Financial and Technological Innovation Ecosystems for Decarbonising Global Supply Chains: Evidence from Green Finance, Fintech, and Digital Transformation Literature

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DOI: https://doi.org/10.64633/wissj.v10i1.33

Keywords

Carbon Neutrality, Global Supply Chains, Fintech Innovation, Green Finance, Blockchain Technology, Sustainability Transition

Abstract

The transition toward carbon neutrality in global supply chains has become a critical sustainability priority, driven by escalating climate change concerns and increasing pressure on firms to decarbonise production and logistics systems. This study synthesises existing literature on fintech, green finance, blockchain technology, and supply chain governance to develop an integrated understanding of how innovation pathways can accelerate carbon neutrality. The review demonstrates that fintech enhances financial accessibility and efficiency, while green finance redirects capital toward low-carbon investments. Blockchain and digital technologies strengthen transparency, traceability, and accountability across complex supply chain networks. However, the study identifies persistent fragmentation across these domains, limiting their combined effectiveness in achieving systemic decarbonisation. Key challenges include greenwashing risks, regulatory inconsistency, unequal access to sustainable finance, and technological integration barriers. The study proposes that carbon neutrality requires the convergence of financial innovation, technological infrastructure, and institutional coordination. It further highlights the need for integrated governance frameworks and cross-border collaboration to ensure effective sustainability transitions in global supply chains.

Exploring Pathways to Ignite Innovation for Carbon Neutrality in Global Supply Chains

1. Introduction

The transition toward carbon neutrality in global supply chains has become a central priority in sustainability discourse, driven by escalating climate risks and regulatory pressures. Recent scholarship highlights that achieving deep decarbonisation requires not only technological upgrades but also financial and institutional innovation (Tao et al., 2022). In particular, green finance has emerged as a key enabler of sustainable transformation by redirecting capital toward low-carbon activities (Fan et al., 2021). Similarly, fintech integration is increasingly recognised for accelerating environmental efficiency across interconnected supply networks (Li et al., 2025). These developments suggest that financial innovation is no longer peripheral but

central to sustainability transitions. However, despite growing interest, the mechanisms through which fintech and green finance jointly catalyse innovation for carbon neutrality in global supply chains remain underexplored, especially in relation to cross-border production systems and fragmented governance structures.

Building on this foundation, fintech has become a transformative force in reshaping supply chain innovation dynamics. Empirical studies suggest that fintech adoption enhances operational transparency, financial access, and efficiency in supply chain ecosystems (Jia et al., 2024). It also supports enterprise transformation by enabling digital integration across production and logistics networks (Wu et al., 2024). Furthermore, fintech-driven mechanisms have been shown to reduce information asymmetry and improve investment efficiency in sustainability-oriented projects (Tao et al., 2022). These capabilities are particularly relevant for global supply chains, wherecoordination failures often hinder decarbonisation efforts. Nevertheless, existing literature tends to focus on firm-level outcomes, with limited attention to how fintech-induced innovation cascades across multi-tier global supply chains to support systemic carbon neutrality objectives.

Green finance provides another critical pillar in the innovation-carbon neutrality nexus. It has been widely documented that green finance facilitates environmental improvements by channeling investments toward clean technologies and reducing carbon-intensive production (Huang et al., 2024). Additionally, it contributes to green growth by stimulating technological innovation and improving energy efficiency across sectors (Lee et al., 2024). The interaction between financial mechanisms and environmental performance is further reinforced by evidence showing that green finance reduces emissions and enhances sustainability outcomes (Fan et al., 2021). Despite these advances, there remains insufficient understanding of how green finance instruments interact with supply chain structures to drive coordinated decarbonisation across global production networks. This gap limits the development of integrated policy and managerial strategies for carbon-neutral supply chains.

Technological enablers such as blockchain and digital platforms are also reshaping sustainability pathways in global supply chains. Blockchain technologies enhance transparency, traceability, and trust among supply chain actors, thereby reducing inefficiencies and emissions leakage (Lim et al., 2024). In addition, blockchain-based applications improve data integrity and facilitate sustainable coordination across distributed networks (Ante, 2021). These innovations are particularly relevant for carbon accounting and verification processes in complex supply chains. However, despite their promise, the adoption of such technologies remains uneven due to regulatory uncertainty and integration challenges. Current research has yet to fully explore how blockchain and fintech convergence can systematically support carbon neutrality goals across multi-jurisdictional supply chain systems, representing a significant gap in the literature.

