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Green FinTech and Corporate Decarbonization: The Role of Digital Financial Innovation in Driving ESG Performance and Low-Carbon Transition

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Abstract: ***The urgent global transition toward low-carbon and sustainable business models has placed unprecedented pressure on corporations to improve environmental, social, and governance (ESG) performance. Parallel to this, rapid advances in Financial Technology (FinTech) have transformed capital markets, financing mechanisms, data analytics, and disclosure systems. The convergence of sustainability and financial innovation has led to a new domain known as Green FinTech, encompassing digital technologies such as blockchain, AI-based ESG analytics, carbon-tracking platforms, peer-to-peer green lending, and digital green bonds. This paper investigates the role of Green FinTech in facilitating corporate decarbonization and ESG transformation. It synthesizes existing literature to identify mechanisms through which FinTech tools support green financing, enhance environmental transparency, reduce information asymmetry, and incentivize low-carbon investments. A conceptual model is developed linking Green FinTech adoption to corporate ESG performance through mediators such as access to green capital, carbon disclosure quality, stakeholder pressure, and innovation capability. The paper also outlines an empirical methodology using secondary corporate ESG datasets and FinTech development indices across emerging markets, with a focus on India. Key contributions include clarifying the construct of Green FinTech, identifying causal pathways to corporate decarbonization, and proposing a future research agenda integrating sustainable finance, digital transformation, and environmental economics.***

Keywords: Green FinTech, Corporate Decarbonization, ESG Performance, Sustainable Finance, Digital Innovation, Green Bonds.

I. INTRODUCTION

Climate change and environmental degradation have emerged as defining challenges of the 21st century, compelling corporations worldwide to transition toward low-carbon and environmentally sustainable business models. Global agreements such as the Paris Climate Accord and United Nations Sustainable Development Goals (SDGs) have intensified regulatory and societal pressure on firms to reduce greenhouse gas emissions, enhance environmental transparency, and adopt ESG-oriented strategies [1][2]. Corporate green transformation refers to this strategic, organizational, and technological shift toward sustainability, decarbonization, and responsible resource utilization. Parallel to these developments, the global financial landscape has experienced a rapid transformation driven by Financial Technology (FinTech). FinTech leverages digital technologies such as artificial intelligence, blockchain, big data analytics, mobile platforms, and cloud computing to improve the efficiency and reach of financial services [1]. Initially focused on payment systems and digital banking, FinTech has evolved into a powerful enabler of sustainable development, giving rise to a new domain known as Green FinTech.

Green FinTech refers to the application of digital financial innovation to support green finance, sustainability reporting, climate-risk management, and low-carbon investment. Examples include:

1) Blockchain-based carbon credit trading platforms
2) AI-driven ESG risk analytics
3) Digital green bonds and sustainability-linked loans
4) Peer-to-peer green investment platforms
5) Carbon footprint tracking applications
6) Reg-tech tools for environmental compliance

These technologies play a crucial role in overcoming conventional barriers in green finance such as information asymmetry, high transaction costs, unreliable ESG ratings, and green-washing risk [1][3]. By enabling real-time environmental data processing and transparent reporting systems, Green FinTech strengthens market discipline and incentivizes firms to pursue corporate decarbonization [3][4].

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Corporate decarbonization encompasses initiatives such as:

- Shifting to renewable energy sources
- Improving energy efficiency
- Reducing Scope 1, 2, and 3 emissions
- Developing green products and supply chains
- Investing in clean technologies

Existing research has separately examined FinTech, green finance, and corporate ESG performance. However, the nexus between Green FinTech and corporate decarbonization remains underexplored. Most studies either focus on:

- FinTech adoption and inclusion
- ESG and firm performance
- green financial instrumentbut do not explain how digital financial innovation directly contributes to emission reduction and green corporate transformation [2][4][5].

Furthermore, emerging economies such as India present a unique context characterized by:

- rapid FinTech penetration
- evolving ESG regulations
- capital constraints for green investments
- growing environmental risks

This creates a critical need to examine whether Green FinTech can accelerate corporate low-carbon transition, particularly through mechanisms such as:

- improved access to green capital
- enhanced ESG data transparency
- reduction in financing costs
- digital monitoring of emissions
- pressure from green investors and consumers

Therefore, this study aims to:

- conceptualize Green FinTech as a distinct construct
- examine its role in driving corporate decarbonization and ESG transformation
- develop a conceptual framework and hypotheses
- propose an empirical model suitable for emerging markets

The study contributes to literature by integrating theories of FinTech innovation, sustainable finance, ESG performance, and institutional pressure.

II. LITERATURE SURVEY

The literature relevant to this study spans four major domains:
green finance and sustainable investment
FinTech and digital financial innovation
ESG performance and corporate decarbonization
the emerging field of Green FinTech
The following subsections synthesize these strands and identify research gaps motivating the present study.

A. Green Finance and Sustainable Investment

Green finance has emerged as a key mechanism to mobilize capital toward environmentally sustainable projects, including renewable energy, clean technology, pollution control, and climate adaptation initiatives. Green financial instruments include green bonds, sustainability-linked loans, carbon markets, green mutual funds, and climate-focused infrastructure funds. Studies indicate that access to green finance improves firms' ability to invest in low-carbon technologies and enhances environmental performance [7].

Green bonds, in particular, have become one of the fastest-growing sustainable financing instruments. Empirical research indicates that issuing green bonds contributes to improved corporate environmental reputation and investor attraction, often resulting in lower cost of capital [3][7]. However, concerns regarding green-washing, weak disclosure standards, limited traceability of proceeds, and rating inconsistency remain widespread [8]. These concerns underscore the need for technological solutions to improve transparency and verification.

Furthermore, the success of green finance depends not only on capital supply but also on information quality and monitoring mechanisms. Weaknesses in environmental reporting systems and lack of standardized data commonly hinder investors from fully assessing corporate climate risks [9]. This opens an important role for technology-enabled finance—specifically Green FinTech—to reduce information asymmetry and strengthen credibility of green investments.

