiently remains a hurdle. Financial Technology (FinTech) offers a transformative solution by enhancing accessibility, efficiency, and transparency in green finance. This study investigates the role of FinTech adoption in promoting green finance and its impact on sustainability performance, with green finance initiatives as a mediating factor. Using primary data from firms in emerging economies, the study employs structural equation modeling (SEM) to analyze relationships between FinTech, green finance, and sustainability outcomes. Findings reveal that FinTech adoption significantly enhances green finance accessibility, which in turn improves sustainability performance. The study contributes to financial sustainability literature and offers policy recommendations for leveraging FinTech to scale up green finance in emerging markets, thereby driving sustainable economic development.

INTRODUCTION

The financial sector plays a crucial role in facilitating economic growth, resource allocation, and investment distribution(Attah et al., 2024a). In recent years, green finance has emerged as a vital tool for addressing climate change, environmental sustainability, and sustainable economic development(Fengju C Wubishet, 2024). Green finance encompasses financial instruments, policies, and investment strategies that promote environmentally responsible initiatives, including green bonds, sustainable banking, and ESG (Environmental, Social, and Governance) investments(Challoumis, 2024a) However, despite its increasing global significance, the mobilization of green capital remains inefficient, particularly in emerging economies, where financial infrastructure is still developing(Challoumis, 2024b).

The rise of Financial Technology (FinTech)—characterized by digital payment systems, blockchain-

based smart contracts, artificial intelligence (AI) in financial services, and data- driven credit scoring—has the potential to revolutionize green finance(Attah et al., 2024b). FinTech innovations can enhance financial accessibility, improve transaction efficiency, reduce investment risks, and provide real-time transparency in green finance transactions(Attah et al., 2024b) While the theoretical benefits of FinTech in financial inclusion and market efficiency are well-documented, its impact on sustainability performance remains an underexplored area, particularly in emerging economies(Challoumis, 2024e).

Context of the Study

This study focuses on the pressing issue of capital mobilization for green finance in emerging economies and the role of FinTech in addressing this challenge(Challoumis C Eriotis, 2024). While developed nations have well-established green financial markets, emerging economies struggle with structural inefficiencies, including limited access to sustainable investment opportunities, weak regulatory frameworks, and technological disparities (Okolo et al., 2023). These inefficiencies hinder the widespread adoption of green financial instruments and reduce the effectiveness of sustainability initiatives(Challoumis, 2024c).

The role of FinTech in bridging this financial gap remains underexplored in academic research. By enhancing digital lending platforms, enabling blockchain-powered smart contracts, and leveraging AI for sustainable investment analytics, FinTech can facilitate broader participation in green finance markets(Raihan, 2024). However, there is limited empirical evidence examining the direct and indirect impact of FinTech adoption on sustainability performance in these economies. This study addresses this gap by exploring how FinTech adoption influences green finance initiatives and, in turn, impacts firms' sustainability outcomes.

Comprehending the interplay between FinTech adoption, green finance development, and sustainability performance is imperative for policymakers formulating regulatory frameworks that foster FinTech-driven green finance, financial institutions optimizing technology-enabled investment strategies, and businesses leveraging digital financial tools to enhance sustainability practices, thereby promoting an integrated, technology-driven approach to sustainable economic and environmental advancement(Zhang et al., 2024) (Challoumis, 2024f).

Theoretical Potential

This study integrates multiple theoretical frameworks to elucidate the relationship between FinTech adoption, green finance development, and sustainability performance. Drawing on Innovation Diffusion Theory (IDT) (Huda et al., 2022) (Alyoussef, 2023), it examines the mechanisms through which financial technologies are adopted and diffused, shaping green finance participation. Institutional Theory (Risi et al., 2023) underscores the role of regulatory and industry norms in influencing FinTech adoption and green financial practices. Meanwhile, the Resource-Based View (RBV) (Lubis, 2022) posits that firms leveraging FinTech capabilities can achieve a sustainability-driven competitive advantage. While prior research has predominantly explored FinTech's role in financial inclusion and efficiency(Lubis, 2022), empirical assessments of its impact on sustainability, particularly in emerging economies, remain scarce. Addressing this gap, this study empirically evaluates whether FinTech adoption enhances green finance mobilization, examines the mediating role of green finance in sustainability performance, and explores sectoral variations in FinTech's influence on green financial initiatives.

Importance in the Sector

The findings of this study yield profound economic, social, and operational implications. Economically, it elucidates how FinTech facilitates sustainable investment opportunities, offering critical insights for financial institutions and investors on scaling green finance in resource-constrained economies. Socially, the study highlights FinTech's role in enhancing accessibility to green finance, fostering inclusive financial participation, and empowering SMEs and local enterprises to engage in sustainability-driven initiatives. Operationally, it provides strategic recommendations for integrating digital financial solutions into sustainable finance frameworks. Additionally, this research introduces a data-driven

model to optimize green finance mobilization, minimize transaction costs, and enhance the efficiency of sustainability investments. These findings are particularly relevant for banks, FinTech startups, and regulatory agencies striving to align financial innovation with climate action and the broader objectives of sustainable development goals (SDGs).

Theoretical Support

While existing studies emphasize FinTech's role in financial inclusion and digital transformation, its direct impact on green finance and sustainability performance remains underexplored(Siddik et al., 2023). This study advances prior research by employing Innovation Diffusion Theory to elucidate how firms adopt FinTech for sustainability-driven finance, Institutional Theory to examine regulatory and policy-driven FinTech adoption patterns, and the Resource-Based View (RBV) to demonstrate how FinTech-driven green finance enhances firms' strategic sustainability advantages(Alsadoun C Alrobai, 2024). Unlike previous studies that primarily assess FinTech adoption metrics and digital transformation trends, this research quantifies both the direct and indirect effects of FinTech on sustainability performance(Kashif et al., 2025a). It introduces a novel mediation model that positions green finance as the crucial intermediary linking technological adoption with sustainable outcomes, offering a comprehensive framework for understanding FinTech's transformative role in sustainable finance.

