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Environmentally Conscious Manufacturing as a Pathway to Supply Chain Resilience: The Roles of Green Collaboration and Environmental Governance

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ABSTRACT: There is a growing pressure in the environment and supply chain domain which has increased the importance of resilient and sustainable supply chains. This paper uses the Natural Resource-Based View and the Dynamic Capabilities Theory to discuss how Green Supply Chain Collaboration (GSC) and Organizational Environmental Governance (OEG) can foster Supply Chain Resilience (SCR), and Environmentally Conscious Manufacturing (ECM) holds a mediating role. The proposed model was estimated with partial least squares structural equation modeling (PLS-SEM) using survey data obtained on 270 respondents at the managerial level in manufacturing companies in Pakistan in the textile and apparel sectors, food processing, chemical, and light engineering sectors. The results indicate that GSC and OEG possess major direct impact on SCR, and positive impact on ECM, which is substantial. Further, ECM also contributes greatly to the supply chain resilience and partially mediates the associations between GSC and SCR, OEG and SCR, where the latter has a stronger mediating impact than the first. The findings support the significance of the fact that environmental cooperation and governance create the resilience mainly when it is converted into the practice of manufacturing. This research contributes to the resilience and sustainability literature by placing environmental conscious manufacturing as one of the key operational processes by which strategic environmental initiatives are converted into resilient supply chain performance giving managers and policymakers in the emerging manufacturing economies valuable insights.

KEYWORDS: Green Supply Chain Collaboration, Organizational Environmental Governance, Environmentally Conscious Manufacturing, Supply Chain Resilience

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Introduction

Over the past few years, supply chains have become more vulnerable to numerous disruptions due to the degradation of the environment, regulatory impacts, weather conditions, and market changes (Chen & Chen, 2017). These have increased the significance of supply chain resilience that is the capacity of supply chains to predict, alter, and recuperate disruptions whilst sustaining operations continuity (Opoku, 2025). With companies striving to enhance resilience, strategies focused on sustainability have become increasingly

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relevant, especially those that incorporate environmentally-focused approaches in the supply chain design and operational decision-making (Nazir et al., 2024).

The concept of green supply chain collaboration has become a strategic issue of critical concern as companies collaborate with their suppliers, customers and other stakeholders to overcome environmental problems (Javed et al., 2024). Through the exchange of environmental expertise, the alignment of sustainability objectives, and the joint development of environmentally friendly processes, the collaborative relations help the firms to increase the level of transparency, minimize environmental risks, and become more responsive to disruptions (Chin et al., 2015). Nevertheless, although collaboration offers external resources and capabilities, its success in improving supply chain resilience is mostly contingent on the success of these collaborative activities in being converted into internal operational practices.

Organizational environmental governance, together with collaboration, is central in the development of environmental orientations and strategic priorities of firms (Oyewo et al., 2025). Environmental governance refers to the official policies, management systems, surveillance, and executive devotion to enforce the adherence to environmental regulations and encourage sustainable operations (Esfahbodi et al., 2017). Effective governance systems help in providing strategic focus, resources, and accountability of environmental initiatives (Niesten et al., 2017). However, the mechanism of governance is not necessarily capable of strengthening resilience, unless it is incorporated into the manufacturing and operational processes.

Environmentally conscious manufacturing is a very important operation capability where environmental strategies are implemented at production level. It entails the use of cleaner technologies, waste minimization, energy saving processes, and environmental responsible production planning (Vangeri et al., 2024). Environmentally conscious manufacturing helps firms to more effectively withstand disruptions and adapt to changing environmental and market conditions by making them more efficient in their resource use, reducing operational vulnerabilities, and making their processes more flexible (Opoku, 2025). It is therefore an important connection between upper-level green strategies and resilience outcomes.