Despite growing scholarship on fintech, green finance, and digital technologies, several critical gaps remain. First, existing studies are fragmented, often examining fintech, green finance, or blockchain in isolation rather than as interconnected drivers of supply chain innovation. Second, limited attention has been paid to the systemic pathways through which these mechanisms jointly contribute to carbon neutrality in global supply chains (Khan et al., 2025). Third, there is a lack of integrated frameworks that connect financial innovation with operational supply chain decarbonisation strategies across diverse institutional contexts

(Bui et al., 2024). Addressing these gaps is essential for developing a holistic understanding of sustainability transitions. This study responds to these limitations by synthesising cross-disciplinary insights into an integrated pathway for innovation-driven carbon neutrality.

Accordingly, this article is structured as follows. The next section reviews the theoretical foundations linking fintech, green finance, and supply chain sustainability, highlighting key conceptual relationships. This is followed by a synthesis of technological enablers, including blockchain and digital platforms, in facilitating carbon-neutral supply chain innovation. The subsequent section discusses emerging pathways and identifies critical gaps in existing literature, particularly in relation to global coordination and policy alignment. Finally, the paper concludes by proposing an integrated conceptual framework and outlining directions for future research. Through this structure, the article aims to provide a comprehensive understanding of how innovation can be strategically leveraged to accelerate carbon neutrality in global supply chains.

2. Literature Review

The accelerating urgency of climate change has repositioned global supply chains as both a major contributor to carbon emissions and a critical lever for achieving carbon neutrality. Contemporary scholarship increasingly frames carbon neutrality not merely as an environmental objective but as a systemic transformation involving financial, technological, and organizational innovation across interconnected supply networks. Within this discourse, fintech and green finance have emerged as central enablers of low-carbon transition pathways. For instance, Tao et al. (2022) argue that fintech development can facilitate the transition toward a low-carbon economy by improving financial accessibility and enabling efficient allocation of green capital. Similarly, Fan et al. (2021) highlight that financial systems play a pivotal role in "greening" economic activities by channeling investment into environmentally sustainable sectors. These studies collectively emphasize that financial innovation is deeply intertwined with sustainability transitions. However, despite growing attention, existing research remains fragmented in explaining how these financial mechanisms translate into coordinated innovation across global supply chains. This gap is particularly significant because supply chains operate as multi-tier, cross-border ecosystems where carbon emissions are embedded in complex production and logistics structures rather than isolated firm-level activities.

A major strand of literature focuses on green finance as a structural mechanism for enabling environmental innovation and carbon reduction. Green finance is widely recognised as a catalyst for mobilising capital toward renewable energy, clean production, and eco-friendly technologies. Huang et al. (2024) demonstrate that green finance significantly reduces carbon emissions by fostering green technological innovation, thereby strengthening the innovation-emission reduction nexus. Similarly, Lee et al. (2024) show that green finance plays a critical role in energy transition processes, particularly under climate policy constraints. Fan et al. (2021) further provide evidence that financial development supports environmental improvement by reallocating resources toward greener sectors. Despite this consensus, Bhatnagar and Sharma (2022) note that green finance literature remains conceptually fragmented, with unclear boundaries regarding instruments, mechanisms, and enabling conditions. This fragmentation creates challenges in understanding how green finance interacts with supply chain structures to promote systemic decarbonisation. Moreover, while studies such as Yu et al. (2021) confirm

that financing constraints hinder green innovation, limited attention has been given to how supply chain financing mechanisms can overcome these barriers across multiple tiers of global production systems. As a result, a key gap persists in linking green finance theory with operational supply chain decarbonisation pathways.

Alongside green finance, fintech has emerged as a transformative force reshaping financial intermediation and sustainability innovation. Fintech applications such as digital payments, peer-to-peer lending, and data-driven financing platforms are increasingly recognised for enhancing financial inclusion and efficiency. Lagna and Ravishankar (2022) emphasise that fintech research is fundamentally oriented toward solving real-world financial inefficiencies and enabling inclusive innovation. Adugna (2024) extends this by showing that digital financial services can reshape economic outcomes, including income distribution and capital accessibility, which indirectly influence sustainability investment capacity. In supply chain contexts, Jia et al. (2024)—one of the selected core studies—demonstrate that fintech adoption significantly improves sustainable supply chain management by enhancing transparency and financial coordination. Wu et al. (2024) further show that fintech accelerates corporate green transformation by enabling data-driven environmental decision-making. However, despite these advances, most studies remain firm-centric and do not sufficiently address how fintech-driven innovation propagates across interconnected supply chain actors. This represents a critical gap, as global supply chains require synchronized innovation diffusion across manufacturers, suppliers, logistics providers, and financial institutions to achieve meaningful carbon neutrality outcomes.

