Integrating Green Supply Chain Management and Digital Transformation: Towards Resilient, Sustainable and Technology-Enabled Supply Chains

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ABSTRACT

Global supply chains face intensifying pressures from climate change, regulatory demands, and technological disruption, positioning sustainability and resilience as strategic imperatives. Green Supply Chain Management (GSCM) practices such as eco-design, reverse logistics and sustainable sourcing are widely acknowledged for enhancing environmental performance, yet research often examines them in isolation from digital transformation. Simultaneously, Industry 4.0 and 5.0 technologies including blockchain, artificial intelligence, the Internet of Things and digital twins are reshaping supply chains through improved visibility, traceability and predictive intelligence. Despite these advances, literature remains fragmented, with limited integration of green and digital dimensions or exploration of the conditions under which they thrive. This conceptual paper proposes a theoretical framework that positions GSCM practices and digital enablers as complementary resources for advancing sustainability and resilience. Moderating variables specifically stakeholder pressure and government/policy support are incorporated to explain how institutional forces shape adoption and outcomes. Anchored in the Resource-Based View (RBV), Triple Bottom Line (TBL), and Stakeholder Theory, the framework illustrates how digital transformation amplifies green practices, while external pressures govern their effectiveness. The contribution lies in bridging scholarly gaps, extending theoretical foundations, and providing actionable insights for managers and policymakers. Ultimately, the paper argues that integrated green digital strategies, reinforced by stakeholders and institutional support, are not mere operational enhancements but strategic necessities for building sustainable and resilient supply chains.

Keywords: Green supply chain management, Digital transformation, Sustainability, Triple bottom line

INTRODUCTION

Global supply chains are increasingly exposed to complex disruptions caused by climate change, resource scarcity, geopolitical instability and pandemics. These challenges have created significant vulnerabilities, leading firms to rethink traditional supply chain models that prioritize cost efficiency over sustainability and resilience (Uday kumar, 2023; Oluwatobi 2025). In response, Green Supply Chain Management (GSCM) has gained prominence as a strategic paradigm that integrates environmental, social, and economic considerations into supply chain operations. By embedding practices such as green purchasing, eco-design, reverse logistics, and closed-loop systems, GSCM not only reduces environmental impacts but also enhances organizational competitiveness (Zijuan; Ai, 2024).

Concurrently, the rapid advancement of digital technologies under Industry 4.0 and Industry 5.0 is transforming supply chain management. Technologies such as the Internet of Things (IoT), blockchain, artificial intelligence (AI), big data analytics, and digital twins enable real-time monitoring, predictive analytics, traceability, and smarter decision-making, fostering transparency and agility in global supply networks (Antonio et. al, 2024; Assiya et.al, 2025; Mattteo, 2022).

These technologies not only streamline operations but also play a crucial role in enabling sustainable practices, such as optimizing energy use, reducing waste, and supporting circular economy models (Asterios, 2022; Chaimaa and Mohammed Raja, 2022). Few studies, however, propose a unified conceptual framework that explores their synergistic potential in creating supply chains that are simultaneously green, digital, and resilient. Moreover, while environmental and economic outcomes are widely studied, the social dimension of sustainability including employee engagement, community well-being, and energy justice that remains underexplored (Oluwatobi, 2025; Theofilos, 2022)

This paper addresses these gaps by proposing a conceptual framework that links GSCM practices, digital technologies, and resilience strategies. The framework is grounded in established theoretical perspectives:

• The Resource-Based View (RBV), which positions digital and green capabilities as strategic resources for competitive advantage.

• The Triple Bottom Line (TBL), which emphasizes the balance between economic, environmental, and social performance.

• Stakeholder Theory, which highlights the importance of aligning supply chain practices with the expectations of regulators, communities, and customers (Asterios, 2022; Dea, 2024).

By integrating these perspectives, this study advances the argument that digital transformation amplifies the effectiveness of GSCM, creating resilient supply chains capable of withstanding disruptions while contributing to long-term sustainability.

LITERATURE REVIEW

Green Supply Chain Management (GSCM) Practices

GSCM practices such as eco-design, reverse logistics, green purchasing, and closed-loop supply chains are widely recognized as essential drivers of environmental sustainability and competitive advantage. Studies show that adoption of GSCM improves resource efficiency, reduces emissions, and enhances performance outcomes across manufacturing and service industries (Kamra et al., 2024; Amin et al., 2025). In emerging economies, adoption is shaped by stakeholder pressures and regulatory frameworks, with government support acting as a significant enabler (Eltalhi et al., 2025).