Although the topic of green supply chain practices and resilience has become increasingly popular, the current literature has mostly studied these constructs separately or in relation to each other. There has been very little focus on how green supply chain partnership and organizational environmental governance are mutually beneficial towards supply chain resilience. Specifically, the moderating effect of eco-friendly production has not been studied properly. This mediating mechanism is also important to understand because it describes how strategic environmental initiatives are implemented in tangible capabilities that make resilience.

This paper will fill this gap by creating a conceptual model and empirically testing it to establish environmentally conscious manufacturing as a key mediating factor between green supply chain collaboration and organizational environmental governance on the one hand and supply chain resilience on the other. With the combination of both strategic and operational thinking, the study offers a more complex insight into the process through which environmental collaboration and governance would translate into the resilient supply chain results. The model hypothesizes that even though green collaboration and governance can have a direct

impact on resilience, their effects are much more effective when they are directed at the resilience through environmentally friendly manufacturing operations.

Literature Review

Green Supply Chain Collaboration and Environmentally Conscious Manufacturing

Green supply chain collaboration is a term used to refer to the level to which companies have cooperative relationships with their supply chains in an effort to solve the environmental goals (Pan et al., 2020). This kind of collaboration includes the exchange of information regarding the environmental practices, coordination of the green initiatives, shared problem-solving regarding the environmental issues, and the unification of the sustainability goals across the organizational borders (Rashid & Rasheed, 2025). Instead of acting alone, companies are becoming more aware that the performance of the environment and sustainable manufacturing results rely on the joint performance of various players in the supply chain (Akhtar et al., 2023).

Environmental strategies manifest themselves operationally in the form of environmental conscious manufacturing. It includes the introduction of cleaner production technologies, waste and emission reduction, efficient use of energy and raw material, product design that is environmentally friendly and constant monitoring of the environmental impact on the manufacturing processes (Andalib Ardakani et al., 2022). Such practices involve not just internal commitments but also external support in terms of knowledge, resources and technological inputs which in many cases are external to the focal firm (Chin et al., 2015).

Green supply chain partnership is important in promoting the implementation of environmentally friendly manufacturing processes since it helps to gain access to supplemental resources and knowledge (Cunha et al., 2018). By working closely with suppliers, companies are able to acquire ecologically friendly raw materials, use cleaner inputs, and co-create sustainable processes of production (Camarinha-Matos et al., 2024). On the same note, cooperation with customers enables the manufacturers to be in a better position to know the expectations of the environment, patterns of use of the products as well as the end-of life factors and this informs the decisions based on environmentally responsible manufacturing (Pan et al., 2020). The adoption of these external contributions into the internal operations improves the capacity of the firms to adopt manufacturing practices that are environmentally friendly and viable.

Cooperation relationships also encourage learning and capacity building which is key to green conscious manufacturing (Camarinha-Matos et al., 2024; Lee, 2008). Joint training, joint environmental inspections, and joint problem-solving initiatives can assist firms to develop technical knowledge in the areas of pollution prevention, resource efficiency, and optimization of the processes (Javed et al., 2024). Such learning mechanisms with time minimize uncertainty that comes with implementation of new green technologies and production processes, hence minimizing the bottlenecks to environmental innovation in production systems (Niesten et al., 2017).

The collaborative supply chain relationship also brings about trust and long-term orientation, which would promote investments in manufacturing that are environmentally-friendly. This is because when firms feel that their supply chain relationships are stable and beneficial, they will be more eager to invest in green technologies and process innovations which can be rather costly in the initial few years (Rashid & Rasheed, 2025). Like shared environmental objectives and their collective performance monitoring, collaborative

governance mechanisms also establish accountability and enhance commitment to sustainable manufacturing practices (Lee, 2008). Consequently, the cooperation minimizes the risks of environmental investments and increases the chances of successful implementation.

Furthermore, the collaboration of green supply chains helps to meet the environmental standards and regulations since the firms can jointly address the regulatory demands. Common knowledge of regulatory modifications and best practice enables the firms to strategically modify their manufacturing operations in an environmentally friendly manner (Cunha et al., 2018). This overall responsiveness helps in ongoing development of environmentally friendly manufacturing activities and keeps pace with the changing environmental demands.