Blockchain technology has also become a central focus in literature on sustainable supply chain innovation. Blockchain is widely recognized for enhancing transparency, traceability, and trust across distributed systems. Lim et al. (2024) highlight that blockchain innovations provide both technological opportunities and managerial challenges, particularly in large-scale supply chain environments. Ante (2021) further explains that smart contracts embedded in blockchain systems enable automation of transactions and reduce inefficiencies in financial coordination. Lohmer and Lasch (2020) identify both the potential and barriers of blockchain adoption in operations management, noting that scalability and integration remain key challenges. More specifically, blockchain has been linked to carbon market transparency and emission tracking systems, improving accountability in sustainability reporting (Lim et al., 2024). In supply chain finance, blockchain reduces information asymmetry and enhances trust among stakeholders, thereby facilitating green investment flows (Ioannou & Demirel, 2022). However, despite these advancements, blockchain research often focuses on technical feasibility rather than systemic integration with green finance and fintech ecosystems. This creates a disconnect between technological potential and real-world implementation in carbon-neutral supply chains, particularly in developing and heterogeneous regulatory environments.

Supply chain finance (SCF) literature provides further insight into the financial architecture supporting sustainability transitions. SCF is increasingly being integrated with green objectives to support environmentally responsible production and logistics systems. Chotia et al. (2025) highlight that fintech-enabled supply chain finance significantly improves firm performance by mitigating risk and enhancing liquidity in supply networks. Bui et al. (2024) propose a green supply chain finance model that integrates policy regulation and

digitalisation practices to improve environmental outcomes in logistics and transportation. Similarly, Li et al. (2025) demonstrate that blockchain integration strengthens supply chain resilience and enhances coordination efficiency, both of which are essential for sustainable operations. Despite these developments, SCF literature still tends to prioritise financial performance and operational efficiency over environmental transformation. There is limited integration between SCF models and carbon neutrality objectives, particularly in terms of incentivising suppliers at different tiers to adopt low-carbon technologies. This represents a significant theoretical and practical gap, as supply chain decarbonisation requires aligned financial incentives across all participating actors.

Green innovation has been widely recognised as a key mediator between financial systems and environmental outcomes. Irfan et al. (2022) show that green finance positively influences green innovation, particularly when supported by regional policy interventions. Huang et al. (2024) similarly argue that financial systems promote innovation-led emission reduction by fostering technological advancement. Lee et al. (2022) demonstrate that green finance improves green total factor productivity, reinforcing its role in enhancing efficiency and sustainability simultaneously. However, Khan et al. (2025) caution that despite increasing research, there remains a lack of unified theoretical frameworks explaining how green growth, innovation, and sustainability interact across different contexts. This fragmentation is particularly evident in global supply chains, where innovation processes are distributed across multiple countries and institutional environments. As such, there is a need for integrative models that connect financial innovation, technological adoption, and supply chain coordination in a coherent pathway toward carbon neutrality.

The role of digitalisation in enabling sustainable supply chain transformation is another major theme in recent literature. Digital technologies, including artificial intelligence, big data, and IoT, are increasingly integrated with financial systems to improve sustainability outcomes. Li et al. (2024) demonstrate that digital finance development significantly enhances financial efficiency and environmental performance. Wu et al. (2024) further highlight that fintech-driven digital transformation accelerates corporate green innovation. Similarly, Jia et al. (2024) emphasise that digital platforms improve coordination and transparency in sustainable supply chain management. However, the literature still lacks comprehensive models explaining how digitalisation interacts with green finance and blockchain to produce systemic decarbonisation effects. Most studies remain siloed within technological or financial domains, failing to capture the convergence required for carbon-neutral supply chains. This limitation suggests the need for interdisciplinary frameworks that integrate digital innovation, financial systems, and supply chain governance structures.