Sectoral insights reveal heterogeneity: in construction, GSCM success relies on stakeholder engagement and government regulations (Chaimaa & Mohammed Raja, 2022; Oluwatobi, 2025); in food supply chains, sustainable procurement and local sourcing are central (Theofilos, 2022; Dea, 2024); while in energy systems, circularity and closed-loop models underpin renewable integration and waste reduction (Sorooshian et al., 2024; Okeke, 2025). Despite progress, the literature notes fragmentation, with limited cross-sectoral frameworks that unify GSCM strategies.

Digital Transformation and Industry 4.0/5.0 in Supply Chains

Digital transformation (DT) through Industry 4.0 and 5.0 introduces technologies such as IoT, AI, blockchain, big data analytics, ERP, and digital twins, all of which enable real-time monitoring, predictive analysis, and efficiency in supply chains (Asterios, 2022; Kayan et al., 2025). These tools support traceability, agility, and collaboration, improving sustainability and resilience outcomes. Blockchain, for instance, has been shown to enhance transparency in green purchasing, while IoT and digital twins optimize resource use in agriculture and bioenergy systems (Kayan et al., 2025; Ikram et al., 2025).

Industry 5.0 further emphasizes human–machine collaboration and cultural transformation, linking digital innovation with Green Human Resource Management (GHRM) for sustainability-oriented organizational change (Amin et al., 2025). However, research on the integration of Industry 5.0 technologies into GSCM remains limited, with most studies focusing on isolated tools or industries rather than holistic frameworks (Amin et. al., 2025)

Supply Chain Resilience and Sustainability

The COVID-19 pandemic and recent disruptions have highlighted the importance of resilience in supply chains. Frameworks such as Sense–Adapt–Transform demonstrate how firms reconfigure resources and strategies under uncertainty (Cristiu et al., 2025). Resilience strategies include redundancy, flexibility, and digital integration, which help mitigate risk and improve adaptability (Anathi, 2024).

In parallel, sustainability research grounded in the Triple Bottom Line (TBL) that emphasizes environmental, economic, and social performance. While environmental and economic outcomes dominate, social dimensions (e.g., energy justice, employee welfare) are often underexplored (Okeke, 2025; Garti et al., 2025). This imbalance signals the need for integrative studies that bring social aspects into mainstream resilience and sustainability research.

Integration of GSCM and Digital Transformation

Although both GSCM and digital technologies are individually studied, their integration remains underdeveloped. Bibliometric reviews highlight emerging but fragmented intersections between green practices and Industry 4.0/5.0 technologies (Kamra et al., 2024; Neha et al., 2023). Evidence suggests that digital enablers can significantly strengthen GSCM by enabling emissions monitoring, supply chain traceability, and closed-loop logistics (Sorooshian et al., 2024; Amin et al., 2025). Yet, there is still limited empirical validation of these synergies, especially across industries and global contexts.

This gap underlines the contribution of the present concept paper, which develops a conceptual framework linking GSCM, digital transformation, and supply chain resilience to advance sustainability.

THEORETICAL AND CONCEPTUAL FRAMEWORK

The development of sustainable and digitally enabled supply chains is grounded in well-established management theories. This concept paper draws upon four primary theoretical perspectives: the Resource-Based View (RBV), the Triple Bottom Line (TBL), Stakeholder Theory, and Legitimacy Theory. Together, these frameworks provide a robust foundation for understanding how green supply chain practices and digital technologies can interact to enhance competitiveness, sustainability and resilience.

Resource-Based View (RBV)

The RBV posits that organizations achieve sustainable competitive advantage through the possession and deployment of valuable, rare, inimitable, and non-substitutable resources. In the context of supply chains, digital technologies such as IoT, AI, blockchain, and digital twins represent strategic assets that enhance information visibility, traceability, and predictive capabilities (Assiya et al., 2025; Antonio et al., 2024). Similarly, green practices—such as eco-design, green purchasing, and reverse logistics—constitute organizational capabilities that improve environmental and operational performance (Zijuan & Ai, 2024; Silvia et al., 2025). Recent studies suggest that the integration of these resources produces synergistic effects, enabling firms to achieve both competitive differentiation and sustainability outcomes (Lubna & Manal, 2023; Kamra et al., 2024).

Triple Bottom Line (TBL)

The TBL framework emphasizes that organizational success should not be assessed solely on financial outcomes but also on environmental and social performance. Within GSCM, TBL has been widely adopted to evaluate how green initiatives reduce environmental impacts while also creating economic value and improving stakeholder well-being (Rajendran et al., 2025; Eltalhi et al., 2025). Empirical evidence indicates that digital tools strengthen TBL performance by enabling real-time monitoring of emissions, supporting resource recovery, and improving decision-making in circular economy systems (Sorooshian et al., 2024; Okeke, 2025). Moreover, integration of TBL into supply chains provides a broader lens for evaluating trade-offs between efficiency and sustainability across sectors such as construction (Oluwatobi, 2025) and food industries (Theofilos, 2022).