In general, the collaboration of green supply chain can be viewed as a key antecedent of the environmentally responsible manufacturing because it provides the resources, knowledge, coordination, and relational support required to successfully implement the environmental considerations in the manufacturing processes. By engaging in joint interactions with supply chain partners, the firms can be in a better position to convert environmental aspirations into tangible manufacturing operations that minimize environmental impact and increase operational sustainability. It is hypothesized on this basis that:

Hypothesis 1: Green supply chain collaboration positively influences environmentally conscious manufacturing.

Organizational Environmental Governance and Environmentally Conscious Manufacturing

Organizational environmental governance can be defined as the formal and informal networks, policies, managerial processes, and managerial leadership that firms use in directing, monitoring, and controlling their environmental efforts (Wang et al., 2024). It involves setting of environmental policies, responsibilities allocation, performance monitoring systems, managerial incentives and top management commitment to environmental goals. These mechanisms ensure that environmental governance offers strategic guidance and institutional evidence on how to incorporate the sustainability consideration in the operations of the organization (Niesten et al., 2017).

Green manufacturing involves a systematic coordination, long-term investment and regular managerial control. Without a friendly system of governance, the use of cleaner technologies, pollution prevention, energy-conserving processes, and an environmentally friendly planning of production are not maintainable (Oyewo et al., 2025). Environmental governance at the organizational environment has a grand role to play in facilitating such practices by entrenching environmental interests in decision-making and the normal course of operations. The manufacturing units tend to align their processes with the strategic goals of the environment when the environmental objectives are well stated at the governance level (Esfahbodi et al., 2017).

Policy formulation and enforcement is one of the main ways the organizational environmental governance affects the environmentally conscious manufacturing (Nazir et al., 2024). Environmental policies set up clear standards and expectations relating to use of resources, waste management, control of emissions and ensuring that there is compliance with environmental policies. These policies are used as guideline to manufacture managers in such a way that the environmental concern is put in orderly manner in the process

of production planning and implementation (Chen & Chen, 2017). The presence of powerful enforcement systems also helps in the regular implementation of environmentally friendly manufacturing procedures instead of considering them as a discretionary measure.

Effective environmental governance is also comprised of leadership commitment and managerial accountability. When the top management promotes the environmental programs, spends enough resources, and shares the strategic significance of the sustainability, the manufacturing units are more likely to embrace the environmental responsible practices (Opoku, 2025). The leadership commitment is an indication of environmental goal legitimacy and encouragement to employees to carry out environmentally sensitive actions. In addition, government systems with a defined responsibility of environmental performance increase the alignment of various departments, which helps to introduce environmental goals into the production cycle (Zahraee et al., 2018).

Environmental governance at the organizational level also affects the environmentally friendly manufacturing by affecting the organizational culture and routines (Islam et al., 2026). The processes used in governance like environmental training programs, performance evaluation systems and incentive structures are used to induce the employees to put environmental considerations in their routine activities (Chen & Chen, 2017). In the long run, these activities create a culture of environmental accountability in manufacturing processes and environmentally conscious manufacturing becomes a normal part of organizational operations as opposed to being a reaction to the external impacts.

Also, environmental governance encourages the use of environment friendly manufacturing through minimization of uncertainty and risk attributed to environmental investments. Governance structures focusing more on long-term sustainability offer stability and a strategic focus to allow firms to invest more in green technologies and innovations in processes with more confidence (Schöggl et al., 2016). The continuous improvement is also promoted through monitoring and reporting systems linked to environmental governance since it allows identifying inefficiencies and emerging chances to improve the environmental performance of manufacturing processes (Hong et al., 2018).