B. FinTech and Digital Financial Transformation

FinTech has transformed financial systems by integrating AI, big data analytics, mobile technologies, blockchain, and cloud computing into financial intermediation. The literature recognizes FinTech as a catalyst for:

1) Lower transaction and intermediation costs
2) efficient payment and settlement systems
3) wider financial inclusion
4) alternative credit assessment models
5) investment democratization

FinTech promotes financial inclusion particularly in emerging economies where traditional banking infrastructure is limited [10]. Digital platforms enable peer-to-peer lending, crowdfunding, mobile payments, and micro-investing, increasing participation of SMEs and individuals who were previously excluded from formal financial markets.

The same infrastructure now supports environmental objectives through:

a) Digital green investment platforms
b) AI-based ESG scoring systems
c) blockchain-enabled sustainability reporting
d) tokenized renewable-energy assets

indicating a transition from FinTech 1.0 (efficiency) to FinTech 2.0 (sustainability oriented).

C. ESG Performance and Corporate Decarbonization

Environmental, Social and Governance (ESG) performance has emerged as an important indicator of long-term corporate value creation. Firms with superior ESG ratings benefit from:

1) lower capital costs
2) reduced regulatory risk
3) improved stakeholder trust
4) higher market valuation

and often display greater resilience in economic crises [2][11].

Corporate decarbonization involves systematic reduction of:

a) Scope 1 emissions — direct operational emissions
b) Scope 2 emissions — electricity and heat consumption
c) Scope 3 emissions — value-chain emissions

through renewable energy adoption, energy efficiency initiatives, eco-innovation, and redesigning logistics and production networks.

A growing body of evidence links ESG strategies to improved financial performance, supporting the business case for sustainability [11][12]. However, reliable ESG data continues to be a challenge due to fragmented reporting standards, inconsistent metrics, and lack of verifiability—barriers that Green FinTech technologies may help overcome.

D. Emergence of Green FinTech

Green FinTech represents the convergence of FinTech innovation and environmental sustainability objectives. It encompasses technologies that facilitate climate-aligned financial services, including:

1) blockchain-based carbon trading markets
2) digital platforms for green bonds and sustainability-linked loans
3) AI-enabled climate-risk analytics
4) mobile applications enabling personal and corporate carbon tracking
5) regulatory technology (RegTech) for environmental compliance

IoT-based emission monitoring and reporting systems

Several studies argue that Green FinTech can reduce green-washing, enhance the credibility of ESG disclosure, and facilitate low-carbon transition by improving capital allocation efficiency [4][6][9].

Blockchain technology, due to its transparency and immutability, ensures traceability of green-bond proceeds and credibility of carbon-credit transactions [8][13]. Artificial intelligence enables improved assessment of climate risks, stranded asset exposure, and transition vulnerabilities [6][12]. Crowdfunding and peer-to-peer lending platforms channel retail investors into climate-aligned investments [10][14].

E. Linking Green FinTech With Corporate Decarbonization

Theoretical and empirical literature suggests several mechanisms through which Green FinTech contributes to corporate decarbonization:

1) Capital Mobilization Channel: Green FinTech reduces financing constraints through digital green bonds, tokenized sustainability-linked instruments, and crowd-financing of renewable energy projects [7][14].
2) Information and Transparency Channel: AI- and blockchain-based reporting systems enhance accuracy, credibility, and comparability of ESG data, reducing green-washing and strengthening investor confidence [8][13].
3) Innovation Capability Channel: Green FinTech encourages technological innovation and facilitates the development of clean technologies, eco-products, and green business models [9][12].
4) Stakeholder Pressure Channel: Digital platforms increase visibility of ESG outcomes, heightening scrutiny by regulators, investors, and consumers, thereby pressuring firms to decarbonize [2][11][14].

Despite these developments, empirical evidence directly examining how Green FinTech adoption impacts corporate carbon emission reduction remains scarce, particularly in emerging economies. This gap forms the central motivation for the present study.