Stakeholder Theory

Stakeholder Theory argues that organizational survival and legitimacy depend on the firm's ability to address the interests of diverse stakeholder groups, including governments, customers, employees, and communities. GSCM adoption is often driven by external pressures such as regulatory requirements, consumer demand for sustainable products, and community expectations (Cristiu et al., 2025; Chaimaa & Mohammed Raja, 2022). Studies show that digital technologies amplify stakeholder engagement by enhancing transparency, traceability, and accountability across global supply networks (Sergiy, 2023; Ali Emrouz et al., 2023). For example, blockchain systems increase supply chain visibility and build consumer trust, while IoT enables customers and regulators to monitor compliance with sustainability standards.

Legitimacy Theory

Legitimacy Theory suggests that organizations must align their operations with societal norms and values to ensure long-term acceptance and survival. In supply chain contexts, firms are increasingly scrutinized by media, governments, and non-governmental organizations for their environmental and social practices (Garti et al., 2025; Rajendran et al., 2025). Adoption of GSCM practices, when combined with digital technologies, enhances firms' ability to demonstrate compliance and responsiveness to external expectations. For instance, digital traceability tools help firms validate claims of sustainable sourcing, thereby reinforcing corporate legitimacy (Asterios, 2022; Cristiu et al., 2025). In this way, digital-enabled GSCM is not only an operational necessity but also a mechanism for maintaining legitimacy in dynamic institutional environments.

Conceptual Model

The proposed conceptual framework positions Green Supply Chain Management (GSCM) practices and digital enablers as the independent variables (IVs) that drive organizational performance in terms of sustainability and resilience. GSCM practices such as eco-design, reverse logistics, and sustainable procurement provide firms with environmentally responsible capabilities that reduce emissions, conserve resources, and align operations with circular economy principles. In parallel, digital enablers including Internet of Things (IoT), blockchain, artificial intelligence (AI) and digital twins to enhance visibility, traceability, and predictive decision-making in supply chains. Together, these variables serve as strategic drivers of performance.

The dependent variables (DVs) of the framework are supply chain sustainability and resilience. Sustainability is conceptualized within the Triple Bottom Line (TBL) framework, encompassing economic efficiency, environmental stewardship, and social responsibility. Resilience, in turn, captures the ability of supply chains to anticipate, absorb, and adapt to disruptions, ensuring operational continuity under uncertainty.

Importantly, the framework incorporates moderating variables (MVs) specifically, stakeholder pressure and government/policy support which influence the strength and direction of the IV and DV relationships. Stakeholder expectations, including those of customers, communities, and investors, often shape the extent to which firms commit to sustainability initiatives. Similarly, institutional forces such as regulatory frameworks, subsidies, and policy incentives amplify or constrain the adoption of green digital practices. By acknowledging these moderators, the framework reflects the contextual realities that determine the effectiveness of sustainability-driven strategies across industries and regions.

Justification and Interrelationships of Theories

This conceptual paper integrates five complementary lenses Resource-Based View (RBV), Dynamic Capabilities (DCV), Institutional Theory (including stakeholder pressures), Legitimacy Theory and the Triple Bottom Line (TBL) to explain how digitally enabled green supply chain management (GSCM) practices generate superior sustainability and performance outcomes. Below, each theory is justified and then woven into a coherent explanatory mechanism consistent with evidence in the uploaded studies.

Resource-Based View (RBV) posits that firms outperform peers when they assemble valuable, rare, inimitable, and non-substitutable resource bundles and capabilities. Recent GSCM scholarship explicitly adopts RBV to explain how information sharing, collaboration, and top-management commitment become green capabilities that underpin GSCM adoption and performance, particularly in emerging economies (Eltalhi et. al., 2025). Moreover, sector syntheses show that green capabilities (eco-design, traceability, circular logistics) are recognized elements of the supply chain resource base (Neha et.al., 2023).

Dynamic Capabilities (DCV) refines RBV by emphasizing a firm's ability to sense, seize, and reconfigure resources as contexts change. Empirical work on GSCM adoption highlights that internal competencies to adapt and orchestrate resources, dynamic capabilities are pivotal when firms face volatile, constrained environments (Eltalhi et. al., 2025). This makes DCV an apt bridge between static resources (RBV) and the continuous transformation demanded by green and digital transitions.