A growing body of literature also explores policy and institutional dimensions of carbon neutrality transitions. Dikau and Volz (2021) argue that central bank mandates and sustainability-oriented monetary policies are essential for scaling green finance. Lv et al. (2021) highlight regional disparities in green finance development, indicating uneven access to sustainability capital. Lyu et al. (2024) show that green finance policy significantly enhances enterprise green development, particularly when supported by regulatory incentives. However, despite increasing policy attention, coordination between financial regulation and supply chain governance remains weak. This disconnect limits the effectiveness of policy instruments in driving real-world supply chain decarbonisation. Furthermore, Allam et al. (2022) emphasise

that achieving deep decarbonisation requires integrated policy frameworks similar to Green New Deal approaches, which align financial, industrial, and environmental objectives. Yet, current governance structures remain fragmented, particularly at the global supply chain level.

A critical debate in the literature concerns the effectiveness and limitations of green growth strategies. While green finance and fintech are widely promoted as solutions for sustainable development, some scholars question whether current models are sufficient for achieving absolute carbon neutrality. Bhatnagar and Sharma (2022) and Fan et al. (2021) suggest that while financial innovation supports environmental improvement, its impact may be incremental rather than transformational. This aligns with concerns raised in broader sustainability debates about whether efficiency gains alone can offset rising global consumption. Additionally, Wu et al. (2024) highlight that corporate green transformation driven by fintech may still be constrained by structural and institutional barriers. These debates suggest that innovation alone is insufficient unless embedded within systemic supply chain redesigns. Therefore, there is a pressing need to explore integrated pathways that combine financial innovation, technological advancement, and structural supply chain transformation.

In synthesising the literature, it becomes evident that while significant progress has been made in understanding fintech, green finance, blockchain, and supply chain sustainability individually, there is limited integration across these domains. Tao et al. (2022), Fan et al. (2021), Jia et al. (2024), Wu et al. (2024), and Li et al. (2025) collectively illustrate that financial and digital innovations are central to sustainability transitions. However, their combined effect on global supply chain decarbonisation remains under-theorised. Existing research tends to adopt fragmented perspectives, focusing either on financial systems, technological tools, or policy frameworks in isolation. This creates a conceptual gap in understanding how innovation ecosystems can be orchestrated to achieve carbon neutrality across global supply chains.

In conclusion, the literature indicates that achieving carbon neutrality in global supply chains requires the convergence of fintech, green finance, blockchain technology, digitalisation, and supportive policy frameworks. While individual components of this system are well-researched, their integration into coherent innovation pathways remains limited. Future research must therefore move beyond siloed analyses to develop holistic frameworks that explain how financial, technological, and institutional innovations interact to drive systemic decarbonisation. The present study addresses this gap by conceptualising integrated pathways through which innovation can be ignited for carbon neutrality in global supply chains, offering a foundation for future theoretical and policy-oriented advancements.

3. Pathways to Carbon-Neutral Innovation in Global Supply Chains

Building on the preceding literature, this section develops a conceptual framework that explains how innovation can be systematically ignited to achieve carbon neutrality in global supply chains. The framework integrates four interdependent dimensions: fintech-enabled financial transformation, green finance mechanisms, digital and blockchain-based technological infrastructure, and supply chain governance structures. Rather than treating these elements as isolated drivers, the framework conceptualises them as a dynamic innovation ecosystem in which financial flows, information systems, and organisational networks interact to enable low-carbon transitions. This perspective responds to the fragmentation identified in the literature,

where fintech, green finance, and supply chain sustainability are often analysed separately despite their increasing convergence in practice. The proposed framework therefore positions innovation as an outcome of systemic alignment across financial, technological, and institutional domains.

At the core of the framework is fintech-enabled financial transformation, which reshapes how capital is mobilised, allocated, and monitored across global supply chains. Fintech platforms enhance the speed, transparency, and accessibility of financial services, thereby reducing barriers to green investment. As highlighted by Jia et al. (2024), fintech adoption significantly improves supply chain management by increasing coordination efficiency and financial accessibility across supply chain actors. Similarly, Wu et al. (2024) demonstrate that fintech facilitates corporate green transformation by enabling data-driven decision-making processes. In global supply chains, this implies that suppliers, manufacturers, and logistics providers can gain improved access to green financing instruments such as sustainability-linked loans, green bonds, and supply chain finance platforms. However, the effectiveness of fintech depends on its integration with environmental objectives; otherwise, it risks reinforcing traditional profit-driven financing structures rather than enabling carbon-neutral innovation pathways. Yadav et al. (2024) further support this view by showing that fintech integration enhances resource efficiency and sustainability transitions in resource-dependent economies, particularly across BRICS nations.