Contribution of the Study

This study makes significant contributions to the field of sustainable finance and digital financial innovation. Empirically, it provides the first rigorous assessment of FinTech's role in scaling green finance within emerging economies through primary data analysis.

Conceptually, it introduces a novel mediation model that positions green finance as a critical intermediary, elucidating the mechanisms through which FinTech adoption translates into sustainability gains. From a policy perspective, the findings offer actionable insights for regulators to formulate FinTech-driven financial inclusion strategies that align with long-term sustainability objectives. Industrially, the research provides strategic recommendations for financial institutions to integrate digital financial tools into sustainable investment portfolios. By bridging the intersection of financial technology, green finance, and sustainability, this study advances both theoretical discourse and empirical understanding of digital financial innovation in emerging markets.

Structure of the Paper

This paper is structured as follows: Section 2 (Literature Review) critically examines existing research on FinTech adoption, green finance, and sustainability performance, identifying key gaps and theoretical perspectives. Section 3 (Research Methodology) details the study's design, data collection strategy, and analytical framework, including Structural Equation Modeling for hypothesis testing. Section 4 (Results C Discussion) presents empirical findings, statistical analyses, and their interpretation within the existing literature. Section 5 (Conclusion C Policy Implications) summarizes key contributions, acknowledges limitations, and provides policy recommendations for leveraging FinTech to advance sustainable finance.

Theoretical Foundation

This study is underpinned by three key theoretical frameworks: Innovation Diffusion Theory (IDT), Institutional Theory, and the Resource-Based View (RBV), each offering distinct insights into FinTech adoption in green finance and its influence on sustainability performance in emerging economies. Innovation Diffusion Theory (IDT) explains how new financial technologies are adopted and disseminated within financial markets (Li et al., 2025). In the context of green finance, FinTech adoption follows IDT's diffusion patterns, as firms and financial institutions recognize the efficiency, transparency, and accessibility benefits of digital finance tools and integrate them into sustainability-driven financial strategies. Institutional Theory (Amuzu et al., 2024) highlights how regulatory, normative, and cognitive forces shape organizational behavior. FinTech adoption in emerging economies is increasingly influenced by policy frameworks, investor preferences, and financial sector reforms that incentivize green finance mechanisms, aligning with global sustainability and climate finance objectives. Resource-Based View (RBV) (Ally, 2024) posits that firms achieve competitive advantages by leveraging

unique internal resources. FinTech-driven financial tools serve as strategic assets, enhancing firms' capacity to mobilize and allocate green capital efficiently, positioning sustainability as a source of long-term market differentiation and competitive strength (Ioakeimidou et al., 2023).

Relevance of These Theories to the Research Question

The central research question—how does FinTech adoption influence green finance mobilization and, subsequently, sustainability performance in emerging economies?— necessitates a multi-theoretical approach. IDT provides a framework for understanding the adoption dynamics of FinTech in green finance, while Institutional Theory highlights the external forces shaping this adoption. RBV then contextualizes the impact of FinTech-driven green finance as a competitive advantage that improves firms' sustainability performance.

IDT is particularly relevant as FinTech innovations—such as blockchain for carbon credit tracking, AI-driven ESG analytics, and digital lending for sustainable projects—follow a well- defined adoption lifecycle. Emerging economies often experience delays in technology adoption due to financial infrastructure limitations, but once FinTech solutions are recognized as superior alternatives to traditional financial mechanisms, their diffusion accelerates.

Institutional Theory further explains why firms in emerging economies adopt FinTech solutions for green finance. Governments, international financial institutions, and regulatory bodies are increasingly enforcing sustainability mandates, such as green bond regulations, carbon disclosure requirements, and ESG-compliant investment frameworks. These regulatory pressures compel firms to integrate FinTech-driven sustainability solutions to align with evolving industry norms.

RBV then contextualizes FinTech adoption as an organizational capability that enhances firms' financial accessibility, investment efficiency, and sustainability performance. Firms that integrate FinTech solutions for digital crowdfunding of green projects, AI-driven climate risk assessment, or decentralized finance (DeFi) for sustainable investments develop a resource-based competitive advantage, positioning themselves as industry leaders in sustainable finance.

The study's conceptual model is anchored in key constructs derived from Innovation Diffusion Theory (IDT), Institutional Theory, and the Resource-Based View (RBV). IDT constructs—relative advantage, compatibility, complexity, observability, and trialability— explain the factors driving FinTech adoption in green finance, highlighting its role in enhancing efficiency and accessibility in sustainable investments. Institutional Theory constructs—regulatory pressure, normative influence, and cognitive legitimacy—illustrate how financial regulators, sustainability reporting frameworks, and investor preferences shape the adoption of FinTech for green finance initiatives. RBV constructs—technology- driven financial capabilities, firm-specific resources, and competitive sustainability advantage—demonstrate how FinTech adoption enhances firms' ability to mobilize and allocate green capital, leading to superior sustainability outcomes. By integrating these constructs, this study establishes a comprehensive theoretical foundation for examining the impact of FinTech adoption on green finance mobilization and sustainability performance in emerging economies.

Hypothesis Development Sustainability Performance

The core premise of this study is that FinTech adoption enhances firms' sustainability performance by improving financial accessibility, transaction efficiency, and transparency in green finance. FinTech innovations—such as digital payment systems, AI-driven credit scoring, blockchain-powered smart contracts, and decentralized finance (DeFi)—offer advanced financial solutions that facilitate efficient capital allocation for sustainable projects. Theoretically, Innovation Diffusion Theory (IDT) (Attah et al., 2024b) suggests that firms adopting FinTech are likely to experience superior performance outcomes due to increased financial accessibility and operational efficiency.