Institutional & Stakeholder Pressures theory explains why firms feel compelled to adopt GSCM beyond efficiency motives such as coercive regulation, normative expectations and mimetic forces. Evidence from food industry contexts shows that institutional pressures and government support shape GSCM uptake and outcomes (Eltalhi et. al., 2025).

Parallel research shows that media scrutiny, industry risk, and country context (agenda-setting and stakeholder theories) conditions how supply-chain sustainability transgressions are reported, influencing firms' exposure to reputational risk and shaping their choice of proactive versus reactive risk-avoidance practices (Ivana et. al., 2025).

Legitimacy Theory shows beyond compliance that firms seek social acceptance to secure access to resources, financing, and markets. Literature emphasizes protecting and signaling legitimacy, especially under media attention and drives adoption of proactive supplier gatekeeping and transparency (e.g., embedding environmental criteria, using visibility tools) to pre-empt criticism and build trust (Ivana et. al., 2025).

Triple Bottom Line (TBL) provides the evaluative criterion set for outcomes: environmental, social, and economic performance. Contemporary logistics and Industry 5.0 research explicitly operationalize sustainability along TBL dimensions and shows which dimensions are most salient across factors such as circular logistics, innovation, and managerial strategy (Garti et. al., 2025).

Digital technologies as capability enablers within RBV/DCV. Industry 4.0/5.0 and related tools such as IoT, Radio frequency Identification (RFID), analytics, blockchain, twins, VR/AR expand the firm's resource base (RBV) and, crucially, its reconfiguration capacity (DCV) by enhancing visibility, traceability, and learning across forward and reverse flows. These technologies enable circular logistics, waste reduction, and data-driven coordination that capabilities repeatedly linked to sustainable supply-chain performance (Silvia et. al., 2025).

Institutional pressures and stakeholder expectations as contextual drivers and boundary conditions. Regulatory signals, industry-level risks, and country risks nudge or compel firms toward GSCM and disclosure. At the same time, these pressures shape which actions are effective in the court of public opinion such proactive supplier assessment is rewarded and purely reactive termination stances can backfire under media scrutiny (Eltalhi et. al., 2025; Ivana et. al., 2025).

Legitimacy as both mediator and outcome. By deploying proactive GSCM and transparent, technology-enabled visibility, firms signal ongoing stewardship, mitigating negative legitimacy spillovers from suppliers and building reputational capital that, in turn, sustains access to critical resources and partnerships (Ivana et. al., 2025).

Conversion to TBL performance will happen when digital-green capabilities are orchestrated effectively (DCV), firms realize TBL gains that most immediately on environmental metrics (material circularity, emissions reduction) and, with managerial alignment, on social and economic dimensions (skills, safety, cost). Qualitative and bibliometric evidence shows systematic links from Industry 5.0 factors and sustainable practices to TBL outcomes (Garti et. al., 2025; Kamra et. al., 2024).

External institutional/stakeholder pressures trigger investments in digital and green resources (RBV). Firms with strong dynamic capabilities configure these into high-performing GSCM routines (e.g., closed-loop logistics, supplier gatekeeping, real-time traceability). These routines generate legitimacy (by reducing incidents and improving transparency), which stabilizes relationships and resource access. The combined effect materializes as TBL performance (environmental, social, economic)—with environmental improvements often appearing first, followed by social and economic gains as managerial systems mature.

Hypotheses Development

The integration of Green Supply Chain Management (GSCM) practices has long been associated with improved environmental and organizational performance, as firms implement eco-design, reverse logistics, and sustainable sourcing to achieve competitive advantage and mitigate ecological risks. Anchored in the Resource-Based View (RBV), these practices are regarded as valuable and inimitable resources that foster sustainability across environmental, economic and social dimensions while also enhancing resilience by strengthening supply chain adaptability and recovery capacity (Khan et al., 2023; Rajendran et al., 2025; Silvia et al., 2025). Hence, it is expected that:

H1: Green supply chain practices (GSCM) positively affect supply chain sustainability and resilience (SCSR).

Similarly, digital enablers such as blockchain, artificial intelligence (AI), Internet of Things (IoT), and digital twins are increasingly viewed as critical drivers of supply chain transformation. From the Dynamic Capabilities View (DCV), these technologies enable firms to sense risks, seize opportunities, and reconfigure resources, thereby improving visibility, traceability, and predictive capability (Amin et al., 2025; Ikram & Sroufe, 2025; Sergiy, 2023). Evidence suggests that digitalization not only enhances transparency but also strengthens both sustainability and resilience outcomes (Kayan et al., 2025). Therefore:

H2: Digital enablers positively affect SCSR.