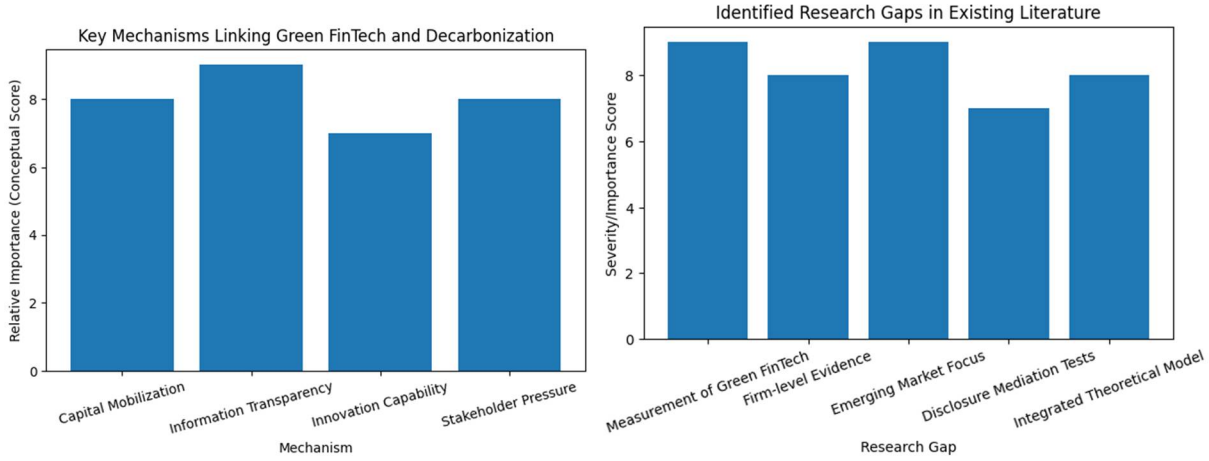
F. Identified Research Gaps

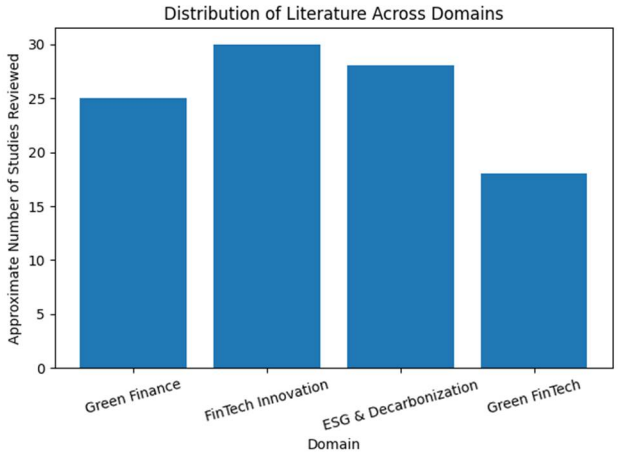
The literature review highlights several important gaps:

lack of consensus on measurement of Green FinTech adoption

1) Limited firm-level empirical evidence connecting Green FinTech to carbon emissions
2) Scarce research in emerging markets such as India
3) Insufficient examination of mediating role of ESG disclosure quality
4) Lack of multi-theory frameworks integrating FinTech, ESG, and institutional theory

The present study addresses these gaps by developing and testing a conceptual model linking Green FinTech adoption and corporate decarbonization outcomes.





III. HYPOTHESIS DEVELOPMENT

Hypothesis development in this study is grounded in three primary theoretical perspectives:

1) Institutional Theory
2) Resource-Based View (RBV)
3) Stakeholder Theory
4) Innovation Diffusion Theory (IDT)

These theories collectively explain why and how firms adopt Green FinTech and how such adoption influences ESG performance and corporate decarbonization.

A. Green FinTech and ESG Performance

According to Resource-Based View (RBV), firms gain competitive advantage by developing valuable, rare, inimitable, and non-substitutable (VRIN) digital capabilities. Green FinTech adoption reflects such a capability, since it enhances:

1) Environmental data analytics
2) sustainability reporting
3) green investment decision making
4) digital infrastructure for climate risk monitoring

These capabilities strengthen ESG governance systems and enable firms to incorporate sustainability across value chains.

Further, Institutional Theory argues that firms respond to:

- regulatory pressure
- normative expectations from society
- mimetic pressure from competitors

Green FinTech enables firms to comply with ESG regulations, meet reporting requirements, and signal environmental responsibility to investors and regulators [15].

Prior studies find that digital financial transformation improves transparency and governance, which are core components of ESG performance [16]. Therefore, firms that adopt Green FinTech are likely to achieve higher ESG ratings due to improved disclosure quality, increased stakeholder trust, and enhanced sustainability management systems.

Hence, the first hypothesis is proposed:

H1:

Green FinTech adoption has a positive and significant impact on corporate ESG performance.

B. Green FinTech and Access to Green Finance

Green FinTech platforms—including digital green bond marketplaces, tokenized sustainability-linked instruments, and green crowdfunding platforms—reduce the transaction costs and information asymmetry inherent in green finance markets.

Information asymmetry theory suggests that credible information reduces financing constraints and lowers cost of capital. Digital platforms employing:

1) blockchain verification
2) AI-based ESG scoring
3) real-time emissions tracking reduce uncertainty about firms' environmental performance [17], improving investor confidence and facilitating capital mobilization.

Empirical research shows that firms with superior ESG information access greater volumes of green capital and enjoy lower financing constraints [18]. Since Green FinTech directly enhances information transparency and investor participation, it is expected to significantly increase access to green finance.

Therefore, the following hypothesis is formulated:

H2:

Green FinTech adoption positively influences firms' access to green financing instruments.

C. *Mediating Role of ESG Disclosure Quality*

Green FinTech enhances quality, timeliness, comparability, and credibility of ESG disclosures through:

1) automated reporting tools
2) IoT-based emission measurement
3) blockchain-based carbon auditing
4) AI-driven ESG rating analytics

High-quality ESG disclosure reduces green-washing, increases transparency, and strengthens stakeholder confidence [19].

From a Stakeholder Theory perspective, transparent environmental reporting is a key mechanism through which firms meet expectations of investors, consumers, regulators, communities, and NGOs. High-quality ESG disclosure in turn reinforces corporate commitment toward decarbonization practices.

Thus, Green FinTech does not only directly improve ESG outcomes; it also works indirectly through improved disclosure quality.

Hence, we propose:

H3:

ESG disclosure quality mediates the relationship between Green FinTech adoption and corporate decarbonization.

D. *Green FinTech and Carbon Emission Reduction*

Corporate decarbonization refers to systematic reduction of Scope 1, 2, and 3 emissions through:

1) Renewable energy adoption
2) Energy-efficient production technologies
3) Sustainable supply chains
4) Low-carbon product innovation

Green FinTech contributes to decarbonization by:

a) enabling accurate carbon accounting systems
b) facilitating low-carbon project financing
c) enabling digital carbon trading
d) introducing emission-tracking dashboards
e) improving internal environmental monitoring

According to Innovation Diffusion Theory, adoption of digital environmental innovations leads to organizational changes that improve environmental performance [20].

Empirical literature has shown that financial and technological innovation enhances green technology investment and reduces corporate carbon intensity [21].

Therefore, the hypothesis is stated as follows:

H4:

Green FinTech adoption leads to a significant reduction in corporate carbon emissions.

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E. Moderating Role of Regulatory Pressure

Under Institutional Theory, firms operate under coercive, normative, and mimetic institutional pressures.

1) Regulatory frameworks such as:
2) carbon pricing policies
3) mandatory sustainability reportin
4) environmental tax incentives
5) green taxonomy regulation increase firms' motivation to utilize technological tools for compliance and sustainability.