The environmental governance mechanisms also improve the coordination between the strategic and operational levels of the organization. Governance structures can be used to translate environmental objectives to operations by aligning corporate environmental strategies with manufacturing objectives (Sheng et al., 2023). This correspondence is especially significant in multifaceted manufacturing settings where the environmental enhancement involves not only the collaboration of cross-functions but also the unified application in numerous manufacturing units (Niesten et al., 2017).

All in all, the organizational environmental governance establishes the institutional requirements that are required to establish the effective application of the environmentally conscious manufacturing practices. Environmental governance allows firms to substantially incorporate environmental concerns in their production processes by offering strategic direction, leadership, accountability, and cultural reinforcement. As a result, companies that have better environmental governance systems are in a better position to build and maintain environmentally minded manufacturing capacities. Following this argument, it is hypothesized that:

Hypothesis 2: Organizational environmental governance positively influences environmentally conscious manufacturing.

Green Supply Chain Collaboration and Supply Chain Resilience

Green supply chain cooperation is not only effective in enhancing the environment but also affects the disruption and recovery capabilities of a firm (Singh et al., 2023). Resilience in the supply chain relies on coordination, visibility, and flexibility among interrelated partners, which are enhanced by working relationships (Negri et al., 2021). As companies work with their supply chain partners on environmental projects, they build mutual understanding, trust and communication networks that can be used at times of uncertainty or disruption (Pan et al., 2020).

Green projects help to improve the sharing of information regarding environmental risks, changes in regulations, and availability of resources (Akhtar et al., 2023). This transparency enhances the capability of firms to foresee disruptions and maneuver their operations to that extent. The joint planning and the coordinated decision-making also enable the firms to respond better to the occurrence of some unforeseen events through reallocation of resources, changing production schedules and the provision of contingency measures (Rashid & Rasheed, 2025). Consequently, cooperation enhances the adaptive and absorptive capabilities, which form the core of supply chain resilience.

Green supply chain collaboration also fosters relational stability and long-term partnerships which are very essential in resilience. Good working relationships minimize opportunistic behavior and encourage support in times of crisis (Andalib Ardakani et al., 2022). When collaborative relationships are established, partners have a higher likelihood of sharing scarce resources, having operational flexibility, and collectively resolving problems (Chin et al., 2015). It is these relational benefits that provide a greater overall strength of the supply chain against disruptions.

Moreover, joint environmental activities promote collective investment in environmental and regulatory shock-resilient sustainable technologies and processes. The joint effort in enhancing environmental performance enables supply chain partners to build capacity that increases efficiency, minimizes reliance on finite resources and operation continuity (Benkhati et al., 2023). These are the results that lead to the strength of the supply chain systems.

On the whole, green supply chain partnership enhances resilience of supply chains by increasing coordination, trust, flow of information and shared problem-solving capabilities. Companies that have been actively involved in joint environmental programs are in a better position to overcome and recuperate the disruption of their supply chains (Bag et al., 2018). It is suggested, therefore, that:

Hypothesis 3: Green supply chain collaboration positively influences supply chain resilience.

Organizational Environmental Governance and Supply Chain Resilience

The connection between the role of organizational environmental governance and supply chain resilience is that the environmental governance in firms determines the strategic orientation of companies to risk management, compliance, and long-term sustainability. Governance mechanisms offer a systematic system

in which firms detect, evaluate and react to environmental risks that can affect the supply chain activities (Priyadarshini et al., 2025). The incorporation of environmental aspects into strategic planning helps firms to improve their readiness to environmental and regulatory uncertainties (Rashid et al., 2024).

Effective environmental governance helps in proactive risk management through the establishment of monitoring systems and performance indicators that are used to monitor environmental vulnerability throughout the supply chain (Rashid et al., 2024). Such systems help companies anticipate any disruption in good time and take corrective measures before these disruptions get out of control. Consequently, the governance systems increase the ability of firms to foresee and avert possible risks, which is a fundamental aspect of supply chain resilience (Chari et al., 2023).