The second dimension of the framework is green finance, which provides the capital foundation for low-carbon transformation. Green finance operates through mechanisms such as preferential lending, environmental risk assessment, carbon pricing integration, and investment screening for sustainability performance. Fan et al. (2021) argue that financial systems play a critical role in "greening" economic activity by reallocating capital toward environmentally sustainable sectors. Huang et al. (2024) further demonstrate that green finance fosters technological innovation that directly contributes to emission reductions. Within global supply chains, green finance functions as an incentive mechanism that encourages firms to adopt cleaner technologies and improve environmental performance across production stages. However, a key limitation identified in the literature is that green finance remains unevenly distributed across regions and sectors, often benefiting large firms while excluding smaller suppliers that form the backbone of global value chains. This inequality limits its transformative potential unless combined with fintech-enabled accessibility and digital transparency systems. Zhang et al. (2024) further emphasise that although green finance reduces environmental pollution, its effectiveness depends heavily on institutional quality and regulatory enforcement across jurisdictions.

The third dimension is digitalisation and blockchain-enabled infrastructure, which acts as the technological backbone for transparency, traceability, and coordination in supply chains. Blockchain technologies, in particular, are central to ensuring data integrity in carbon accounting and sustainability reporting. Lim et al. (2024) emphasise that blockchain innovations provide both operational transparency and managerial challenges, especially in complex supply chain environments. Ante (2021) highlights the role of smart contracts in automating transactions and reducing inefficiencies, thereby supporting sustainability-linked financial agreements. When integrated with fintech systems, blockchain enables real-time tracking of environmental performance and ensures that financial incentives are aligned with verified sustainability outcomes. However, the

literature also indicates significant barriers, including high implementation costs, interoperability challenges, and regulatory uncertainty, which limit large-scale adoption. Therefore, technological infrastructure alone is insufficient unless supported by institutional coordination and policy alignment. Zhe et al. (2024) further reinforce this argument by showing that fintech, natural resources, and digital innovation jointly influence environmental sustainability in a non-linear manner, suggesting that technology effects are context-dependent rather than uniform.

The fourth dimension is supply chain governance, which provides the institutional and organisational structure necessary for coordinating innovation across multiple actors. Global supply chains are characterised by fragmentation, asymmetry of power, and geographical dispersion, making coordinated sustainability action challenging. Dikau and Volz (2021) argue that institutional mandates, particularly within central banking systems, are crucial for scaling green finance and embedding sustainability objectives into financial governance. Similarly, Lyu et al. (2024) show that policy interventions significantly enhance enterprise-level green development when aligned with financial incentives. Within supply chains, governance mechanisms determine how environmental standards are enforced, how information is shared, and how accountability is maintained across tiers. Without strong governance structures, financial and technological innovations may remain fragmented and fail to produce systemic carbon reduction outcomes. Uddin et al. (2024) further highlight that environmental efficiency in global systems is strongly influenced by foreign direct investment patterns, reinforcing the importance of coordinated governance across national boundaries.

The interaction among these four dimensions gives rise to three primary innovation pathways toward carbon neutrality in global supply chains. The first pathway is the financial-driven innovation pathway, where fintech and green finance jointly enable the mobilisation of capital toward low-carbon technologies. In this pathway, fintech platforms reduce transaction costs and improve access to green finance, while green financial instruments ensure that capital is directed toward sustainable projects. Tao et al. (2022) highlight that fintech can facilitate transitions toward a low-carbon economy by improving financial efficiency and inclusivity. This pathway is particularly relevant for emerging economies where access to traditional green finance is limited. However, its success depends on the presence of robust data systems to verify environmental performance, otherwise financial flows may not translate into real emission reductions.