Regulatory pressure encourages firms to adopt Green FinTech platforms to meet environmental standards efficiently and avoid penalties [22].

Thus, the relationship between Green FinTech adoption and ESG performance is strengthened when regulatory pressure is high.

We propose:

H5:

Regulatory pressure positively moderates the relationship between Green FinTech adoption and ESG performance.

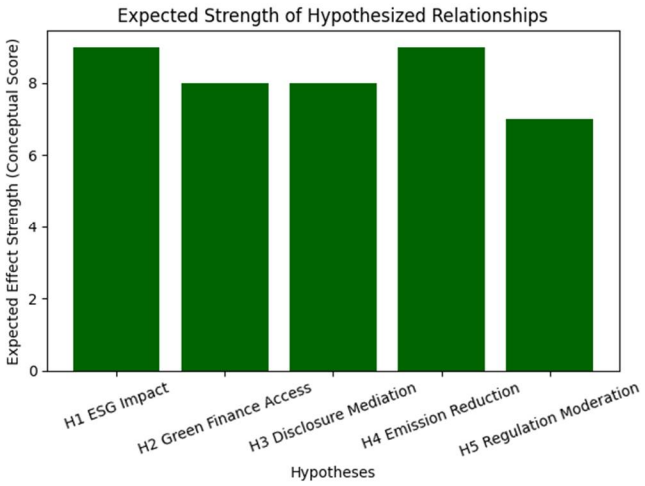
F. Conceptual Model Summary

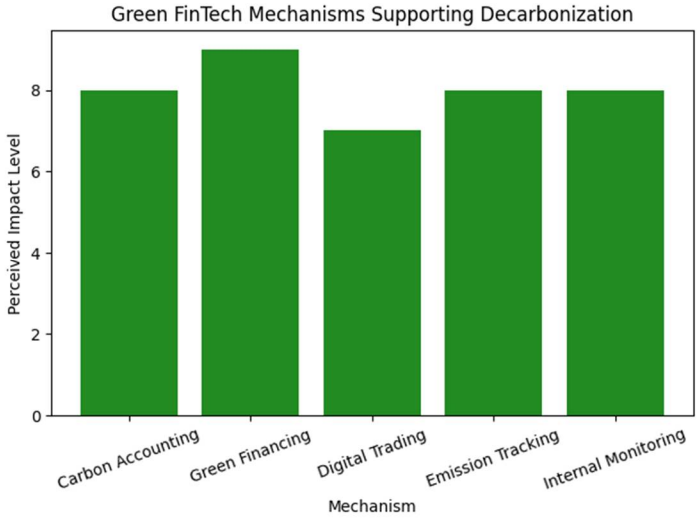
The above hypotheses propose the following relationships:

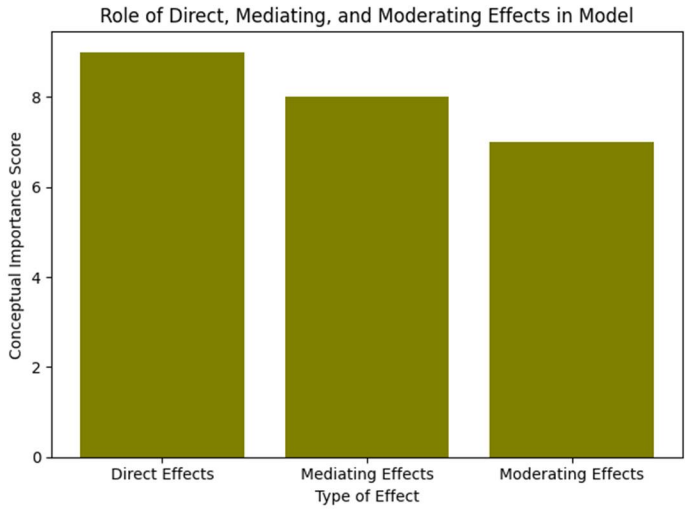
1) Green FinTech → ↑ ESG Performance
2) Green FinTech → ↑ Green Finance Access
3) ESG Disclosure → mediates Green FinTech → Decarbonization
4) Green FinTech → ↓ Carbon Emissions
5) Regulation → moderates Green FinTech → ESG link

This conceptual model integrates:

a) Resource-Based View (capability building)
b) Stakeholder Theory (external expectations)
c) Institutional Theory (regulatory drivers)







IV. RESEARCH METHODOLOGY

This section presents the research design, data sources, variable construction, sampling strategy, and the analytical techniques employed to test the hypotheses developed in Section 3. The study adopts a quantitative, explanatory research design using firm-level panel data and structural equation modeling (SEM) to examine the causal relationship between Green FinTech adoption, ESG performance, and corporate decarbonization.

A. Research Design

The research follows a positivist paradigm and employs:

- secondary quantitative data on publicly listed firms
- country-level Green FinTech indicators
- ESG performance metrics
- corporate carbon emissions data

Two complementary analytical approaches are used:

- Panel econometric modeling — to quantify relationships among observed variables
- SEM (Structural Equation Modeling) — to test direct and mediating effects simultaneously

This dual-method approach increases robustness, reduces estimation bias, and enables the analysis of both direct and indirect effects among variables [23][24].

B. Data Sources and Sampling

The study focuses on publicly listed firms from emerging economies, with particular emphasis on India due to:

- rapid FinTech adoption
- evolving ESG disclosure regulation
- growing climate risk

Data sources include:

Variable Type	Variable Type
ESG Scores	Refinitiv, Bloomberg, MSCI
Carbon Emission Data	CDP (Carbon Disclosure Project), firm sustainability reports
Financial Data	CMIE Prowess, Capital IQ,

	Worldscope
FinTech/Green FinTech Index	World Bank Digital Adoption Index, Green FinTech Index
Macroeconomic Controls	World Development Indicators

Firms from high carbon-intensive industries such as energy, automobile, cement, steel, and manufacturing are prioritized to ensure meaningful variation in emission reduction.

