FinTech-Enabled Pathways for Achieving Carbon Neutrality in Global Supply Chains: Integrating Blockchain, Artificial Intelligence, and Green Finance for Systemic Sustainability

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Abstract

The global imperative for carbon neutrality has positioned FinTech as a critical driver of sustainable innovation in supply chains. This study explores how financial technology can enable the green transition by integrating technological innovation, financial incentives, verification systems, and policy alignment to reduce carbon emissions across multi-tier supply chains. Drawing on recent literature, a conceptual framework is developed to illustrate seven pathways, financial accessibility, real-time monitoring, innovation-driven adoption, policy alignment, collaboration, risk management, and capacity building, via which FinTech fosters systemic sustainability. The framework highlights the role of blockchain, AI analytics, and digital finance in enhancing transparency, incentivizing low-carbon investments, and mitigating operational and environmental risks. The study identifies existing research gaps, including limited operational pathways for multi-tier carbon reduction and fragmented regulatory support, and proposes three objectives: (1) to examine FinTech-enabled mechanisms for sustainable supply chain practices; (2) to explore pathways for integrating finance, technology, and policy; and (3) to provide a conceptual roadmap for achieving carbon neutrality without empirical analysis. The findings provide insights for managers, policymakers, and researchers seeking to align economic growth with environmental responsibility in global supply chains.

1. Introduction

The growing urgency of climate change and global carbon reduction commitments has spurred interest in innovative financial solutions that can accelerate the green transition. FinTech, encompassing digital finance, blockchain, and AI-driven financial services, presents a promising avenue for facilitating environmentally sustainable practices across

industries (Yalcin et al., 2026; Zhuang & Wu, 2026). Recent studies highlight the potential of green FinTech to enhance corporate carbon neutrality by improving financing efficiency, incentivizing sustainable investments, and fostering scale economies in environmentally conscious projects (Li et al., 2025; Jia et al., 2024). Despite growing literature, a gap persists in understanding how these technologies can integrate within global supply chains to drive carbon reduction without requiring extensive empirical modeling, leaving room for conceptual and pathway-focused analyses (Du, 2025; Li & Zhang, 2024).

FinTech innovations not only streamline financial transactions but also contribute to broader environmental sustainability goals. Green finance mechanisms, including sustainable investment platforms and blockchain-enabled transparency solutions, have been shown to support energy transition initiatives and reduce carbon footprints at firm and industry levels (Lee et al., 2024; Huang et al., 2024; Xu et al., 2023). While empirical evidence demonstrates positive correlations between FinTech adoption and energy efficiency improvements, existing research often focuses on single-country case studies, limiting the generalizability of findings (Kashif et al., 2026; Zhang et al., 2023). There is a clear need to explore the pathways through which FinTech can drive systemic changes across supply chains, emphasizing conceptual frameworks and innovation potential rather than quantitative modeling (The future of green finance, 2025).

The intersection of blockchain technology and FinTech has emerged as a critical driver of green innovation. Energy-efficient consensus mechanisms, such as Green-PoW, demonstrate how blockchain can reconcile digital financial operations with sustainability objectives, addressing prior criticisms of blockchain's high energy consumption (Lasla et al., 2022; Lim et al., 2024). Furthermore, blockchain integration enhances traceability, accountability, and incentive alignment in supply chains, which are essential for monitoring carbon reduction strategies (Li et al., 2025; Luo et al., 2022). Nevertheless, the literature reveals a gap in synthesizing these technological innovations within a holistic framework for global supply chains, indicating the necessity of studies that explore pathways and mechanisms conceptually rather than empirically (Akanfe et al., 2024).

While FinTech adoption has been linked to improved operational and financial efficiency, its role in promoting circular economy practices and sustainable business models remains underexplored (Kumar et al., 2025; Lv et al., 2021). The literature suggests that combining digital finance with corporate sustainability strategies can catalyze innovation, reduce carbon emissions, and strengthen supply chain resilience (Li et al., 2025; Du, 2025). However, challenges persist in harmonizing regulatory frameworks, stakeholder incentives, and technology adoption across borders, creating gaps in policy-oriented guidance (Zhang et al., 2023; Udeagha & Muchapondwa, 2025). Addressing these gaps requires an integrated discussion that maps FinTech pathways to carbon neutrality without relying on complex empirical modeling.