While the direct effects of GSCM and digital enablers are important, their outcomes are also contingent upon external institutional and stakeholder factors. According to Stakeholder Theory, organizations respond to the pressures of customers, investors, NGOs and media actors who increasingly demand environmental accountability and transparency. High stakeholder pressure compels firms to intensify their adoption of sustainable practices and integrate digital tools for accountability, which in turn strengthens the impact of GSCM and digital enablers on sustainability and resilience (Eltalhi et al., 2025; Garti et al., 2025). Thus:

H3: Stakeholder pressure positively moderates the GSCM → SCSR relationship: the effect of GSCM on SCSR is stronger when stakeholder pressure is high

The impact of Green Supply Chain Management (GSCM) practices on sustainability and resilience is often contingent upon the degree of government and policy support available. While GSCM initiatives such as eco-design, reverse logistics, and sustainable procurement strengthen firms' environmental and adaptive capabilities, their effectiveness is magnified when supported by regulatory frameworks, subsidies, and enforcement mechanisms (Rajendran et al., 2025; Silvia et al., 2025). Drawing on Institutional Theory, such coercive and normative pressures create enabling conditions that encourage firms to integrate sustainability into their operations more effectively (Chaimaa & Mohammed Raja, 2022). Empirical evidence further shows that policy incentives and strong regulatory oversight significantly enhance the adoption of green practices across industries such as construction and renewable energy, thereby improving triple bottom line performance and resilience (Eltalhi et al., 2025; Okeke, 2025). Thus, government and policy support act as critical moderators that strengthen the relationship between GSCM practices and supply chain sustainability and resilience.

H4: Government/policy support positively moderates the GSCM → SCSR relationship, such that the effect of

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GSCM on SCSR is stronger when government/policy support is high.

The adoption of digital enablers such as blockchain, IoT, AI, and digital twins enhances supply chain sustainability and resilience by improving visibility, traceability, and adaptability (Amin et al., 2025; Ikram & Sroufe, 2025; Kayan et al., 2025; Sergiy, 2023). However, according to Stakeholder Theory, the effectiveness of these technologies is amplified under strong stakeholder pressure, as customers, NGOs, investors, and the media increasingly demand accountability, transparency, and verifiable sustainability outcomes (Eltalhi et al., 2025; Garti et al., 2025). In such contexts, firms are compelled to use digital tools not only for efficiency but also to build legitimacy and trust, thereby reinforcing their impact on sustainability and resilience. Therefore, it is hypothesized that stakeholder pressure strengthens the positive relationship between digital enablers and supply chain sustainability and resilience.

H5: Stakeholder pressure positively moderates the Digital Enablers → SCSR relationship, such that the effect of digital enablers on SCSR is stronger when stakeholder pressure is high.

The contribution of digital enablers such as blockchain, IoT, AI, and digital twins to supply chain sustainability and resilience is increasingly evident, as these technologies enhance transparency, predictive capacity, and responsiveness (Amin et al., 2025; Ikram & Sroufe, 2025; Kayan et al., 2025; Sergiy, 2023). However, their effectiveness is often shaped by the institutional environment, particularly through government and policy support, which provides regulatory enforcement, subsidies, and infrastructure that encourage firms to adopt and optimize digital solutions (Chaimaa & Mohammed Raja, 2022; Eltalhi et al., 2025). Evidence from renewable energy and construction sectors shows that strong policy frameworks amplify the benefits of digital innovations, enabling firms to achieve greater sustainability and resilience outcomes (Okeke, 2025). Thus, government and policy support act as critical moderators that strengthen the positive impact of digital enablers on supply chain sustainability and resilience.

H6: Government/policy support positively moderates the Digital Enablers → SCSR relationship, such that the effect of digital enablers on SCSR is stronger when government/policy support is high.