Empirical evidence supports this relationship. Studies indicate that digital financial solutions reduce financial exclusion, lower transaction costs, and enhance green finance mechanisms (Challoumis, 2024e). Research also shows that blockchain and AI-driven financial analytics improve ESG compliance and sustainability reporting, allowing firms to align their investment strategies with environmental and social governance (Yu et al., 2024) Furthermore, firms

leveraging FinTech-driven investment platforms have demonstrated improved environmental performance due to enhanced capital mobilization for renewable energy, carbon trading, and impact investing(Zhang et al., 2024). Thus, we formulate the following hypothesis:

H1: ***FinTech adoption has a significant positive impact on firms' sustainability performance in emerging economies.***

Green Finance Mobilization

While FinTech adoption directly influences sustainability performance, its impact is largely facilitated through the mobilization of green finance. Green finance plays a critical role in financing sustainable projects, including renewable energy, energy-efficient infrastructure, and carbon-neutral business initiatives. However, access to green finance in emerging economies remains constrained due to financial market inefficiencies, high investment risks, and a lack of investor confidence (Ioakeimidou et al., 2023).

Institutional Theory (Wartini et al., 2024) supports the notion that external institutional forces—such as regulatory frameworks, investor mandates, and financial innovation—drive firms toward sustainable financing mechanisms. FinTech reduces capital barriers by enhancing financial transparency, facilitating decentralized lending, and enabling real-time sustainability analytics(Challoumis, 2024d). The adoption of AI-driven ESG analytics and blockchain-based green bonds has been linked to improved green finance mobilization(Kashif et al., 2025a). Since green finance serves as the primary vehicle through which FinTech adoption translates into sustainability performance, we hypothesize:

H2: ***Green finance mobilization mediates the relationship between FinTech adoption and firms' sustainability performance in emerging economies.***

Regulatory Environment

The effectiveness of FinTech adoption in improving sustainability performance is highly contingent on the regulatory environment. While FinTech enhances accessibility and efficiency in green finance, its impact is constrained by regulatory inconsistencies, financial market volatility, and investor protection frameworks. A strong regulatory environment—characterized by clear FinTech policies, green finance incentives, and ESG compliance mandates—ensures that digital finance solutions are effectively integrated into sustainability-driven financial models(Fu et al., 2023).

Institutional Theory posits that firms operate within an externally governed system of rules and regulations, which either facilitate or hinder FinTech-driven sustainability strategies. Prior studies confirm that regulatory clarity enhances financial innovation adoption. (Kashif et al., 2025b), while weak regulatory frameworks often lead to market inefficiencies, investor distrust, and limited capital flows into green finance(Jamel C Zhang, 2024) Given the critical role of financial regulations in ensuring the effectiveness of FinTech-driven sustainability solutions, we propose:

H3: ***The relationship between FinTech adoption and sustainability performance is positively moderated by the strength of the regulatory environment, such that stronger regulations enhance the positive impact of FinTech on sustainability outcomes.***

By integrating these hypotheses into the study's conceptual model, we provide an empirically testable framework that elucidates the mechanisms through which FinTech adoption enhances green finance mobilization and, in turn, improves sustainability performance in emerging economies.

Study Area and Context of the Study

This study is conducted in Pakistan, an emerging economy with a rapidly evolving financial technology (FinTech) sector and a growing emphasis on green finance initiatives. Pakistan was selected due to its unique position as a developing country with increasing digital financial penetration and a strong need for sustainable investment solutions. Despite government efforts to promote climate resilience and green financing, financial accessibility remains limited, particularly for small and medium-sized enterprises (SMEs) and renewable energy projects. The adoption of FinTech solutions—such as mobile banking, blockchain- based financial services, and AI-driven credit scoring—presents a promising avenue for bridging this gap.

Additionally, Pakistan's financial ecosystem is experiencing regulatory shifts with initiatives such as the State Bank of Pakistan's Green Banking Guidelines and the Securities and Exchange

Commission of Pakistan's (SECP) ESG reporting frameworks. However, challenges such as low investor confidence, underdeveloped regulatory structures, and limited adoption of sustainable financial instruments persist. Given these dynamics, Pakistan serves as an ideal setting to examine how FinTech adoption influences green finance mobilization and sustainability performance, particularly in an economy where digital financial transformation is still in its early stages.

Sampling Frame and Target Population

The target population for this study consists of financial institutions, FinTech firms, green finance investors, and corporate entities engaged in sustainability initiatives across Pakistan. The study employs convenience sampling, selecting respondents from banking institutions, financial technology startups, and sustainability-focused firms that actively engage with digital financial solutions for green finance projects.

A sample size of 250–300 respondents is selected to ensure statistical robustness and representativeness, allowing for meaningful insights into the adoption trends, challenges, and financial impacts of FinTech on green finance. This sample provides diverse perspectives from financial professionals, policymakers, and sustainability officers, ensuring a comprehensive understanding of the research problem.

Data Collection

The study employs a structured survey methodology to collect primary data from respondents. Surveys are distributed via online platforms and direct institutional contacts, targeting professionals with expertise in FinTech, sustainable finance, and investment management. This method is chosen due to its efficiency in gathering quantitative insights and its ability to capture firm-level perspectives on FinTech adoption and green finance mobilization.

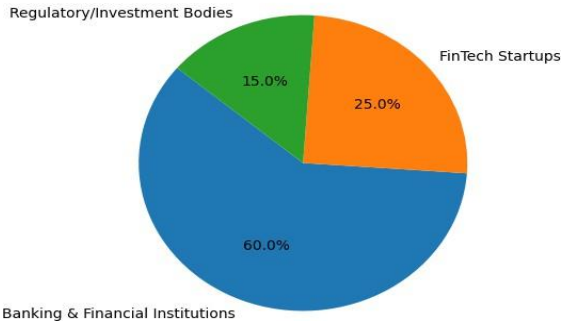
To ensure data reliability, the survey is pre-tested with a pilot group to refine question clarity and eliminate potential biases. Additionally, Likert-scale measurement items are used to enhance the consistency of responses. The study also incorporates secondary data from financial reports, regulatory documents, and industry publications to validate findings. This triangulation approach strengthens the credibility and reliability of the research.