The concept of environmental governance is also a contributor to resilience in that they promote organizational flexibility and alignment. There are established governance arrangements that make it easier to make coordinated decisions in case of disruption, so that priorities related to environmental and operations are in line (Bag et al., 2018). Environmental goals commitment by leadership also enhances a long-term viewpoint, which allows companies to balance between short-term responses of disruption and long-term sustainability objectives (Chari et al., 2023).

Also, the governance systems increase the adherence to the environmental rules and standards, diminishing the chances of the regulatory interruptions that are likely to disrupt the supply chain processes. Companies that have strong environmental governance can easily adjust to changes in the regulations and continue with operations in the changing environmental conditions (Camarinha-Matos et al., 2024). Such regulatory flexibility is conducive to the resiliency and stability of supply chains. Organizational environmental governance through these mechanisms enhances the capacity of firms to withstand, adapt and recover after disruptions. Thus, it is hypothesized that:

Hypothesis 4: Organizational environmental governance positively influences supply chain resilience.

Environmentally Conscious Manufacturing and Supply Chain Resilience

Green manufacturing is at the center of improving the resilience of supply chains by modifying operations to ensure better efficacy, adaptability, and flexibility (Niesten et al., 2017). Manufacturing methods that focus on resource efficiency, waste reduction and cleaner production lessen reliance on limited inputs and reduce operation weaknesses. These attributes help firms to better absorb shocks and keep production uninterrupted in the case of disruptions (Nyamah et al., 2026).

Through the adoption of the environmentally friendly production methods, companies enhance the standardization of processes and technological advancement, which enhance the flexibility of their operations (Benkhati et al., 2023). Disruptions can be met by flex manufacturing systems that can quickly adjust production volumes, input materials and process configurations. This flexibility enhances the recovery and the ability to perform under unfavorable circumstances (Hong et al., 2018).

The manufacturing aspect that is environmentally conscious is also a contributing factor towards resilience by minimizing vulnerability to environmental and regulatory hazards (Sheng et al., 2023). The possibility of disruptions and radical quit of operations during compliance and resource waste are reduced due to cleaner

production processes and efficient use of resources (Islam et al., 2026). Moreover, socially responsible production improves the image and relations of companies with stakeholders that can serve as a complement in times of crisis (Oyewo et al., 2025).

Moreover, organizational learning and innovation are promoted by continuous improvement that is related to environmentally conscious manufacturing. Such capabilities can help firms respond in creative ways to disruptions and put in place adaptive responses that will increase long-term resilience (Esfahbodi et al., 2017). Consequently, the environmentally-aware production becomes a key functional competence that directly contributes to resiliency in supply chain. Considering this argument, it is hypothesized that:

Hypothesis 5: Environmentally conscious manufacturing positively influences supply chain resilience.

Environmentally Conscious Manufacturing Mediates Between GSC and SCR

Although the collaboration of the green supply chain is more resilient, it has the best effect when the collaboration is converted into the action of operation. Green manufacturing is one of the primary tools by which the joint environment projects can affect the resilience (Chari et al., 2023). Cooperation makes available shared knowledge, technologies and resources but these inputs have to be incorporated in manufacturing processes to produce a real resilience benefit (Rashid et al. , 2024).

By working together, companies obtain materials that are environmentally friendly, cleaner technologies, and process innovations that aid in manufacturing that is environmentally conscious. These practices enhance operational efficiency and flexibility hence enhancing resilience (Cunha et al., 2018). The benefits of collaboration can potentially be confined to the level of strategic alignment without such operational integration instead of leading to quantifiable resilience outcomes (Vangeri et al., 2024).

Green manufacturing is therefore a channel that transforms the collaborative environmental practices into functioning capabilities that further boost the strength of supply chains (Hong et al., 2018). Incorporating the collaborative knowledge into the manufacturing processes, companies enhance their response rate to disruption and performance maintenance. Thus, the following hypothesis is suggested:

Hypothesis 6: Environmentally conscious manufacturing mediates the relationship between green supply chain collaboration and supply chain resilience.