The study aims to explore three specific objectives: (1) to analyze how FinTech innovations can accelerate the green transition across global supply chains, (2) to identify the key mechanisms and pathways through which FinTech supports carbon neutrality, and (3) to evaluate policy and managerial implications for leveraging digital financial technologies to foster sustainable innovation. This conceptual approach will synthesize insights from multiple disciplines, including finance, environmental

management, and digital technology, offering a structured framework for future research and practical implementation (Yalcin et al., 2026; Lee et al., 2022; Jia et al., 2024). By doing so, it addresses gaps in cross-disciplinary integration and provides actionable pathways for stakeholders.

This article is organized into six sections. Following this introduction, Section 2 reviews the theoretical foundations and current literature on FinTech, green finance, and supply chain carbon neutrality. Section 3 discusses technological innovations, including blockchain and digital finance platforms, in the context of sustainability. Section 4 identifies potential pathways and mechanisms through which FinTech can drive carbon-neutral practices. Section 5 presents policy and managerial implications, while Section 6 concludes with research contributions and future directions. No empirical analysis is included, as the focus is on conceptual clarity and identifying actionable pathways (Du, 2025; Li et al., 2025; Huang et al., 2024).

2. Literature Review

2.1 Overview of FinTech and Green Transition

FinTech has transformed financial intermediation, risk assessment, and capital allocation (Lagna & Ravishankar, 2022; Li et al., 2025). Over the past decade, this transformation has expanded beyond traditional banking into areas of environmental sustainability and climate finance (Kashif et al., 2026; The future of green finance, 2025). Green transition efforts aim to decouple economic growth from carbon emissions through innovations that reduce environmental impact while supporting economic resilience (Lee et al., 2024; Huang et al., 2024). In the context of global supply chains, where multiple stakeholders coordinate production, transportation, and logistics, FinTech technologies can introduce transparency, mobilize capital for sustainability investments, and enable market-based incentives for carbon-neutral practices (Jia et al., 2024; Li & Zhang, 2024).

Early conceptualizations of green finance focused on specialized financial instruments such as green bonds and sustainability-linked loans (Lee & Lee, 2022; Lv et al., 2021). However, with the rise of digital financial infrastructure, the scope of green finance now includes algorithmic credit scoring for sustainable vendors, blockchain-enabled carbon tracking, and decentralized markets for carbon credits (Lasla et al., 2022; Lim et al., 2024). These innovations hold promise for supply chain decarbonization, but their adoption patterns vary widely across geographies and industries (Li et al., 2025; Wang et al., 2024a).

Despite this promise, the literature reflects fragmentation: most studies examine FinTech or green transition impacts in isolation or within single domains such as energy markets, bank performance, or firm-level sustainability reporting (Aziz et al., 2024; Cheng et al., 2023). A comprehensive understanding of how FinTech can systematically drive carbon neutrality across global supply chains remains underdeveloped, motivating this review.

2.2 Technological Foundations: Digital Finance, Blockchain, and AI

2.2.1 Digital Finance and Sustainable Investment

Digital financial services (DFS) have expanded financial inclusion, reduced transaction costs, and facilitated cross-border capital flows (Adugna, 2024; Li et al., 2025). When oriented toward environmental outcomes,

DFS can redirect savings and investment towards sustainable enterprises by enabling low-cost access to green investment platforms (Li & Zhang, 2024; The future of green finance, 2025). Digital platforms can facilitate fractional ownership of green assets, democratizing participation in sustainability markets (Li et al., 2025). For supply chains, especially in emerging markets, this democratization can reduce capital constraints for smaller suppliers seeking to adopt cleaner technologies.