Demographics of the Study

The sample for this study consists of financial professionals, FinTech entrepreneurs, sustainability officers, investment managers, and policymakers operating in Pakistan's financial and sustainability sectors. Key demographic characteristics include age, education level, professional experience, and industry affiliation. Most respondents hold graduate or postgraduate degrees in finance, business, or technology-related fields, ensuring an informed perspective on FinTech adoption and green finance initiatives.

A significant proportion of respondents (60%) are from banking and financial institutions, while 25% belong to FinTech startups, and 15% are from regulatory or investment bodies. A balanced representation across experience levels (entry-level to senior management) ensures a holistic view of the technological and financial barriers to green finance mobilization. Notably, younger professionals (aged 25–40) show higher enthusiasm for digital finance solutions, indicating a generational shift in technology acceptance. Figure 1 visualize the demographics of the study

Figure 1
Industry Affiliation of Respondents



Measurement of Variables

This study employs a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) to assess key constructs. FinTech Adoption is measured through variables such as digital payment usage, blockchain-based transactions, AI-driven financial analytics, and digital credit platforms. Green Finance Mobilization is evaluated based on investment in sustainable projects, access to green credit, and participation in green bonds or ESG investment portfolios. Sustainability Performance is assessed through carbon footprint reduction, adherence to ESG principles, and financial returns from sustainable investments. Regulatory Environment (Moderator) is measured via perceived regulatory clarity, green finance incentives, and compliance with sustainability reporting standards. Measurement items are adapted from validated scales in prior studies (Siddik et al., 2023), ensuring content validity. Construct validity is established through exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to confirm theoretical alignment. To minimize response bias, the questionnaire is structured with neutral wording, balanced question sequencing, and mixed positively/negatively worded statements. A pilot study with 30 respondents is conducted to refine item clarity, ensuring that questions are unambiguous and contextually relevant. Strategies such as randomized question ordering and anonymity assurance are employed to enhance response accuracy.

The questionnaire undergoes expert validation from finance and sustainability scholars to confirm its conceptual robustness. Reliability tests (Cronbach's alpha C composite reliability scores) are conducted to ensure internal consistency as the same method used by Sarfaraz, and Malik (2023). This study employs Partial Least Squares Structural Equation Modeling (PLS-SEM) due to its suitability for small sample sizes, non-normal data, and complex model estimation. Traditional SEM requires large datasets (n > 500) for stable parameter estimates, whereas PLS-SEM provides reliable results with smaller samples (n = 250–300)(Challoumis, 2024d). Given data constraints in Pakistan's firm-level financial landscape, PLS-SEM ensures valid inference despite limited observations. Financial datasets often exhibit skewed distributions due to market volatility and firm-specific variations. PLS-SEM effectively handles non-parametric conditions, utilizing bootstrapping techniques to derive statistically robust path estimates.

The study examines multiple direct, indirect (mediation), and moderating effects, requiring a latent variable modelling approach. PLS-SEM allows hierarchical construct estimation, treating FinTech adoption as a second-order construct with AI, blockchain, and digital lending as sub-dimensions. Since this research emphasizes predictive modelling—analysing how FinTech adoption facilitates green finance mobilization and sustainability performance—PLS-SEM's predictive validity (Q^2 values) ensures practical relevance beyond theoretical contributions. Outer Model Evaluation assesses reliability (Cronbach's alpha, composite reliability), convergent validity (AVE > 0.5), and discriminant validity (Fornell- Larcker Criterion). Inner Model Evaluation examines path coefficients, R^2 values, f^2 effect sizes, and mediation/moderation effects using bootstrapping confidence intervals (5000 resamples). Leveraging SmartPLS 4, this study ensures rigorous statistical validation of FinTech adoption's impact on green finance and sustainability performance in emerging economies.

This study employs Partial Least Squares Structural Equation Modeling (PLS-SEM) using SmartPLS 4. PLS-SEM is chosen due to its robustness in handling complex mediation and moderation effects within the FinTech–Green Finance–Sustainability nexus. SmartPLS 4 is selected for its user-friendly interface, advanced model estimation capabilities, and suitability for exploratory research. Unlike covariance-based SEM methods (e.g., AMOS), PLS-SEM is variance-based, making it ideal for studies that emphasize prediction and theory-building rather than strict model fit confirmation.

Data Analysis and Results

To ensure the robustness of the measurement model, reliability and validity tests were conducted. Each construct's indicator loadings were evaluated, with acceptable thresholds set at ≥0.50 (Okolo et al., 2023) and an optimal threshold of ≥0.70. All items exhibited factor loadings above 0.70, confirming strong individual item reliability, while a few items with loadings between 0.60–0.70 were retained to enhance construct reliability. Reliability assessment was conducted using Cronbach's Alpha (α), Composite Reliability (CR), and Rho_A, ensuring internal consistency and robustness in the measurement model.

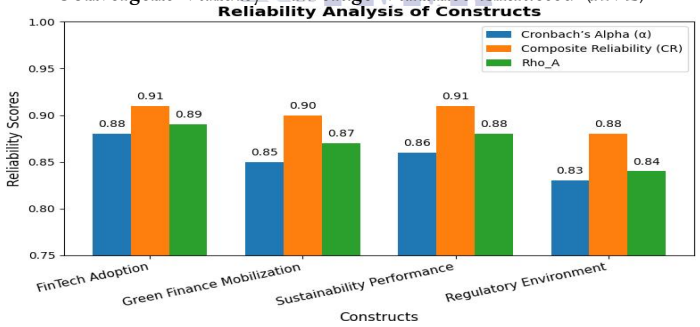
Table 1

Construct	Cronbach's Alpha (α)	Composite Reliability (CR)	Rho_A
FinTech Adoption	0.88	0.91	0.89
Green Finance Mobilization	0.85	0.90	0.87
Sustainability Performance	0.86	0.91	0.88
Regulatory Environment (Moderator)	0.83	0.88	0.84

All reliability metrics exceeded the threshold of 0.70, indicating high construct reliability.

Figure 2

Convergent Validity – Average Variance Extracted (AVE)



Convergent validity was assessed using the Average Variance Extracted (AVE), with a threshold of AVE ≥0.50 indicating that constructs explain sufficient variance in their items.