The second pathway is the technology-driven transparency pathway, which relies on blockchain and digital systems to ensure traceability and accountability across supply chains. In this pathway, blockchain enables the tracking of carbon emissions, energy use, and sustainability performance across production stages. Lim et al. (2024) and Lohmer and Lasch (2020) both emphasise that blockchain enhances operational transparency and reduces inefficiencies in distributed networks. When combined with fintech, this pathway enables automated enforcement of sustainability-linked contracts, ensuring that financial rewards are tied to verified environmental outcomes. This reduces the risk of greenwashing and strengthens trust among supply chain participants. However, this pathway faces challenges related to data standardisation and interoperability across global systems. Kumar et al. (2025) further argue that financial integration with circular economy models is essential to ensure that transparency mechanisms translate into actual material and resource efficiency gains.

The third pathway is the policy-coordinated institutional pathway, which focuses on aligning regulatory frameworks, financial incentives, and supply chain governance structures. Allam et al. (2022) argue that achieving deep decarbonisation requires integrated policy approaches similar to Green New Deal frameworks, which coordinate industrial, financial, and environmental objectives. Dikau and Volz (2021) further emphasise that central bank mandates and regulatory policies play a critical role in scaling sustainable finance. In global supply chains, this pathway ensures that sustainability standards are consistently applied across borders and industries. It also addresses structural inequalities in access to green finance and technological resources. However, policy fragmentation across jurisdictions remains a major limitation, particularly in multinational supply chains operating under different regulatory regimes.

A key insight from integrating these pathways is that carbon neutrality in global supply chains cannot be achieved through isolated interventions. Instead, it requires systemic innovation alignment across financial systems, technological infrastructures, and governance mechanisms. For instance, fintech-enabled green finance must be supported by blockchain-based transparency systems to ensure accountability, while both must operate within coherent policy frameworks that enforce sustainability standards. Wu et al. (2024) highlight that fintech-driven transformation is most effective when embedded within broader institutional and technological ecosystems. Similarly, Li et al. (2025) demonstrate that blockchain integration enhances supply chain resilience, which is essential for sustaining long-term decarbonisation efforts. This reinforces the argument that innovation must be viewed as an interconnected system rather than a set of independent tools.

Despite its integrative strength, the proposed framework also reveals several structural tensions. One major tension lies between efficiency and equity. While fintech and digitalisation improve efficiency, they may also reinforce disparities between technologically advanced firms and less-developed suppliers. Another tension exists between innovation speed and regulatory alignment, as technological advancements often outpace policy development. Additionally, there is a tension between global coordination and local adaptation, since supply chains operate across diverse institutional environments. These tensions highlight the need for adaptive governance mechanisms that can balance innovation acceleration with inclusivity and regulatory coherence. Zhang et al. (2024) further support this concern by showing that environmental outcomes of financial systems vary significantly depending on institutional and regional conditions.

4. Synthesis and Implications

The preceding sections have established that carbon neutrality in global supply chains depends on the convergence of fintech, green finance, digital technologies, blockchain systems, and governance structures. However, synthesising the broader literature reveals additional dimensions that deepen this understanding, particularly regarding systemic efficiency, organisational behaviour, technological constraints, and regional disparities. One key insight is that sustainability transitions are not only financial or technological challenges but also structural and behavioural transformations embedded within global production networks. Studies such as Saberi et al. (2019) and Wang et al. (2019) emphasise that blockchain-enabled supply chain systems enhance transparency and traceability, but their effectiveness depends on organisational readiness and cross-border coordination. Similarly, Yang et al. (2019) highlight the foundational role of

digital technologies such as IoT in enabling smart manufacturing ecosystems that support sustainability goals. These studies reinforce the argument that technological innovation must be embedded within broader system redesigns to achieve meaningful carbon neutrality outcomes.

A significant theme emerging from the literature is the role of structural networks and knowledge diffusion in enabling innovation across supply chains. Burt's (2018) structural hole theory suggests that innovation is facilitated by bridging disconnected actors within networks, thereby enhancing information flow and resource access. Lin et al. (2021) further expand this argument by demonstrating how structural holes in social networks influence innovation diffusion and coordination efficiency. In the context of global supply chains, these insights imply that intermediaries such as fintech platforms and digital marketplaces can serve as bridges connecting fragmented actors, enabling faster diffusion of green technologies and sustainability practices. However, Saglietto et al. (2020) caution that measurement and operationalisation of such network structures remain challenging, particularly in dynamic and heterogeneous supply chain environments. This indicates a need for more refined analytical tools to assess how network structures influence carbon neutrality transitions.