However, the literature reveals significant gaps. Empirical studies often measure digital finance adoption indirectly using proxies such as mobile money transactions or banking outreach indicators (Adugna, 2024; Li et al., 2025). Rarely do they examine how digital finance intersects with carbon accounting or sustainability metrics in supply chains, a topic central to this research.

2.2.2 Blockchain for Transparency and Trust

Blockchain technologies create tamper-proof records and decentralized ledgers, which can improve transparency in supply chains (Akanfe, Lawong, & Rao, 2024; Lim et al., 2024). Through distributed ledgers, stakeholders can trace product origin, energy usage, and emissions data—a capability crucial for green claims verification (Li et al., 2025; Luo et al., 2022). Energy-efficient consensus models such as Green-PoW address prior concerns about blockchain's environmental footprint, aligning digital ledger technologies with sustainability objectives (Lasla et al., 2022).

Nevertheless, many supply chain blockchain initiatives remain pilot projects without clear pathways to scalability or integration with financial incentives (Lim et al., 2024). While proof-of-concept studies demonstrate feasibility, comprehensive frameworks that link blockchain traceability to carbon credit monetization and green financing instruments are scarce (Li et al., 2025; Udeagha & Muchapondwa, 2025). This gap underscores the need to conceptualize integrated platforms that align digital verification with economic incentives for carbon reduction.

2.2.3 Artificial Intelligence and Predictive Analytics

AI-driven analytics can enhance risk assessment and forecasting across supply networks, enabling predictive carbon management and proactive sustainability planning (Li et al., 2025; Lim et al., 2024). Machine learning models process large-scale IoT sensor data from logistics to estimate emissions and identify optimization opportunities. When coupled with financial instruments, AI can tailor credit access based on environmental performance metrics, incentivizing eco-friendly supplier practices.

The current literature on AI in sustainability tends to concentrate on technical feasibility rather than governance, ethical use, or interoperability within FinTech–green finance ecosystems (Li & Zhang, 2024; Lim et al., 2024). Moreover, there is limited research on how AI-integrated FinTech platforms can support carbon neutrality goals through real-time, finance-linked decision support systems in complex supply chains.

2.3 Green Finance Mechanisms and Decarbonization Pathways

2.3.1 Carbon Markets and Sustainable Securities

Carbon markets have gained attention as mechanisms for pricing emissions and allocating reduction responsibilities (Cheng et al., 2023; Lv

et al., 2021). FinTech innovations such as blockchain-based carbon credit registries can potentially improve market liquidity and reduce transaction friction (Lasla et al., 2022; Li & Zhang, 2024). Sustainable securities like green bonds and sustainability-linked loans integrate environmental performance criteria with financial returns, thus promoting long-term commitments to carbon reduction (Kumar et al., 2025; Lee & Lee, 2022).

However, the degree to which carbon markets integrate FinTech capabilities remains heterogeneous across regions. Some frameworks are still paper-based or confined to closed registries, limiting transparency and cross-jurisdictional interoperability essential for global supply chains (Udeagha & Muchapondwa, 2025; Wang et al., 2024a). Additionally, the effectiveness of carbon markets in driving real-world emissions reductions is debated, as market volatility and regulatory uncertainty can distort price signals (Aziz et al., 2024; Cheng et al., 2023).

2.3.2 Green Finance Policies and Institutional Incentives

National and regional policies play critical roles in shaping FinTech adoption for sustainability (Lee et al., 2024; Huang et al., 2024). For instance, policies that mandate climate risk disclosure or incentivize clean energy investments can stimulate FinTech-enabled green finance products. Regulatory sandboxes and innovation hubs also allow FinTech experimentation under controlled environments (Anwar, Waheed, & Aziz, 2024).

Despite these policy efforts, the literature indicates challenges in aligning regulatory frameworks across jurisdictions (Udeagha & Muchapondwa, 2025). Policymakers often lag behind technological innovation, leading to uncertainty that can deter investment in scalable green FinTech solutions (Li et al., 2025). Moreover, policies that promote sustainability in financial markets may not directly translate to greener practices at the supply chain level, where regulatory reach is limited and actors are dispersed (The future of green finance, 2025).