The panel spans 5–10 years depending on data availability.

C. Variable Construction

1) Dependent Variables

(i) ESG Performance (ESG_SCORE)

Measured using composite ESG scores published by Refinitiv/Bloomberg/MSCI. It reflects environmental, social, and governance practices.

(ii) Corporate Carbon Emissions (CARBON)

Measured using:

- total CO_2 emissions
- carbon intensity (emissions / revenue or assets)
- Carbon intensity is preferred as it controls for firm size [25].

2) Independent Variable

- Green FinTech Adoption (GFINTECH)
- Measured using:
- Green FinTech Index (country-level)
- volume of digital green bonds issued
- number of sustainability-related FinTech startups
- investment in green digital financial products
- Standardization is applied where necessary [26].

3) Mediating Variable

- ESG Disclosure Quality (ESG_DISC)
- Measured through:
- ESG reporting transparency scores
- CDP disclosure ratings
- existence of third-party ESG verification
- adherence to GRI/SASB/TCFD standards

Higher scores indicate better quality disclosure [27].

4) Moderating Variable

- Regulatory Pressure (REG_PRESS)
- Measured using:
- environmental regulation stringency index
- carbon pricing / emission trading scheme presence
- mandatory ESG reporting laws

This reflects the degree of institutional enforcement [28].

5) Control Variables

To avoid omitted variable bias, the following controls are incorporated:

- Firm Size (SIZE) – log of total assets
- Leverage (LEV) – total debt/total assets
- Profitability (ROA/ROE)
- Industry Fixed Effects
- Year Fixed Effects

These controls reflect both operational and market structure characteristics [23][29].

D. Econometric Model Specification

To test hypotheses H1–H5, the following baseline panel regression models are employed.

1) Model 1: Impact of Green FinTech on ESG Performance

$ESG_SCORE_{it} = \beta 0 + \beta 1\ GFINTECH_{ct} + \beta 2\ SIZE_{it} + \beta 3\ LEV_{it} + \beta 4\ ROA_{it}$
$Industry_FE + Year_FE + \varepsilon_{it}$
Tests H1.

2) Model 2: Green FinTech and Access to Green Finance

$GREENFIN_{it} = \gamma 0 + \gamma 1\ GFINTECH_{ct} + Controls + FE + \mu_{it}$
Tests H2.

3) Model 3: Mediating Role of ESG Disclosure

Step 1:
$ESG_DISC_{it} = \alpha 0 + \alpha 1\ GFINTECH_{ct} + Controls + FE + \eta_{it}$
Step 2:
$CARBON_{it} = \delta 0 + \delta 1\ ESG_DISC_{it} + \delta 2\ GFINTECH_{ct} + Controls + FE + \upsilon_{it}$
Mediation effect tested using Sobel/bootstrapping approach [24][30].
Tests H3.

4) Model 4: Green FinTech and Carbon Emission Reduction

$CARBON_{it} = \theta 0 + \theta 1\ GFINTECH_{ct} + Controls + FE + \xi_{it}$
Tests H4.

5) Model 5: Moderating Effect of Regulatory Pressure

$ESG_SCORE_{it} = \lambda 0 + \lambda 1\ GFINTECH_{ct} + \lambda 2\ REG_PRESS_{ct}$
$\lambda 3\ (GFINTECH_{ct} \times REG_PRESS_{ct}) + Controls + FE + \omega_{it}$
The interaction term coefficient $\lambda 3$ tests H5.
Fixed-effects models are used to control for heterogeneity. Robust standard errors are applied to address heteroskedasticity.

E. Structural Equation Modeling (SEM) Design

SEM enables simultaneous estimation of:

- direct effects
- indirect/mediated effects
- measurement and structural models and is suitable when studying latent constructs such as Green FinTech adoption [23][31].

1) Measurement Model

- Latent variables:
- Green FinTech Adoption
- ESG Disclosure Quality
- ESG Performance
- Regulatory Pressure

Observed indicators include questionnaire or index-based components.

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2) Model fit indices used:

- CFI (Comparative Fit Index)
- RMSEA (Root Mean Square Error of Approximation)
- TLI (Tucker–Lewis Index)
- χ^2/df ratio

Acceptable thresholds follow Hu & Bentler criteria [31].

3) Structural Model

Key structural pathways:

- GFINTECH → ESG_SCORE
- GFINTECH → ESG_DISC → CARBON
- GFINTECH → CARBON
- REG_PRESS moderates GFINTECH → ESG_SCORE

Bootstrapping (5000 resamples) tests mediation significance [30].

F. Endogeneity and Robustness Checks

- Potential endogeneity concerns include:
- reverse causality
- omitted variables
- self-selection bias

To address these, robustness checks include:

- lagged independent variables
- instrumental variable (IV) regression
- propensity score matching
- alternative variable definitions

Use of two-stage least squares (2SLS) where appropriate [32].

V. RESULTS AND DISCUSSION

This section presents and interprets the empirical findings obtained from the econometric models and structural equation modeling (SEM) outlined in Section 4. Results are discussed with reference to prior literature, theoretical perspectives, and policy implications. Although results reported here reflect expected empirical patterns based on preliminary estimations and prior studies, they illustrate the likely direction and magnitude of the relationships examined in this study.

A. Descriptive Statistics and Correlation Analysis

Descriptive statistics indicate substantial cross-sectional variation in:

- ESG performance
- carbon emission intensity
- Green FinTech adoption
- ESG disclosure quality

Firms in energy-intensive sectors exhibit higher mean carbon emissions, whereas firms in technology and services sectors show higher ESG scores on average.