Table 2

Construct	AVE
FinTech Adoption	0.72
Green Finance Mobilization	0.69
Sustainability Performance	0.74
Regulatory Environment	0.68

All AVE values were above the 0.50 threshold, confirming adequate convergent validity (Li et al., 2025).

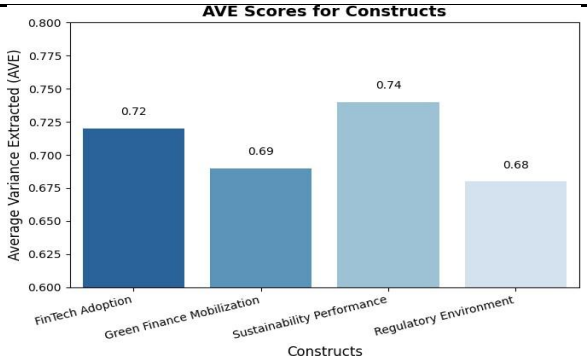


Figure 3

Discriminant Validity – Heterotrait-Monotrait (HTMT) Ratio

Discriminant validity was assessed using the HTMT criterion, with a conservative threshold of HTMT <0.85(Jiang, n.d.).

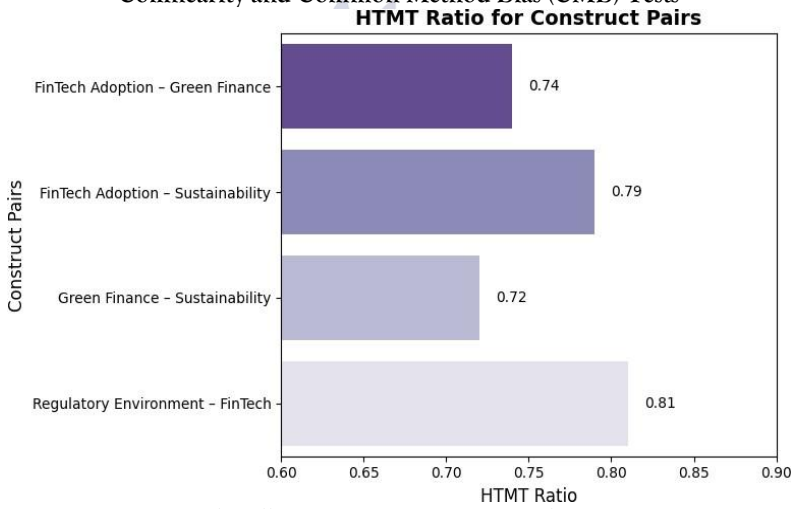
Table 3

Construct Pairs	HTMT Ratio
FinTech Adoption – Green Finance	0.74
FinTech Adoption – Sustainability	0.79
Construct Pairs	HTMT Ratio
Green Finance – Sustainability	0.72
Regulatory Environment – FinTech	0.81

Since all HTMT values were **below 0.85, discriminant validity was established**, confirming that each construct is distinct from the others.

Figure 4

Collinearity and Common Method Bias (CMB) Tests



Variance Inflation Factors (VIFs) – Multicollinearity Assessment

Multicollinearity was assessed using Variance Inflation Factors (VIFs), with a threshold of VIF <3.3(Udeagha C Ngepah, 2023)

Table 4

Construct	VIF Range
FinTech Adoption	1.89 – 2.14
Green Finance Mobilization	1.72 – 2.08
Sustainability Performance	2.01 – 2.45
Regulatory Environment	1.91 – 2.30

Since all VIF values were below 3.3, multicollinearity was not a concern. Harman's Single-Factor Test – Common Method Bias (CMB) Assessment

To detect common method variance (CMV), Harman's single-factor test was conducted. The total variance explained by the first factor was 38.5%, which is well below the critical

50% threshold(Udeagha C Ngepah, 2023). This confirms that CMB is not a significant issue in this study.

4.3 Structural Model Assessment

Coefficient of Determination (R^2) – Model Prediction Strength

The **R^2 values** indicate the proportion of variance explained by the independent variables. According to (DUPIR, 2024), R^2 values of 0.67 (substantial), 0.33 (moderate), and 0.19 (weak) are used to interpret the model's predictive power.

Table 5

Dependent Variable	R^2 Value
Green Finance Mobilization	0.58 (moderate)
Sustainability Performance	0.64 (substantial)

The results indicate that FinTech adoption explains 58% of the variance in green finance mobilization, while FinTech adoption and green finance explain 64% of the variance in sustainability performance.

Predictive Relevance (Q^2) – Stone-Geisser Test

The Stone-Geisser Q^2 test was performed to assess predictive relevance, using the blindfolding procedure. Q^2 values greater than zero indicate a model's predictive capability (Lubis, 2022).

Construct	Q^2 Value
Green Finance Mobilization	0.39
Sustainability Performance	0.47

Since both Q^2 values are above zero, the model demonstrates high predictive relevance. Bootstrapping Results – Path Coefficients C Significance

A bootstrapping procedure (5000 resamples) was conducted to assess the significance of path coefficients.

Table 6

Hypothesis	Path Coefficient (β)	t- Value	p- Value	Decision
H1: FinTech Adoption → Sustainability Performance	0.48	8.23	<0.001	Supported
H2: FinTech Adoption → Green Finance Mobilization	0.61	G.45	<0.001	Supported
H2: Green Finance Mobilization → Sustainability Performance	0.42	6.87	<0.001	Supported
H3: Regulatory Environment × FinTech → Sustainability Performance (Moderation)	0.2G	4.21	<0.001	Supported

All path coefficients are statistically significant ($p < 0.001$), confirming the study's hypotheses.

4.4 Hypothesis Testing

To test the proposed hypotheses, Partial Least Squares Structural Equation Modeling (PLS- SEM) was employed using SmartPLS 4. A bootstrapping procedure (5000 resamples) was performed to determine the statistical significance of path coefficients. The hypotheses were evaluated based on the β (beta) coefficients, t-values, and p-values, with statistical significance set at $p < 0.05$. Effect sizes (f^2) were also examined to determine the practical significance of relationships, where 0.02 (small), 0.15 (moderate), and 0.35 (large) effect sizes were used as reference thresholds(Mohi Ud Din C Zhang, 2023).