2.4 Supply Chain Decarbonization and FinTech Integration

2.4.1 Supply Chain Complexity and Carbon Accountability

Global supply chains involve multiple tiers of suppliers, transporters, and intermediaries, each contributing to carbon emissions through energy use, logistics, and production (Jia et al., 2024; Li et al., 2025). FinTech systems can facilitate carbon tracking by linking financial transactions with environmental data, enabling real-time monitoring of emissions performance. Digital financial platforms could theoretically support dynamic pricing models that reward lower emissions or penalize high-emission activities.

Academic research on supply chain digitization mainly focuses on operational efficiency rather than the integration of financial and environmental data streams (Li et al., 2025; Lim et al., 2024). There is limited evidence on how FinTech-enabled data integration mechanisms can be operationalized in multi-tiered supply chains to support carbon neutrality objectives without empirical provisioning. This highlights a crucial gap where research must explore conceptual frameworks for integrated FinTech–sustainability platforms.

2.4.2 Incentive Structures for Carbon Reduction

Financial incentives such as green financing rates, carbon pricing, and reward mechanisms can motivate supply chain actors to adopt

cleaner technologies and processes (Kumar et al., 2025; Anwar et al., 2024). FinTech tools could automate these incentive structures—for example, by adjusting loan terms based on real-time emissions data or tokenizing carbon credits that reward sustainability improvements.

While theoretical models exist for performance-based green finance, the literature reveals a scarcity of implementation frameworks that demonstrate how such mechanisms operate end-to-end in digital ecosystems (Li et al., 2025; Udeagha & Muchapondwa, 2025). Most studies emphasize high-level potential rather than pathway visualization or roadmap development. Addressing this gap is essential for advancing understanding of how FinTech can drive systemic carbon reduction in supply networks.

2.5 Research Gaps and Theoretical Opportunities

Across the reviewed literature, several key gaps stand out. First, while numerous studies validate the potential of FinTech for sustainability, most focus on narrow domains such as corporate finance, energy markets, or single-country contexts (Aziz et al., 2024; Cheng et al., 2023). An integrated perspective that situates FinTech within global supply chains is lacking. Second, many empirical studies use proxy variables or limited datasets that do not capture real-time environmental performance metrics tied to financial outcomes (Adugna, 2024; Li et al., 2025). Third, while technological innovations such as blockchain and AI are discussed extensively, there are fewer frameworks linking these technologies to incentive-compatible green finance mechanisms that operate across supply chain tiers.

These gaps suggest theoretical opportunities to develop integrated models emphasizing pathwaysthrough which FinTech innovations can accelerate carbon neutrality in interconnected supply networks. Specifically, conceptual frameworks could map interactions among digital finance platforms, blockchain-based transparency systems, carbon markets, and policy incentives to reveal leverage points for decarbonization.

3. Conceptual Framework

Building on the literature reviewed, this study proposes a comprehensive conceptual framework that illustrates how FinTech can facilitate the green transition and carbon neutrality across global supply chains. While previous research has examined FinTech adoption, blockchain integration, or green finance instruments in isolation, there remains a lack of unified models that capture their interdependencies in supporting systemic decarbonization. The proposed framework addresses this gap by conceptualizing FinTech-enabled supply chain decarbonization as a multi-layered system that integrates technological innovation, financial incentives, and policy alignment to create actionable pathways for sustainability. It emphasizes the mechanisms through which digital finance platforms, blockchain technologies, and artificial intelligence (AI) analytics can collectively drive innovation, optimize resource allocation, and ensure transparency in emissions reduction efforts (Li et al., 2025; Lim et al., 2024; Du, 2025).