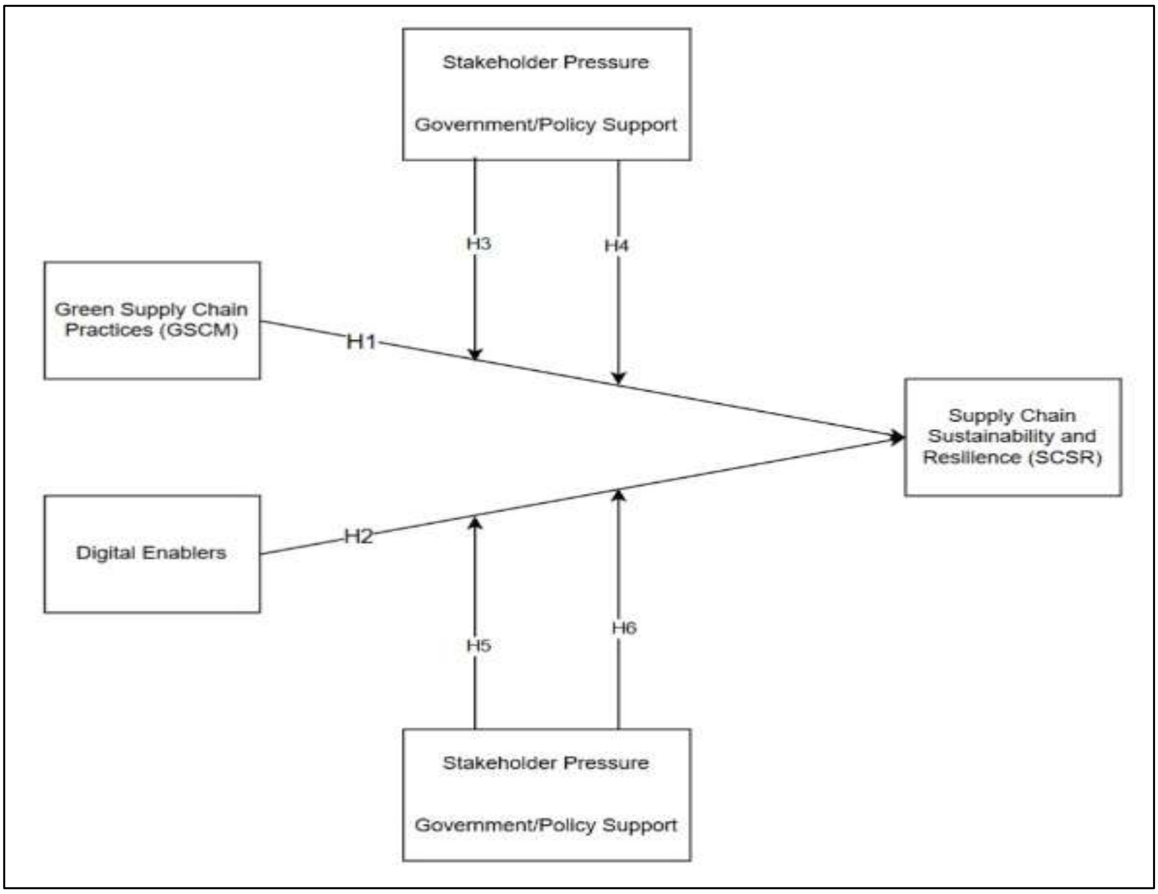

Fig. 1 The Proposed Conceptual Framework

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METHODOLOGY

Research Design

This study adopts a multi-method design to comprehensively examine the conceptual framework. The primary approach will be a quantitative, survey-based design, analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). SEM is selected due to its ability to capture complex interrelationships, moderating effects, and validate both measurement and structural models simultaneously (Eltalhi et al., 2025; Aamir et al., 2025).

As a complementary method, system dynamics (SD) modeling will be employed to simulate causal feedback loops and dynamic interactions (e.g., between stakeholder pressure, government support, and supply chain resilience). This dual approach strengthens both statistical generalizability and dynamic realism. For validation and deeper insights, selected case studies (e.g., in manufacturing and logistics sectors) will triangulate survey findings, highlighting best practices and contextual nuances.

The initial search yielded over 60 papers. After applying inclusion/exclusion criteria focused on relevance to integration and sustainability outcomes, 36 papers were selected for in-depth analysis and synthesis.

Sampling and Data Collection

Survey data will be collected from managers in manufacturing, construction, food, logistics, and energy sectors, which are characterized by significant environmental impact and stakeholder scrutiny. Respondents will include supply chain managers, operations managers, sustainability officers, and IT/analytics managers.

A stratified random sampling technique ensures proportional representation across industries and firm sizes. At least 300 valid responses will be targeted to satisfy SEM requirements (10-times rule; ≥200 for medium-complexity models).

Surveys will be distributed digitally. To minimize common method bias (CMB), procedural remedies such as psychological separation of measures, reverse-coded items, and multiple respondents per firm (where possible) will be applied. Statistical checks (Harman's single-factor test, marker variables) will validate CMB control (Podsakoff et al., 2003).