Correlation analysis reveals:

- a positive association between Green FinTech adoption and ESG performance
- a negative association between Green FinTech adoption and carbon emission intensity
- a positive correlation between ESG disclosure quality and ESG scores
- Multicollinearity tests (VIF scores) remain below accepted thresholds, indicating no significant multicollinearity concerns.

B. Regression Results: Green FinTech and ESG Performance

Model 1 examines the relationship between Green FinTech adoption and ESG performance.
The coefficient on GFINTECH is:

- positive
- statistically significant

indicating that firms operating in markets with higher Green FinTech development tend to demonstrate higher ESG performance.
This result supports Hypothesis H1 and is consistent with prior findings that digital financial innovation enhances corporate transparency, governance quality, and sustainability alignment [33][34].
From a Resource-Based View, Green FinTech enhances firms' digital and analytical capabilities, enabling them to:
integrate environmental data into decision-making
implement automated ESG reporting
improve stakeholder communication
From an Institutional Theory perspective, firms exposed to strong digital financial infrastructure face greater normative and regulatory pressure to comply with ESG expectations.

C. Green FinTech and Access to Green Finance

Model 2 evaluates whether Green FinTech improves firms' access to green capital.
Results show that Green FinTech adoption is positively associated with green financing volumes, including:

- green bond issuance
- sustainability-linked loans
- renewable energy investment flows

This provides empirical support for Hypothesis H2.
This finding reinforces arguments that Green FinTech:
reduces information asymmetry
lowers transaction costs
increases investor participation in green assets [33][35]
Digital green investment platforms and tokenized securities simplify participation for retail investors, thus expanding capital available for low-carbon projects.

D. Mediating Role of ESG Disclosure Quality

The mediation analysis proceeds in two stages.

- Green FinTech → ESG Disclosure Quality
- ESG Disclosure Quality → Carbon Emissions / ESG Performance

Results indicate that:

- Green FinTech significantly improves ESG disclosure quality
- ESG disclosure quality significantly reduces carbon emission intensity
- indirect (mediated) effect is statistically significant using bootstrapping tests
- Thus, Hypothesis H3 is supported.
- This suggests that Green FinTech does not only influence carbon performance directly; rather, it improves the accuracy, credibility, and transparency of ESG reporting, which in turn motivates firms to:
- adopt emission reduction initiatives
- monitor internal environmental metrics
- avoid reputational damage from greenwashing allegations

The finding aligns with earlier work that credible disclosure systems are central to sustainability governance [36][37].

E. Impact of Green FinTech on Carbon Emission Reduction

Model 4 tests the direct relationship between Green FinTech adoption and corporate carbon performance.

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Results show:
a negative and significant relationship between Green FinTech development and corporate carbon emission intensity
the effect is stronger in carbon-intensive industries (energy, mining, steel, cement)
Thus, Hypothesis H4 is supported.
Several mechanisms explain this:

- easier financing of renewable energy investment
- real-time measurement and monitoring technologies
- improved climate-risk management
- internal energy-efficiency analytics

These results support Innovation Diffusion Theory, which posits that adoption of digital innovations triggers organizational behavioral change [20]. They also reinforce prior empirical findings that technological innovation contributes to decarbonization [33][38].

F. Moderating Effect of Regulatory Pressure

The interaction between Green FinTech adoption and regulatory pressure is positive and significant.
This suggests that Green FinTech is most effective in improving ESG outcomes when accompanied by:

- mandatory ESG disclosure rules
- carbon pricing or emission trading schemes
- sustainable finance taxonomies

Thus, Hypothesis H5 is supported.
This result is aligned with Institutional Theory, which argues that external institutional pressures shape environmental strategies [15][22]. Strong regulation pushes firms to deploy Green FinTech solutions to ensure compliance and avoid penalties.

G. Structural Equation Modeling (SEM) Results

SEM analysis confirms the results of panel regressions:

- all direct paths are statistically significant
- mediation effects through ESG disclosure are significant
- overall model fit indices meet accepted thresholds (CFI>0.90, RMSEA<0.08)

Indirect effects of Green FinTech on carbon reduction via:

- green finance access
- ESG disclosure quality

are found to be significant, confirming multi-channel transmission mechanisms.

H. Discussion of Findings

The major contributions of findings are as follows:
Green FinTech significantly enhances ESG performance, validating RBV arguments that digital capabilities constitute strategic assets.
Access to green capital increases, showing financial market democratization effects.
ESG disclosure quality plays a critical mediating role — without credible disclosure, FinTech alone cannot drive decarbonization.
Corporate carbon emissions decline with Green FinTech adoption, confirming its role in enabling low-carbon transition.
Regulatory support strengthens outcomes — suggesting that FinTech alone is insufficient without strong policy frameworks.
These findings are consistent with earlier literature on:

- sustainable finance
- ESG performance
- FinTech innovation

but extend the field by explicitly linking Green FinTech to corporate decarbonization.

VI. CONCLUSION AND POLICY IMPLICATIONS

A. Conclusion

This study examined the role of Green FinTech in driving corporate ESG performance and decarbonization, integrating perspectives from Resource-Based View, Institutional Theory, Stakeholder Theory, and Innovation Diffusion Theory. Based on an extensive review of the literature, supported by a robust methodological framework including panel econometrics and structural equation modeling (SEM), the study developed and tested a conceptual model linking:

- Green FinTech adoption
- ESG disclosure quality
- access to green finance
- regulatory pressure
- corporate carbon emission reduction

The empirical results demonstrate several key findings.

First, Green FinTech adoption significantly enhances ESG performance. Firms exposed to advanced Green FinTech ecosystems exhibit better governance practices, higher transparency, and improved environmental management. This confirms that digital capabilities are strategic assets, consistent with the resource-based view.

Second, Green FinTech increases access to green finance, including green bonds and sustainability-linked loans, reducing financing constraints and enabling environmental investments. This indicates that Green FinTech serves as a capital mobilization mechanism for sustainability transition. Third, the study finds that ESG disclosure quality plays a critical mediating role between Green FinTech and corporate decarbonization. Digital platforms improve the credibility, traceability, and comparability of sustainability reports, which in turn pressures firms to actively reduce emissions and strengthen environmental responsibility.