At the core of the framework is the data integration layer, which serves as the foundation for FinTech-enabled decision-making. Digital financial systems, integrated with enterprise resource planning (ERP), IoT devices, and sustainability reporting platforms, enable the collection, processing, and real-time monitoring of carbon emissions across supply chain tiers (Luo et al., 2022; Li et al., 2025). By providing a

holistic view of environmental performance, firms can identify carbon-intensive operations, optimize logistics, and allocate capital efficiently to support sustainability initiatives. Predictive analytics and AI algorithms further enhance the value of integrated data by forecasting emissions trends, identifying mitigation opportunities, and linking operational insights to financial decisions. Despite its potential, the literature highlights that most studies focus on technical feasibility rather than conceptualizing cross-tier integration of financial and environmental data streams, revealing a critical research gap (Jia et al., 2024; Du, 2025).

The framework also emphasizes the importance of incentive mechanisms that transform environmental performance into tangible financial outcomes. FinTech platforms can enable dynamic, performance-linked financial instruments, such as green loans with interest rates tied to verified reductions in emissions or tokenized carbon credits that reward suppliers and stakeholders for sustainable practices (Kumar et al., 2025; Lasla et al., 2022). By embedding environmental metrics into financial decision-making, supply chain actors are encouraged to adopt clean technologies, enhance energy efficiency, and invest in sustainable operations. The incentive mechanism layer therefore ensures that participants are not only compliant but actively engaged in achieving carbon neutrality. Existing literature provides theoretical support for such mechanisms; however, operational pathways for implementing these models across multi-tier supply chains remain limited, highlighting the need for integrative frameworks that align financial incentives with emissions reduction (Udeagha & Muchapondwa, 2025; Huang et al., 2024).

Verification and transparency constitute another essential component of the framework. Blockchain and distributed ledger technologies can record emissions data immutably, ensuring trust among geographically dispersed supply chain partners and preventing manipulation of environmental claims (Lim et al., 2024; Lasla et al., 2022). Smart contracts enable the automated execution of incentives or penalties based on verified performance, linking the verification layer directly to financial and operational outcomes. The integration of verification and incentive mechanisms ensures that sustainability commitments are measurable, credible, and enforceable. Despite growing interest in blockchain applications, comprehensive studies examining its integration with financial incentives across multi-tier global supply chains are scarce, representing a significant conceptual gap (Li et al., 2025; Lim et al., 2024).

Finally, the framework incorporates a governance and policy alignment layer, recognizing that technological and financial interventions require supportive institutional contexts to be effective. Harmonized carbon reporting standards, cross-border regulatory frameworks, and policy-driven innovation hubs enable FinTech experimentation while mitigating risks associated with inconsistent enforcement or market volatility (Wang et al., 2024; Anwar et al., 2024). Policies that incentivize participation in green finance markets, enforce climate risk disclosure, or support small and medium enterprises in sustainability investments are crucial to scaling the impact of FinTech-enabled decarbonization. Literature indicates that fragmented regulatory environments often hinder adoption, underscoring the importance of conceptualizing governance as an integral layer within the framework (Udeagha & Muchapondwa, 2025).

The framework emphasizes four innovation pathways emerging from the interaction of its layers. First, data-driven decision pathways enable supply chain managers to leverage integrated information for emissions optimization. Second, incentive-induced innovation pathways encourage adoption of clean technologies through financial rewards. Third, verification-facilitated pathways ensure credible sustainability claims, enhancing trust and market efficiency. Finally, policy-enabling pathways align institutional support with technological and financial innovations to reinforce systemic decarbonization. These pathways collectively create a self-reinforcing cycle, wherein technological adoption stimulates financial innovation, which, in turn, incentivizes sustainable behavior, verified through transparent systems and supported by governance structures (Li et al., 2025; Du, 2025; Huang et al., 2024).

In practice, the framework offers significant theoretical and managerial contributions. Conceptually, it provides an integrated model that links digital finance, blockchain, and AI with green finance mechanisms and governance structures, addressing persistent gaps in the literature regarding multi-tier supply chain decarbonization. For managers, the framework highlights operational levers for implementing FinTech-enabled sustainability initiatives, including data-driven performance monitoring, incentive design, and verification protocols. For policymakers, it identifies critical areas where regulatory alignment, standardization, and innovation support are necessary to scale FinTech-enabled decarbonization across regions and industries. By offering a continuous, holistic perspective, the framework serves as a roadmap for understanding, designing, and implementing sustainable financial innovation in complex supply chains without the need for empirical analysis.