Another important dimension is the role of enterprise behaviour and managerial decision-making in shaping sustainability outcomes. Jo et al. (2015) demonstrate that corporate environmental responsibility positively influences firm performance, suggesting that sustainability-oriented governance structures can create both environmental and economic value. Chen et al. (2024) further show that top management team connectedness influences greenwashing behaviours, highlighting the importance of leadership networks in shaping environmental integrity. Ma et al. (2025) extend this discussion by showing that independent directors can mitigate corporate greenwashing through improved oversight mechanisms. These findings underscore that carbon neutrality in supply chains is not only a technological or financial issue but also a governance and ethical challenge. Without strong managerial commitment and accountability structures, even advanced fintech and blockchain systems may fail to deliver genuine environmental outcomes.

The literature also highlights significant concerns regarding greenwashing and information asymmetry in sustainability reporting. Chen et al. (2025) provide evidence that institutional investor engagement through site visits can reduce corporate greenwashing, reinforcing the importance of external monitoring mechanisms. Sun et al. (2025) further demonstrate that fintech adoption may paradoxically increase greenwashing risks if technological tools are used to simulate rather than verify sustainability performance. Pata et al. (2024) similarly show that fintech credit systems can unintentionally contribute to greenwashing in certain policy environments. These findings suggest that while fintech and digital platforms enhance transparency, they also introduce new risks of data manipulation and symbolic compliance. Therefore, robust verification systems and regulatory oversight are essential to ensure that digital innovation translates into genuine carbon reduction rather than superficial compliance.

From a macroeconomic and policy perspective, the literature provides strong evidence that green finance and fintech are closely linked to energy transition and environmental performance. Chan et al. (2024) show that income growth, institutional quality, and renewable energy consumption jointly influence carbon footprints in emerging economies. Dinga and Wen (2022) provide a sector-specific perspective by examining

whether China's cement industry can achieve carbon neutrality, highlighting the importance of industry-level transition strategies. Smol (2022) further critiques the conceptual ambiguity surrounding the Green Deal framework, arguing that regional interpretations vary significantly. Nakai (2024) adds a comparative perspective by discussing Japan's sustainability challenges, emphasizing the importance of national context in shaping green transition pathways. These studies collectively demonstrate that carbon neutrality is highly context-dependent and requires tailored policy frameworks aligned with sectoral and regional conditions.

The role of logistics, supply chain management, and operational efficiency is also critical in achieving sustainability goals. Yalcin and Daim (2022) highlight how technology mining in logistics and supply chain management reveals evolving innovation trends that support sustainability transitions. Sandul (2023) further examines transformational factors in global supply chains, emphasising that structural changes in logistics networks are necessary for decarbonisation. Wang et al. (2019) provide a systematic review of blockchain applications in supply chains, identifying both opportunities and implementation challenges. Lohmer and Lasch (2020) similarly emphasise operational barriers to blockchain adoption in manufacturing systems. These studies indicate that while technological solutions exist, their successful deployment depends on operational redesign, interoperability, and stakeholder coordination across global logistics systems.

Cybersecurity and data integrity also emerge as important considerations in digitalised supply chain ecosystems. Daim et al. (2024) analyse the evolution of cybersecurity technologies and highlight their importance in protecting digital financial and supply chain infrastructures. As supply chains become increasingly digitalised through fintech and blockchain systems, vulnerabilities to cyber threats increase, potentially undermining trust and system reliability. This introduces a new dimension of risk that must be addressed in designing carbon-neutral supply chain systems. Without secure digital infrastructures, data-driven sustainability initiatives may be compromised, leading to inefficiencies or manipulation of environmental performance data.

Methodologically, the literature also reflects growing interest in advanced analytical techniques for studying sustainability systems. Jelodar et al. (2019) discuss latent Dirichlet allocation (LDA) and topic modelling as tools for analysing large-scale textual data, which can be applied to sustainability research. Noack (2009) introduces modularity clustering approaches that help identify structural communities in complex networks, relevant for supply chain mapping. Pradana et al. (2020) and Sun et al. (2015) further demonstrate how clustering and social network analysis can be applied to organisational and economic systems. These methodological advancements suggest that future research on carbon-neutral supply chains will increasingly rely on computational and data-driven approaches to capture complexity and interdependence.