Environmentally Conscious Manufacturing Mediates Between OEG and SCR

The effects of organizational environmental governance on supply chain resilience involve the effects it has on the practices of its operations (Opoku, 2025). The governance mechanisms define strategic intent and the institutional backup of environmental initiatives, and the results of resilience are determined by the implementation of these initiatives at the manufacturing level (Oyewo et al., 2025). Green manufacturing is the fulfillment of environmental administrative approaches through the operations.

Environmental governance guides the resources, establishes standards of performance and defines accountability of environmental activities (Caniëls et al., 2016; Schöggl et al., 2016). The elements of governance facilitate the implementation of manufacturing processes, which are environmentally friendly and efficient in minimizing risks, flexibility, and efficiency of processes. In this way, the firms minimize vulnerabilities

and enhance their ability to overcome disruptions (Abu Seman et al., 2019).

Environmentally conscious manufacturing in this case, is a mediating variable that connects environmental governance to the outcomes of resilience (Azevedo et al., 2011). The manufacturing patterns are influenced by the governance structures and hence resilience ability of firms. Environmentally conscious manufacturing intensifies the strengthening impacts of environmental governance by rendering the intentions of governance structurally into action (Azevedo et al., 2011; Chen & Chen, 2017). It is hypothesized, therefore, that:

Hypothesis 7: Environmentally conscious manufacturing mediates the relationship between organizational environmental governance and supply chain resilience.

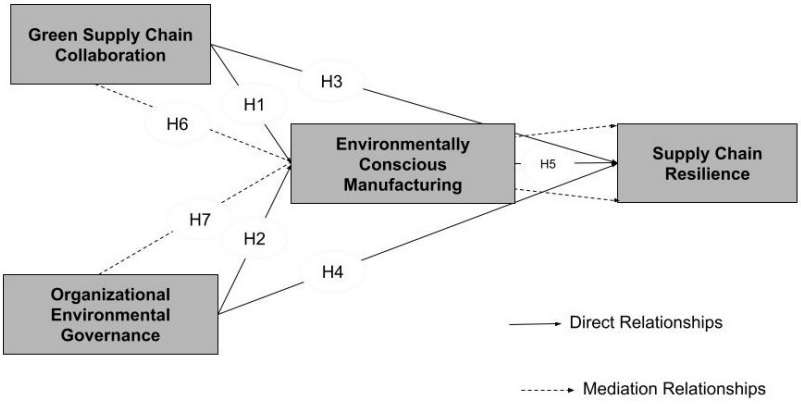
Theocratical and Conceptual Framework

This paper draws on the Natural Resource-Based View by (Hart, 1995) and Dynamic Capabilities Theory by (Teece, 2018) to elucidate how green supply chain alliance and governance of the organization environment can lead to the resiliency of the supply chain through sustainable manufacturing. Collectively, these theories explain how environmental strategies are converted into operational capabilities that help build resilience in a shifting supply chain environment. The Natural Resource-Based View underlines the fact that the environmental resources and capabilities could be the sources of the long-term competitive advantage. In this sense, green supply chain collaboration and organizational environmental governance can be discussed as the strategic environmental resources helping the firms to reach mutual knowledge, share sustainability goals, and formalize environmental priorities. As a strategic resource that is environmentally embedded, environmentally conscious manufacturing is an expression of an operational capability in which these resources are implemented. Green manufacturing helps companies to ensure a consistent and stable supply chain and improve the reliability of operations by creating a more efficient use of resources, lessening environmental threat, and lowering the chances of unexpected issues with the supply chain. The Dynamic Capabilities Theory (Teece, 2018) provides a supplement to this perspective, green supply chain partnership increases the capability of firms to feel the environmental threats and opportunities with enhanced problem-solving and information-sharing. Organizational environmental governance facilitates the capture and alignment of environmental initiatives through the alignment of the strategic intent and resource allocation. Ecofriendly production is the transformation aspect of the dynamic capabilities since the manufacturing process can be continually reconfigured to cater to the changing environmental and operational needs. Combining these views, this paper introduces environmentally conscious manufacturing as the key process in which strategic environmental activities are transformed into supply chain resilience.