4. Pathways and Mechanisms

The adoption of FinTech in global supply chains for achieving carbon neutrality operates through multiple interconnected pathways and mechanisms that bridge technological innovation, financial structures, and environmental management. This section explores how FinTech catalyzes systemic change in supply chain sustainability. While prior literature predominantly focuses on firm-level adoption of digital finance or blockchain technologies, few studies provide a structured understanding of the mechanisms that translate these innovations into measurable environmental outcomes. The integration of FinTech platforms, green finance instruments, and digital verification tools creates a multi-dimensional system that enables real-time decision-making, incentivizes sustainable practices, ensures data transparency, and aligns operations with policy frameworks, thereby fostering pathways toward carbon neutrality (Qiao et al., 2025; Xu et al., 2023; The future of green finance, 2025).

One critical mechanism is the enhancement of financial accessibility and efficiency through digital platforms, which allows small, medium, and large enterprises to engage in green investments with reduced transaction costs and improved liquidity. FinTech innovations such as blockchain-based financing, peer-to-peer green loans, and AI-driven credit scoring allow supply chain participants to access capital contingent on sustainability performance (Du, 2025; Anwar et al., 2024). These financial pathways reduce barriers to entry for environmentally friendly technologies, encourage investment in low-carbon infrastructure, and provide firms with the necessary liquidity to implement renewable energy solutions and carbon-efficient production

processes (Zhang et al., 2023; Xu et al., 2023). By tying access to finance directly to sustainability metrics, firms are motivated to improve environmental performance while maintaining financial viability.

Another pathway emerges from real-time monitoring and verification of environmental performance. Advanced FinTech systems integrate IoT sensors, AI analytics, and distributed ledger technologies to track carbon emissions, energy consumption, and resource use across supply chain tiers (Fan, 2024; He et al., 2024; Lasla et al., 2024). Blockchain ensures immutability of records, while AI-driven analytics provide predictive insights into carbon-intensive operations, enabling proactive mitigation measures. This combination of real-time data and transparency reinforces accountability among suppliers and distributors, while facilitating performance-based financing, insurance incentives, and compliance reporting (Lim et al., 2024; Li et al., 2024). The verification pathway ensures that environmental claims are credible, measurable, and actionable, forming a foundation for effective decision-making and cross-border supply chain collaboration.

Innovation-driven pathways are also facilitated by FinTech, as digital finance platforms promote experimentation and adoption of new green technologies. By providing financial resources and risk-sharing mechanisms, FinTech enables firms to explore renewable energy solutions, circular economy models, and low-carbon logistics strategies without incurring prohibitive upfront costs (Li et al., 2025; Du, 2025; Qiao et al., 2025). The adoption of blockchain-enabled supply chain management allows for dynamic reconfiguration of operations, enabling firms to integrate sustainable suppliers and optimize production processes. Simultaneously, tokenization of carbon credits and gamified sustainability metrics stimulate continuous improvement, fostering a culture of green innovation throughout the value chain (Li et al., 2024; Lim et al., 2024).

The policy alignment pathway emphasizes the role of governance structures in reinforcing FinTech-enabled sustainability initiatives. Regulatory frameworks, standardization of carbon reporting, and supportive government policies amplify the effectiveness of digital finance mechanisms (Udeagha & Muchapondwa, 2025; Wang et al., 2024; Anwar et al., 2024). Policies that incentivize participation in green finance markets, provide tax breaks for renewable energy investments, and establish carbon-trading platforms create systemic conditions for scaling FinTech interventions. By integrating policy with financial and technological innovation, firms can adopt sustainable practices with reduced regulatory uncertainty, ensuring that decarbonization efforts are consistent, measurable, and replicable across regions (Kashif et al., 2026; The future of green finance, 2025).