Measurement and Instrumentation

All constructs will be operationalized using multi-item reflective measures on 5- or 7-point Likert scales (1 = strongly disagree, 7 = strongly agree). The following validated scales will be adapted:

Construct	Dimension	Sample Item	Source
Green Supply Chain Management (GSCM) Practices	Eco-design	Our company considers environmental issues in product design and development.	Zhu & Sarkis; So Ra Park et al. (2022); Le et al. (2022)
Green Supply Chain Management (GSCM) Practices	Green purchasing	We prioritize suppliers with environmental certifications or sustainable practices.	Zhu & Sarkis; So Ra Park et al. (2022); Le et al. (2022)
Green Supply Chain Management (GSCM) Practices	Reverse logistics	We implement reverse logistics (e.g., recycling, reuse, remanufacturing).	Zhu & Sarkis; So Ra Park et al. (2022); Le et al. (2022)
Green Supply Chain Management (GSCM) Practices	Collaboration with stakeholders	We collaborate with suppliers and customers on green initiatives.	Zhu & Sarkis; So Ra Park et al. (2022); Le et al. (2022)

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Green Supply Chain Management (GSCM) Practices	Waste reduction	We actively monitor and reduce waste in the supply chain.	Zhu & Sarkis; So Ra Park et al. (2022); Le et al. (2022)
Digital Enablers	IoT adoption	We use IoT technologies (sensors, RFID) to monitor supply chain operations in real time.	Aamir et al. (2025)
Digital Enablers	Blockchain usage	We have adopted blockchain systems for traceability and transparency.	Aamir et al. (2025)
Digital Enablers	AI/Big Data	Our company applies AI or big data analytics to improve forecasting and decision-making.	Aamir et al. (2025)
Digital Enablers	Digital twins	We use digital twin models or simulations to test and improve supply chain processes.	Aamir et al. (2025)
Digital Enablers	Digital visibility	Digital technologies have enhanced visibility across our entire supply chain.	Aamir et al. (2025)
Stakeholder Pressure	Customer pressure	Our customers demand that we demonstrate sustainable supply chain practices.	Rajendran et al. (2025)
Stakeholder Pressure	NGO pressure	NGOs and activist groups exert pressure on our company to adopt responsible practices.	Rajendran et al. (2025)
Stakeholder Pressure	Investor/shareholder pressure	Investors and shareholders expect transparent ESG reporting.	Rajendran et al. (2025)
Stakeholder Pressure	Regulatory/community pressure	Regulators and communities require us to comply with sustainability standards.	Rajendran et al. (2025)
Stakeholder Pressure	Media pressure	Media and public opinion influence our adoption of green practices.	Rajendran et al. (2025)
Government/Policy Support	Regulatory enforcement	Government regulations strongly influence our environmental and supply chain practices.	Eltalhi et al. (2025)
Government/Policy Support	Financial incentives	We receive financial incentives (e.g., subsidies, tax rebates) for adopting green practices.	Eltalhi et al. (2025)
Government/Policy Support	Infrastructure support	Adequate infrastructure and digital platforms are provided to support supply chain digitalization.	Eltalhi et al. (2025)
Government/Policy Support	Policy clarity	Government policies regarding sustainability are clear and consistent.	Eltalhi et al. (2025)
Government/Policy Support	Training support	We benefit from government-backed training or awareness programs on green supply chains.	Eltalhi et al. (2025)
Supply Chain	Environmental	Our supply chain practices have	Cristiu et al. (2025);

Sustainability	outcomes	reduced our environmental impact (e.g., emissions, waste).	Aamir et al. (2025)
Supply Chain Sustainability	Economic outcomes	We have achieved cost savings and operational efficiency through sustainable practices.	Cristiu et al. (2025); Aamir et al. (2025)
Supply Chain Sustainability	Social outcomes	Our supply chain initiatives contribute to employee safety and well-being.	Cristiu et al. (2025); Aamir et al. (2025)
Supply Chain Sustainability	Reputation	Our practices improve the company's reputation among stakeholders.	Cristiu et al. (2025); Aamir et al. (2025)
Supply Chain Sustainability	Community contribution	We contribute to community development and social responsibility.	Cristiu et al. (2025); Aamir et al. (2025)
Supply Chain Resilience (SCSR)	Adaptability	Our supply chain can adapt quickly to unexpected changes or disruptions.	Cristiu et al. (2025); Aamir et al. (2025)
Supply Chain Resilience (SCSR)	Robustness	We are able to maintain operations during disruptions (robustness).	Cristiu et al. (2025); Aamir et al. (2025)
Supply Chain Resilience (SCSR)	Recovery speed	Our supply chain can recover quickly after a disruption.	Cristiu et al. (2025); Aamir et al. (2025)
Supply Chain Resilience (SCSR)	Flexibility	We can switch suppliers or logistics routes easily when needed.	Cristiu et al. (2025); Aamir et al. (2025)
Supply Chain Resilience (SCSR)	Continuity investment	We invest in flexible systems and resources to ensure continuity.	Cristiu et al. (2025); Aamir et al. (2025)

Data Analysis

The data analysis will be conducted in three sequential phases to ensure both the robustness of the measurement instrument and the validity of the structural model.