The Natural Resource-Based View (Hart, 1995) is the perspective that describes the strategic worth of environmental cooperation and management whereas the Dynamic Capabilities Theory is the perspective that elucidates how these approaches are executed into adaptive manufacturing capacities. This is a combined concept that is a good theoretical base of the hypotheses that are being tested as well as the mediating effect of environmentally conscious manufacturing. Conceptual framework and relationship between variables are provided in Figure 1.

Figure 1

Conceptual Framework



Source: Author work

Methodology

The research design used in this study is quantitative and cross-sectional as it seeks to test the proposed conceptual model (Hair et al., 2025). The data were gathered in the form of a structured questionnaire from the respondents at the managerial level who worked in manufacturing companies in the textile and apparel, food processing, chemical and light engineering industries based in Multan and Faisalabad, Pakistan. These industries have been taken because of their high reliance on the coordination of supply chains, the rising environmental pressure, and the rise of the focus on sustainable production. The participants were supply chain, operations, and production managers and executives, who have a direct knowledge of manufacturing and supply chain activities of their respective firms. The sampling method used was purposive in nature to be able to make sure that respondents possessed specific expertise in regard to the study constructs (Nyimbili & Nyimbili, 2024). The number of valid responses obtained equals 270, which is enough to meet a minimum sample size with the partial least squares structural equation modeling. All the constructs were measured by multi-item scales that had been developed based on existing instruments in earlier studies as stated in Table 1 and measured on a 5-point Likert scale. All the participants were informed about their participation and gave informed consent before data collection. The questionnaire was also pre-tested to be clear and in context. The measurement and structural models were analyzed with partial least squares structural equation modelling as it is more appropriate when the model is complex and requires a mediation test (Hair et al., 2021). A short description of the respondents including demographic details are presented in Table 2.

Table 1

Measurement Instrument

Variable/Construct	No of Items	Adapted from
Green Supply Chain Collaboration	4	(Benzidia et al., 2021; Rashid et al., 2025)
Organizational Environmental Governance	5	(Namagembe et al., 2025)
Environmentally Conscious Manufacturing	8	(Bag et al., 2018; Rashid, Baloch, et al., 2024)
Supply Chain Resilience	4	(Bag et al., 2018; Rashid, Baloch, et al., 2024)

Source: Author's Adaptation based on existing literature

Demographic Profile of the Respondents

Table 2

Respondents Profile (n=270)

Characteristic	Percentage
Firm Size	
Small (less than 1000 Employees)	54%
Medium (1000-3000 Employees)	46%
Industry Type	
Food Processing	26%
Textile & Apparel	38%
Light Engineering	17%
Chemicals & Plastics	19%
Academic Qualification	
Bachelors	54%
Masters	46%
Years of Service	
2-5 Years	45%
6-9 Years	38%
10 Years and above	17%
Organizational Rank	
Supply Chain Manager	18%
Assistant Manager	30%
Supply chain Executive	52%

Source: Author's calculation based on responses received

Analyses

Path Analysis

The Table 3 demonstrates total, direct, and indirect impacts between the constructs of the study according to the structural model. The findings show that, there is the strong positive influence on Environmentally Conscious Manufacturing (ECM) (β = 0.715) and the moderate positive influence on Supply Chain Resilience (SCR) (β = 0.279) by Organizational Environmental Governance (OEG). Likewise, Green Supply Chain Collaboration (GSC) has the positive impact on both ECM ((β = 0.183) and SCR ((β = 0.188). Moreover, the positive effect of ECM alone on SCR (β = 0.398) is significant, which shows its importance in increasing resilience. The findings of the mediation indicate that ECM partially mediates relationships between GSC and SCR ((β = 0.073) and between OEG and SCR ((β = 0.284), the mediation effect of which is much higher in the case of OEG. In general, the consistency of the original sample with the sample means values, as well as rather low values of standard deviation, indicate the strength and soundness of the estimated effects (Hair et al., 2021).