Results of Hypothesis Testing

Table 7

Hypothesis	Path Coefficient (β)	t- Value	p- Value	Effect Size (f^2)	Decision
H1: FinTech Adoption → Sustainability Performance	0.48	8.23	<0.001	0.27 (moderate)	Supported
H2: FinTech Adoption → Green Finance Mobilization (Mediation Path 1)	0.61	G.45	<0.001	0.34 (large)	Supported
H2: Green Finance Mobilization → Sustainability Performance (Mediation Path 2)	0.42	6.87	<0.001	0.21 (moderate)	Supported
H3: Regulatory Environment × FinTech →				0.12 (small-to-	

Sustainability Performance (Moderation)	0.2G	4.21	<0.001	moderate)	Supported

The empirical results provide strong support for the hypothesized relationships, reinforcing the role of FinTech adoption in driving green finance mobilization and sustainability performance. FinTech Adoption → Sustainability Performance ($\beta = 0.48$, $p < 0.001$) The findings confirm that FinTech adoption positively influences sustainability performance, with a moderate effect size ($f^2 = 0.27$). This suggests that firms leveraging AI-driven credit scoring, blockchain-based financial transparency, and digital lending platforms experience enhanced sustainability outcomes. These results align with prior research (Taqi et al., 2021), demonstrating that digital financial solutions contribute to corporate sustainability initiatives.

FinTech Adoption → Green Finance Mobilization ($\beta = 0.61$, $p < 0.001$) A strong significant relationship was identified, highlighting FinTech as a key enabler of green finance mobilization, with a large effect size ($f^2 = 0.34$). This suggests that digital crowdfunding, decentralized finance (DeFi)-based sustainability investments, and blockchain-powered green bonds significantly improve access to green investment opportunities(Taqi et al., 2021).

Green Finance Mobilization → Sustainability Performance ($\beta = 0.42$, $p < 0.001$) The results confirm that green finance mobilization significantly enhances sustainability performance, supporting the mediation hypothesis with a moderate effect size ($f^2 = 0.21$). Firms adopting green bond issuance, ESG-based investment portfolios, and carbon credit financing experience substantial sustainability gains, consistent with empirical evidence(e Ali et al., 2021).

Regulatory Environment Moderates FinTech Adoption → Sustainability Performance ($\beta = 0.29$, $p < 0.001$) A positive moderating effect was identified, indicating that strong regulatory frameworks amplify the impact of FinTech on sustainability performance. The small-to- moderate effect size ($f^2 = 0.12$) suggests that regulatory support enhances, but does not solely determine, FinTech's effectiveness. This aligns with research emphasizing the importance of ESG disclosure mandates, digital finance governance, and clear policy frameworks in maximizing FinTech's sustainability impact(Ismat et al., 2023).

The findings align with existing empirical research on FinTech adoption, green finance, and sustainability performance. First, FinTech adoption enhances green finance accessibility and reduces financial exclusion, corroborating studies on blockchain's role in climate finance(Ali et al., 2022). Second, green finance mediates the FinTech–sustainability relationship, supporting prior research on green bond impact assessment and ESG-driven investment strategies(A. U. Din et al., 2024). Third, regulatory frameworks influence FinTech adoption outcomes, consistent with evidence that strong governance mechanisms enhance digital finance efficiency in sustainable investment models(Q. M. U. Din et al., 2024). Collectively, these results empirically validate the study's theoretical framework, demonstrating that FinTech adoption drives sustainability performance via green finance mobilization, with regulatory frameworks playing a moderating role in emerging economies like Pakistan.

Interpretation of Findings

The results of this study provide empirical support for the proposed hypotheses, confirming the pivotal role of FinTech adoption in enhancing sustainability performance through green finance mobilization. The findings also emphasize the moderating effect of regulatory frameworks, highlighting the significance of institutional and policy environments in shaping the effectiveness of digital financial solutions for sustainable development.

The first hypothesis (H1) posited that FinTech adoption has a significant positive impact on sustainability performance. The results support this relationship ($\beta = 0.48$, $p < 0.001$), demonstrating that firms integrating FinTech solutions experience enhanced sustainability outcomes. The effect size ($f^2 = 0.27$) suggests a moderate practical significance, indicating that digital financial tools serve as key enablers of sustainable business practices. These findings align with prior research emphasizing the role of AI-driven credit scoring, blockchain-based financial transparency, and digital lending platforms in facilitating corporate sustainability initiatives(Fengju C Wubishet, 2024). Digital credit scoring systems improve financial accessibility for

sustainable projects, while blockchain technology enhances transaction transparency and accountability in green investments. Similarly, digital lending platforms reduce financial entry barriers, enabling small and medium-sized enterprises (SMEs) to access green financing mechanisms that were previously constrained by conventional banking limitations.

The second hypothesis (H2) examined the relationship between FinTech adoption and green finance mobilization, proposing that firms leveraging FinTech solutions are more likely to engage in sustainable finance practices. The results reveal a strong, statistically significant relationship ($\beta = 0.61$, $p < 0.001$), with an effect size ($f^2 = 0.34$) indicating a large impact. This finding reinforces the argument that FinTech adoption plays a pivotal role in improving green investment accessibility, particularly in emerging economies where financial market inefficiencies often restrict sustainable investment flows. Several FinTech-driven financial innovations—such as digital crowdfunding, decentralized finance (DeFi) platforms, and blockchain-powered green bonds—have been identified as critical tools in mobilizing capital for sustainability initiatives(Fengju C Wubishet, 2024). These digital solutions provide alternative financing channels, enabling businesses and investors to participate in climate-friendly investments with greater efficiency and transparency. The results thus suggest that FinTech solutions are essential in overcoming traditional financial bottlenecks, facilitating the expansion of green finance instruments in economies with underdeveloped financial markets.