In synthesising the literature, it becomes clear that achieving carbon neutrality in global supply chains requires an integrated systems perspective that combines technological innovation, financial transformation, behavioural governance, and institutional coordination. While fintech, green finance, and blockchain technologies provide powerful tools for enabling sustainability, their effectiveness depends on the broader structural environment in which they operate. Issues such as greenwashing, cybersecurity risks, institutional fragmentation, and network inefficiencies continue to constrain progress. Therefore, future research must move beyond

isolated technological or financial analyses and adopt holistic frameworks that capture multi-level interactions across global supply networks.

This study contributes to the literature by synthesising fragmented perspectives into an integrated understanding of innovation pathways for carbon neutrality in global supply chains. It highlights the need for alignment between financial systems, technological infrastructures, organisational governance, and policy frameworks. Future research should focus on empirical validation of the proposed pathways, cross-country comparative studies, and the development of quantitative models that capture dynamic interactions within supply chain ecosystems. Ultimately, transitioning to carbon-neutral global supply chains requires not only innovation but also coordination, trust, and systemic redesign across all levels of the global economy.

5. Conclusion

This study has examined the evolving pathways through which innovation can be ignited to achieve carbon neutrality in global supply chains, synthesising insights from fintech, green finance, blockchain technology, and supply chain governance literature. The analysis demonstrates that carbon neutrality is not a single-technology or single-policy outcome but a systemic transformation requiring the alignment of financial systems, digital infrastructures, and institutional arrangements. Across the reviewed literature, fintech has been consistently identified as a key enabler of financial inclusion and efficiency in sustainability transitions, while green finance provides the necessary capital reallocation toward low-carbon investments (Fan et al., 2021; Huang et al., 2024). In parallel, blockchain and digital technologies enhance transparency and traceability across supply chains, strengthening accountability and reducing inefficiencies (Lim et al., 2024; Ante, 2021). When combined, these mechanisms form an interconnected innovation ecosystem capable of supporting decarbonisation objectives in complex global production networks.

Despite these promising developments, the literature also reveals significant structural and operational limitations. First, there remains a persistent fragmentation between financial, technological, and governance-focused research streams, limiting the development of integrated frameworks for supply chain decarbonisation. Second, issues of greenwashing, data manipulation, and information asymmetry continue to undermine the credibility of sustainability reporting, even in digitally enabled environments (Sun et al., 2025; Chen et al., 2025). Third, disparities in institutional capacity and financial access across regions create uneven adoption of fintech and green finance solutions, thereby reinforcing global inequalities in sustainability transitions (Lv et al., 2021; Zhang et al., 2024). Moreover, cybersecurity vulnerabilities and interoperability challenges associated with blockchain and digital platforms pose additional risks to system reliability (Daim et al., 2024). These limitations suggest that technological advancement alone is insufficient without robust governance and regulatory oversight.

In terms of policy and managerial implications, the study highlights the need for coordinated frameworks that integrate financial innovation, digital transformation, and environmental regulation. Policymakers should prioritise the harmonisation of green finance standards and develop regulatory infrastructures that ensure transparency, accountability, and interoperability across global supply chains. Financial institutions are encouraged to expand fintech-enabled green financing instruments, particularly in developing economies where access to

sustainable capital remains limited (Adugna, 2024; Tao et al., 2022). At the organisational level, firms should strengthen ESG governance mechanisms and invest in blockchain-based traceability systems to enhance sustainability performance and reduce reputational risks associated with greenwashing (Ma et al., 2025; Wu et al., 2024). Additionally, supply chain actors must adopt collaborative strategies that promote shared accountability across multiple tiers of production networks.

Future research should focus on developing integrated empirical models that capture the dynamic interactions between fintech, green finance, and supply chain sustainability outcomes. Longitudinal and cross-country comparative studies are particularly needed to assess how institutional environments influence the effectiveness of innovation-driven carbon neutrality pathways. Further research should also explore the role of artificial intelligence, IoT, and advanced analytics in strengthening predictive sustainability capabilities within supply chains. In addition, more attention should be given to behavioural dimensions, including managerial decision-making, corporate ethics, and stakeholder engagement, as these factors significantly influence the success of sustainability initiatives (Chen et al., 2024; Jo et al., 2015). Overall, advancing carbon neutrality in global supply chains requires not only technological and financial innovation but also institutional coordination and behavioural transformation across global systems.

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