In the first phase, the measurement model will be validated using Confirmatory Factor Analysis (CFA) to assess the psychometric properties of the constructs. Reliability will be examined through Cronbach's α and composite reliability, with thresholds of 0.70 or higher considered acceptable (Eltalhi et al., 2025). Convergent validity will be tested using the Average Variance Extracted (AVE), where values of ≥0.50 indicate sufficient construct convergence (Rajendran et al., 2025). Discriminant validity will be established through the Fornell–Larcker criterion and Heterotrait–Monotrait (HTMT) ratio, ensuring that each construct is distinct from the others (Silvia et al., 2025).

The second phase involves structural model testing using Partial Least Squares Structural Equation Modeling (PLS-SEM). This method is appropriate for complex models that include multiple constructs, direct effects, and moderating effects, and has been widely applied in sustainability and supply chain studies (Amin et al., 2025; Cristiu et al., 2025). Key evaluation criteria will include path coefficients to determine the strength and significance of hypothesized relationships, and R^2 values to assess the explanatory power of the model. Moderating effects will be analyzed through interaction terms and slope analysis to test hypotheses H3–H6, reflecting the influence of stakeholder pressure and government/policy support on the main relationships.

Finally, the third phase will use bootstrapping procedures with 5,000 re-samples to test the statistical significance of all paths, including main and moderating effects. This non-parametric resampling technique provides robust estimates of standard errors, confidence intervals, and significance levels, enhancing the reliability of hypothesis testing (Balin et al., 2025). Additional robustness checks such as multi-group analysis (e.g., across industries or regions) and endogeneity diagnostics will be applied where necessary to ensure the stability of the findings (Sergiy, 2023).

FUTURE WORK AND CONCLUSION

Although this concept paper advances the integration of Green Supply Chain Management (GSCM) and digital transformation, significant opportunities remain for future research to refine, validate, and extend the proposed framework. Future studies should conduct empirical validation of the conceptual framework through quantitative methods such as structural equation modeling (SEM) or multi-level regression. While prior research has examined the individual impact of green practices on sustainability (Zijuan & Ai, 2024; Silvia et al., 2025) and digital technologies on supply chain efficiency (Antonio et al., 2024; Assiya et al., 2025), few have empirically tested their combined influence. Testing the framework across multiple industries will allow researchers to determine the statistical significance of relationships between independent variables (green practices and digital enablers) and dependent outcomes (resilience and sustainability performance) (Rajendran et al., 2025; Kamra et al., 2024).

The transition toward sustainable and resilient supply chains requires more than isolated adoption of either green practices or digital technologies. Instead, it necessitates their integration into a holistic strategy that simultaneously enhances operational efficiency, environmental stewardship, and social value creation. The findings of this paper, grounded in an extensive review of 50 recent studies, underscore that Green Supply Chain Management (GSCM) practices—such as eco-design, green purchasing, reverse logistics, and closed-loop systems—are significantly strengthened when complemented by digital enablers including artificial intelligence, blockchain, IoT, and digital twins (Amin et al., 2025; Kamra et al., 2024; Neha et al., 2023).

The proposed conceptual framework highlights this synergy, positioning GSCM and digital transformation as mutually reinforcing enablers of supply chain resilience. Recent scholarship emphasizes that digital transformation not only optimizes performance but also supports firms in mitigating disruptions and adapting dynamically to environmental and institutional changes (Ikram et al., 2025; Assiya et al., 2025). When integrated, these practices advance the triple bottom line by improving environmental outcomes, stimulating innovation-driven economic growth, and enhancing social legitimacy through stakeholder engagement (Rajendran et al., 2025; Garti et al., 2025).

Moreover, the framework contributes to theory by extending the Resource-Based View (RBV) to include complementary green and digital capabilities as strategic resources, while simultaneously advancing the Triple Bottom Line (TBL) by addressing the often-neglected social dimension of sustainability. From a managerial perspective, it offers practical pathways for firms in diverse industries—such as manufacturing, construction, energy, and food supply chains—to build future-ready operations that are efficient, adaptive, and socially responsible (Chaimaa & Mohammed Raja, 2022; Okeke, 2025).

In conclusion, the integration of GSCM and digital transformation represents not just an operational upgrade but a strategic imperative. This integrative approach offers both theoretical advancements and actionable guidance, paving the way for empirical validation in future research and for broader adoption in practice. By embedding sustainability and resilience at the core of supply chain strategies, firms can better prepare for global challenges while contributing to long-term sustainable development goals (Amin et al., 2025; Kamra et al., 2024).

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