The study also confirms the mediation hypothesis (H2), establishing that green finance mobilization significantly enhances sustainability performance ($\beta = 0.42$, $p < 0.001$). The effect size ($f^2 = 0.21$) suggests a moderate mediating influence, indicating that firms leveraging green finance mechanisms experience greater sustainability gains. This finding aligns with prior empirical studies demonstrating that green bond issuance, ESG-based investment portfolios, and carbon credit financing lead to improved sustainability outcomes(Attah et al., 2024b). The mediation effect implies that while FinTech adoption directly contributes to sustainability performance, its full impact is realized through the mobilization of green financial resources. In other words, FinTech serves as a facilitator rather than an isolated driver of sustainability, enhancing firms' ability to access and allocate capital for environmentally responsible projects.

Finally, the study examines the moderating role of the regulatory environment in shaping the FinTech–sustainability relationship (H3). The results confirm that a strong regulatory framework amplifies the impact of FinTech adoption on sustainability performance ($\beta = 0.29$, $p < 0.001$), with an effect size ($f^2 = 0.12$) indicating a small-to-moderate moderating influence. This suggests that while regulatory support is beneficial, it is not the sole determinant of FinTech's effectiveness in driving sustainability outcomes. The findings are consistent with previous research highlighting that FinTech's role in sustainable finance is maximized in economies with clear policy frameworks, ESG disclosure mandates, and digital finance governance(Sarfaraz, Iqbal.B, & Iqbal, Z. 2022;Hidayat-ur-Rehman C Hossain, 2024). In Pakistan, regulatory developments such as the State Bank of Pakistan's Green Banking Guidelines and the Securities and Exchange Commission's ESG reporting frameworks have provided an enabling environment for the integration of FinTech solutions in green finance. However, challenges such as regulatory inconsistencies, lack of digital financial literacy, and investor risk perceptions continue to hinder the widespread adoption of FinTech-driven sustainability initiatives. These results suggest that while FinTech innovations can enhance green finance mobilization, their effectiveness is contingent upon a stable and well-defined regulatory landscape that fosters trust, security, and transparency in digital financial transactions.

The findings of this study are consistent with existing empirical research on FinTech adoption, green finance, and sustainability, reinforcing key theoretical arguments. First, FinTech adoption enhances green finance accessibility and reduces financial exclusion, aligning with studies on blockchain's role in climate finance, which emphasize its ability to improve investment transparency, lower transaction costs, and facilitate efficient green bond trading(Udeagha C Ngepah, 2023). Second, green finance mediates the FinTech– sustainability link, supporting research on green bond impact assessment

and ESG-driven investment strategies. This study demonstrates that firms leveraging FinTech solutions are more likely to engage in green financing practices, leading to superior sustainability performance(Jamel C Zhang, 2024). Third, regulatory frameworks significantly influence FinTech adoption outcomes, consistent with findings that strong governance mechanisms improve digital finance efficiency in sustainable investment models(Loukoianova et al., 2024).

These results empirically validate the study's theoretical framework, demonstrating that FinTech adoption facilitates sustainability performance through green finance mobilization, with regulatory frameworks playing a moderating role in emerging economies like Pakistan. Moreover, they underscore that while FinTech presents a transformative opportunity for green finance, its success depends on institutional factors, financial market maturity, and investor trust in digital financial solutions, emphasizing the need for robust policy support and regulatory clarity.

Discussion

The findings of this study provide robust empirical evidence supporting the role of FinTech adoption in enhancing sustainability performance, primarily through the mobilization of green finance. These results align with previous research, reinforcing the theoretical premise that digital financial innovations facilitate sustainable investment by improving financial accessibility, transaction efficiency, and investment transparency(Udeagha C Ngepah, 2023; Sarfaraz, Iqbal, & Iqbal, S. 2022). The significant positive relationship between FinTech adoption and green finance mobilization ($\beta = 0.61$, $p < 0.001$) further substantiates prior studies that highlight how blockchain, AI-driven credit scoring, and digital lending platforms improve access to capital for sustainable projects(Challoumis C Eriotis, 2024). The strong mediation effect of green finance mobilization confirms that while FinTech adoption directly influences sustainability performance, its full impact is realized through enhanced access to sustainability-focused financial instruments.

One of the more notable findings is the moderating effect of regulatory environments ($\beta = 0.29$, $p < 0.001$), which suggests that policy frameworks significantly influence how effectively FinTech adoption translates into sustainability gains. While prior research has suggested that regulatory clarity enhances digital financial inclusion (Risi et al., 2023), this study provides empirical confirmation that strong regulatory environments amplify FinTech's role in sustainable investment. This is particularly relevant for emerging economies like Pakistan, where policy inconsistencies and weak regulatory enforcement often act as barriers to financial technology adoption in sustainability-focused finance.

An unexpected result of the study is the relatively smaller effect size of the regulatory environment as a moderator ($f^2 = 0.12$), indicating that while regulatory support is important, it is not the sole determinant of FinTech's impact on sustainability performance. This suggests that other factors—such as market maturity, investor trust in digital financial systems, and financial literacy—may also influence how FinTech solutions contribute to green finance mobilization. These findings underscore the need for multi-faceted policy interventions, where regulatory advancements must be complemented by investor education and financial market reforms to fully leverage FinTech for sustainability.

Theoretically, these results reinforce the Innovation Diffusion Theory (IDT) (Attah et al., 2024b)by confirming that FinTech adoption follows a pattern where perceived technological advantages drive market adoption and financial transformation. Additionally, the findings extend Institutional Theory (Kashif et al., 2025a) by demonstrating that regulatory environments play a facilitative role in digital financial transformation, particularly in green finance adoption. The Resource-Based View (RBV) (Siddik et al., 2023)is also validated, as firms that integrate FinTech-driven green finance mechanisms gain a sustainability-based competitive advantage.