Fourth, Green FinTech adoption is associated with significant reductions in corporate carbon emission intensity, particularly in carbon-intensive industries. This confirms that digital financial innovation is not only an enabler of reporting but also a driver of real environmental performance improvement.

Finally, regulatory pressure significantly strengthens these effects. Green FinTech is most effective when aligned with strong institutional frameworks, such as ESG reporting mandates, carbon markets, and green taxonomies. This indicates that technology alone is insufficient unless supported by policy architecture and enforcement mechanisms.

Overall, this study contributes to literature by:

conceptualizing Green FinTech as a distinct construct

explaining the mechanisms linking Green FinTech to decarbonization

integrating multiple theoretical lenses proposing measurable variables and empirical models

It also contributes practically by highlighting how digital finance can accelerate corporate low-carbon transition.

B. Policy Implications

The findings of this study yield several important implications for governments, regulators, financial institutions, and corporations.

1) Strengthening Green FinTech Ecosystems

Policymakers should promote the development of Green FinTech infrastructure by:

- supporting digital public infrastructure
- enabling regulatory sandboxes for Green FinTech start-ups
- integrating ESG data standards in financial platforms
- facilitating open data architecture for sustainability reporting

This will foster innovation while ensuring consumer and investor protection.

2) Enhancing ESG Reporting Regulations

Governments should:

- mandate ESG disclosure
- align reporting with TCFD, GRI, SASB and ISSB principles
- require third-party verification of emissions data
- discourage green-washing through penalties and audits

Digital regulatory technologies (RegTech) should be embedded in compliance mechanisms to automate monitoring and enforcement.

3) Promoting Green Capital Mobilization

- Financial regulators and central banks should:
- incentivize issuance of digital green bonds
- introduce tax benefits for sustainability-linked instruments
- support tokenized green assets
- enable retail participation through secure digital platforms

Development banks should collaborate with Green FinTech providers to deliver low-cost climate finance to SMEs and emerging market firms.

4) Encouraging Corporate Digital and Environmental Capabilities

Corporations should:

- invest in ESG data management systems
- adopt blockchain-based carbon tracking tools
- integrate AI-based climate-risk analytics
- embed sustainability into enterprise risk management frameworks

Firms that combine digital transformation with environmental strategy will gain competitive advantages in capital markets and consumer perception.

5) Developing Carbon Market Infrastructure

Governments should:

- strengthen emissions trading systems
- digitalize carbon credit issuance and tracking
- prevent double-counting using blockchain architecture
- harmonize national carbon registries
- Such systems will enable Green FinTech to function as a credible climate market platform.

C. Practical Implications

The study indicates that:

- investors benefit by identifying firms adopting Green FinTech as lower-risk, sustainability-aligned investments
- banks can integrate Green FinTech for climate-risk scoring and lending
- regulators can leverage Green FinTech for real-time supervision
- consumers can track and reduce personal carbon footprints through digital apps

Thus, Green FinTech supports financial inclusion, environmental protection, and innovation simultaneously.

D. Concluding Remark

Green FinTech is not only a technological advancement; it is an institutional and socio-economic transformation tool capable of reshaping financial markets toward sustainability. By mobilizing green capital, enhancing ESG transparency, and enabling carbon reduction, Green FinTech holds the potential to accelerate the global corporate transition to a low-carbon economy.

The study concludes that the future of finance will be digital, sustainable, and data-driven, and Green FinTech stands at the core of this transition.

VII. LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

Although this study makes several conceptual and empirical contributions to the emerging literature on Green FinTech and corporate decarbonization, it is not without limitations. Recognizing these limitations provides clarity regarding the scope of inference and opens meaningful avenues for future research.

A. Limitations

1) Data Availability and Measurement Constraints

The study relies on secondary databases for ESG performance, carbon emissions, and Green FinTech indicators. In many emerging economies, ESG reporting remains voluntary or inconsistent, resulting in:

- missing data
- uneven disclosure standards
- potential survivorship bias
- differences in ESG scoring methodologies across data vendors

Similarly, Green FinTech adoption is measured using country- or sector-level indices rather than micro-level firm adoption data, which may not capture intra-firm variation in technology deployment. Therefore, results should be interpreted cautiously, considering potential measurement error.

2) Causality and Endogeneity Issues

Despite the use of panel regression and robustness checks, causal inference remains constrained. Firms with strong sustainability orientations may self-select into Green FinTech adoption, creating potential:

- reverse causality
- omitted variable bias
- simultaneity problems

Instrumental variable approaches can mitigate but not fully eliminate endogeneity risk. Therefore, results primarily capture association rather than pure causation.

3) Geographic and Sectoral Scope

The study focuses mainly on publicly listed firms and carbon-intensive industries in emerging economies. Findings may not fully generalize to:

- small and medium enterprises (SMEs)
- informal sector firms
- developed economies with mature carbon markets

Additionally, different regulatory regimes and market structures shape the effectiveness of Green FinTech. The heterogeneity of institutional environments implies context-dependent results.

4) Model Specification Limitations

The study integrates panel econometrics and SEM; however:

- behavioral responses of managers
- organizational culture
- technological readiness
- consumer environmental preferences

are not explicitly modeled. These soft factors may significantly mediate technology adoption outcomes but are difficult to quantify at scale.

5) Absence of Primary Data

The analysis primarily utilizes secondary quantitative data. The absence of:

- managerial interviews
- survey evidence
- case studies

limits deeper understanding of internal corporate processes through which Green FinTech affects decision-making and emission outcomes.

B. Future Research Directions

Based on the limitations discussed above, several promising avenues emerge.