Furthermore, FinTech promotes collaborative pathways across supply chain actors, leveraging network effects to optimize environmental outcomes. Platforms that share data on supplier performance, carbon footprints, and sustainability compliance enable stakeholders to coordinate production, logistics, and procurement decisions that minimize emissions (Du, 2025; Qiao et al., 2025; Zhang et al., 2023). Collaborative digital ecosystems facilitate information sharing between manufacturers, distributors, investors, and regulators, enabling multi-tier optimization of carbon reduction strategies. This pathway not only strengthens supply chain resilience but also fosters collective responsibility for sustainability outcomes,

addressing limitations in traditional top-down environmental compliance approaches (Xu et al., 2023; Fan, 2024).

The risk management pathway highlights the capacity of FinTech to mitigate environmental and financial risks associated with carbon-intensive supply chains. AI-powered predictive analytics, coupled with blockchain verification, allows firms to anticipate disruptions related to regulatory changes, climate impacts, or supplier non-compliance (He et al., 2024; Lasla et al., 2024). By linking risk assessment to adaptive financial instruments, such as dynamic green loans or performance-linked insurance, supply chain actors can absorb shocks while maintaining environmental objectives. This risk-sensitive approach ensures long-term sustainability and financial resilience, creating a feedback loop where risk mitigation reinforces innovation adoption and emissions reduction (Li et al., 2025; Du, 2025).

Finally, capacity-building pathways are supported by FinTech through knowledge dissemination, training, and digital literacy programs. Platforms can educate suppliers on sustainable practices, provide real-time feedback on performance metrics, and facilitate access to expertise in green technology implementation (Qiao et al., 2025; The future of green finance, 2025). By integrating training and support mechanisms, FinTech strengthens the absorptive capacity of supply chain actors, ensuring that innovations are adopted effectively and sustainability goals are realized. This pathway bridges the gap between technological potential and operational implementation, ensuring that carbon neutrality objectives are not only planned but executed efficiently.

5. Conclusion

This study has examined the role of FinTech in driving the green transition within global supply chains, emphasizing pathways and mechanisms for achieving carbon neutrality. By synthesizing the literature and developing a multi-layered conceptual framework, the study illustrates how data integration, financial incentives, verification technologies, and governance structures interact to facilitate sustainable supply chain practices. The framework highlights seven key pathways, financial accessibility, real-time monitoring, innovation-driven adoption, policy alignment, collaboration, risk management, and capacity building, that collectively enable firms to adopt low-carbon technologies, optimize resource allocation, and enhance transparency in carbon reporting. These pathways provide a systematic approach to understanding the multidimensional impact of FinTech beyond isolated technological adoption, bridging gaps between financial mechanisms, digital innovations, and sustainability objectives (Qiao et al., 2025; Li et al., 2025).

The analysis demonstrates that FinTech offers unique opportunities to create alignment between financial and environmental goals. Performance-linked financing, tokenized carbon credits, and AI-powered predictive analytics empower firms to manage emissions proactively, incentivize innovation, and mitigate risks in complex supply chain networks. By integrating governance frameworks and policy interventions, FinTech adoption becomes more scalable and impactful, ensuring that environmental improvements are consistent across multiple tiers of supply chains. This conceptual integration responds to gaps identified in the literature, including the limited operational pathways for multi-tier carbon reduction, fragmented regulatory oversight, and

insufficient attention to the role of digital verification mechanisms in driving supply chain sustainability (Du, 2025).

Overall, the study contributes to both theory and practice. The proposed framework provides a foundation for future research on FinTech-enabled sustainability, offering actionable insights for managers and policymakers seeking to achieve carbon neutrality goals. By mapping the pathways and mechanisms through which financial technology supports green transitions, this study emphasizes the strategic potential of integrating digital finance, blockchain, and AI with environmental management. Future research can empirically test these pathways, examine contextual variations across regions and industries, and explore the long-term effects of FinTech adoption on supply chain resilience and climate mitigation (Qiao et al., 2025; Li et al., 2025; Du, 2025). In conclusion, FinTech is not merely a facilitator of operational efficiency but a transformative tool for sustainable innovation, offering pathways to align economic growth with environmental responsibility in global supply chains.

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