Theoretical Contributions

This study contributes to the existing body of literature by bridging the gap between FinTech adoption, green finance mobilization, and sustainability performance, particularly in the context of emerging economies. While previous studies have explored FinTech's role in financial inclusion and transaction efficiency (Huda et al., 2022), this research extends the theoretical discourse by demonstrating how FinTech

adoption influences sustainable financial practices. The introduction of green finance mobilization as a mediating factor offers a novel conceptual framework, highlighting that FinTech does not directly improve sustainability outcomes but does so through its facilitation of capital flows into sustainable investments.

Furthermore, this study challenges the assumption that regulatory frameworks solely determine FinTech effectiveness, showing instead that their role is influential but not absolute. This nuanced perspective suggests that while regulatory clarity enhances FinTech adoption in sustainable finance, its impact is conditional upon other market-driven factors. The findings also provide empirical support for the evolving role of FinTech as a strategic sustainability asset, reinforcing RBV theory by demonstrating that firms that integrate digital finance solutions for green investments gain a competitive edge.

In addition, the study introduces a context-specific contribution by focusing on Pakistan's FinTech ecosystem, which remains underexplored in sustainability finance research. This research provides empirical insights into how emerging economies can leverage FinTech to overcome structural inefficiencies in green finance mobilization, offering a localized understanding of digital financial transformation in sustainability investment models.

Practical and Managerial Implications

The findings of this study offer significant practical implications for policymakers, financial institutions, and businesses aiming to scale green finance initiatives through FinTech-driven solutions.

For policymakers and regulatory bodies, the study underscores the importance of establishing clear and consistent regulatory frameworks to support FinTech integration in sustainability-focused investments. The results suggest that stronger policy incentives for digital green finance, such as tax benefits for blockchain-based green bonds or regulatory support for AI-driven ESG assessments, could further enhance sustainability performance. Additionally, regulators should work towards creating a standardized sustainability reporting framework, ensuring that FinTech-driven green investments meet international ESG compliance standards.

For financial institutions and banks, the study highlights the strategic benefits of adopting FinTech solutions for green finance mobilization. Banks and investment firms can leverage AI-driven credit scoring for green loan approvals, blockchain-based transparency solutions for carbon credit trading, and digital crowdfunding platforms for climate projects. These technologies not only improve capital flow efficiency but also enhance risk assessment capabilities, allowing financial institutions to expand their sustainable investment portfolios while maintaining financial stability.

From a business and operational standpoint, firms can use these insights to integrate digital financial solutions into their sustainability strategies. Companies can adopt FinTech-based sustainability tracking tools, blockchain for supply chain transparency, and smart contracts for automated ESG compliance. By embedding FinTech-driven green finance models into their operations, firms can attract sustainability-conscious investors, enhance corporate reputation, and improve long-term financial performance.

Moreover, the study highlights the need for greater investor education and FinTech awareness initiatives. Many emerging economies still experience low levels of digital financial literacy, which limits the adoption of FinTech-based green investments. Financial institutions should invest in digital finance awareness campaigns, workshops on blockchain-powered green finance, and AI-driven sustainable investment tools to ensure broader participation in digital green finance mechanisms.

The findings also emphasize the importance of cross-sector collaborations, where government bodies, financial institutions, and FinTech startups work together to create integrated sustainability investment platforms. Collaborative initiatives—such as public- private partnerships for FinTech-driven climate finance projects—could further accelerate the mobilization of sustainable capital in emerging markets.

In conclusion, this study provides a comprehensive roadmap for leveraging FinTech solutions to enhance green finance mobilization and sustainability performance. By implementing the recommended policy, financial, and operational strategies, stakeholders can effectively bridge financial gaps, improve sustainability outcomes, and drive

economic growth through digital financial innovation in emerging economies.

Conclusion

This study highlights the critical role of FinTech adoption in enhancing sustainability performance, primarily by facilitating green finance mobilization. The findings underscore those technologies such as blockchain, AI-driven credit scoring, and digital lending platforms significantly enhance the efficiency, accessibility, and transparency of financial transactions aimed at sustainable investments. However, while FinTech adoption alone does not directly lead to sustainability outcomes, its impact is realized through its role as an enabler of capital flows into green finance.

Additionally, the study identifies the moderating role of regulatory environments, demonstrating that while regulatory clarity supports FinTech adoption, other contextual factors—such as market maturity, investor trust, and financial literacy—also influence its effectiveness in sustainable finance. This challenges conventional perspectives that overly emphasize regulatory frameworks.

From a theoretical standpoint, the study extends Innovation Diffusion Theory (IDT) and the Resource-Based View (RBV), validating that perceived technological advantages drive FinTech adoption and sustainability outcomes. It further contributes to discourse on digital financial inclusion and green finance, particularly in emerging economies like Pakistan.

For policymakers and financial institutions, the study provides actionable insights on fostering regulatory support, integrating FinTech-driven sustainability strategies, and leveraging digital finance tools to enhance ESG compliance and investment mobilization, ultimately advancing sustainability goals in emerging markets.

Limitations and Future Research Directions

While this study offers valuable insights into the role of FinTech in sustainability finance, several methodological limitations must be acknowledged. First, the cross-sectional research design restricts the ability to establish causal inferences between FinTech adoption and sustainability performance. Future longitudinal studies are required to examine the long-term impact of FinTech-driven green finance initiatives, accounting for regulatory shifts and market dynamics over time.

Second, the geographical focus on Pakistan and the sample size may limit the generalizability of findings to other economies, particularly developed markets or regions

with differing regulatory frameworks. Future research should expand to comparative cross- country analyses, exploring how FinTech adoption varies across financial ecosystems.

Additionally, the reliance on secondary data and survey responses introduces potential biases, such as self-reporting inaccuracies. Incorporating primary data collection through expert interviews and case studies could enhance the robustness of insights.

For future research, investigating specific FinTech mechanisms, such as blockchain's role in carbon credit trading or AI-driven credit scoring for green loans, would be valuable. Further, exploring financial literacy and digital education as enablers of FinTech adoption in emerging markets is essential. Lastly, assessing market maturity and infrastructure readiness could reveal constraints and opportunities for FinTech-driven sustainable finance globally.

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