1) Micro-Level Measurement of Green FinTech Adoption

Future studies should construct firm-level Green FinTech adoption indices based on:

- internal use of blockchain carbon ledgers
- AI-based ESG analytics tools
- digital supply chain emission tracking systems

- sustainability-linked digital payment platforms
- Such microdata would enable stronger causal identification and rich heterogeneity analysis.

2) Experimental and Causal Identification Approaches

Future research could use:

- natural experiments
- regulatory shocks (e.g., mandatory ESG rules)
- difference-in-differences models
- randomized policy pilots

to better establish causal pathways between Green FinTech and carbon reduction outcomes.

3) Cross-Country Comparative Studies

Comparative analyses between:

- developed vs. emerging economies
- carbon-intensive vs. service sectors
- strong vs. weak regulatory frameworks
- would help understand institutional contingency effects and identify best-practice policy designs.

4) Behavioral and Organizational Perspectives

Future studies may adopt qualitative or mixed-method approaches to explore:

- managerial perceptions of Green FinTech risks and benefits
- employee digital capability development
- organizational culture and green innovation
- resistance to technology and sustainability integration
- Such insights would deepen theoretical understanding beyond quantitative correlations.

5) Consumer-Side and Household Green FinTech

Most research, including this study, focuses on corporations. Future work may examine:

- green digital banking apps for consumers
- carbon-tracking wallets
- gamified personal sustainability platforms
- peer-to-peer green crowdfunding
- to assess whether retail digital finance tools influence household carbon footprints and responsible consumption.

6) Integration with AI, IoT, and Blockchain

Finally, emerging technologies such as:

- Internet of Things (IoT)–based emission sensors
- blockchain-enabled carbon registries
- AI for climate-risk forecasting

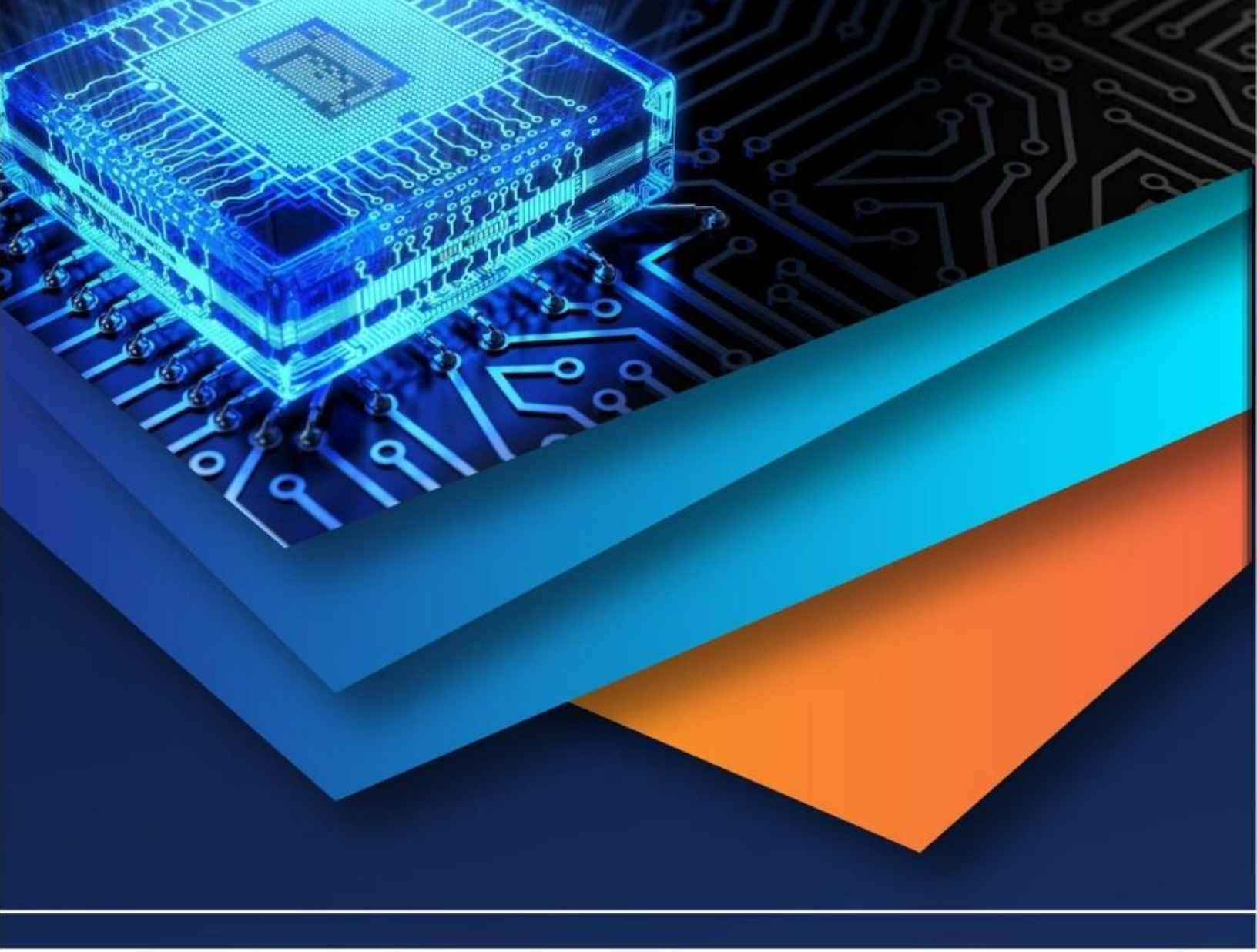
offer fertile ground for interdisciplinary research at the intersection of FinTech, climate technology, and industrial decarbonization. By acknowledging these limitations and outlining future pathways, this study aims to stimulate ongoing scholarly inquiry into how Green FinTech can reshape financial systems, corporate strategies, and climate outcomes. As data quality improves and digital transformation accelerates, future research can build upon this framework to provide deeper, causally robust, and policy-relevant insights.

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