Table 3

Path Analysis

Total, Effects	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)
GSC -> ECM	0.183	0.185	0.059
OEG -> ECM	0.715	0.714	0.056
GSC -> SCR	0.188	0.185	0.064

OEG -> SCR	0.279	0.285	0.089
ECM -> SCR	0.398	0.396	0.084
GSC -> ECM -> SCR	0.073	0.074	0.031
OEG -> ECM -> SCR	0.284	0.281	0.059

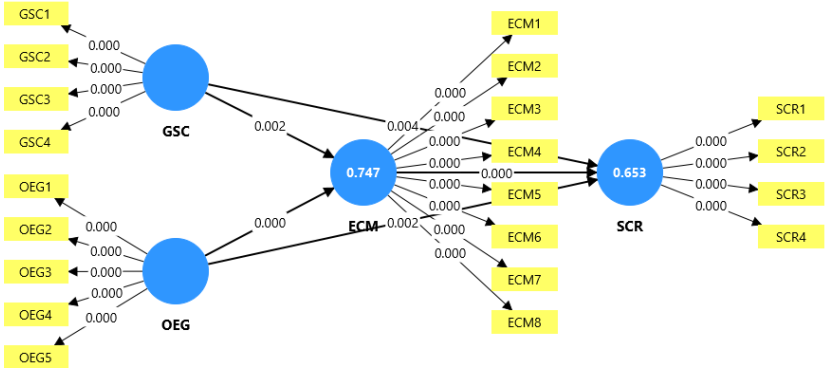
Source: SEM-PLS Output

Note: GSC; Green Supply Chain Collaboration, OEG; Organizational Environmental Governance, ECM; Environmentally Consciousness Manufacturing, SCR; Supply Chain Resilience

SEM-PLS MODELS

Figure 2

Structural Model



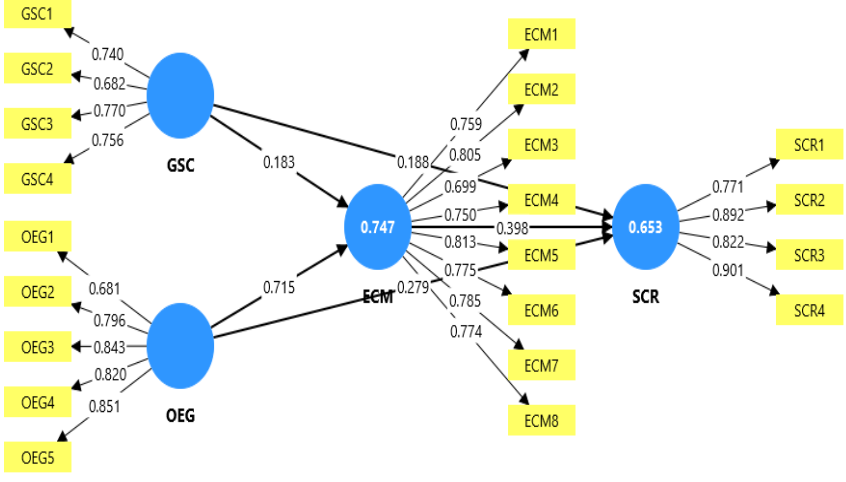
Source: SEM-PLS Output

Note: GSC; Green Supply Chain Collaboration, OEG; Organizational Environmental Governance, ECM; Environmentally Consciousness Manufacturing, SCR; Supply Chain Resilience

Measurement Model

Figure 2

Measurement Model



Source: SEM-PLS Output

Note: GSC; Green Supply Chain Collaboration, OEG; Organizational Environmental Governance, ECM; Environmentally Consciousness Manufacturing, SCR; Supply Chain Resilience

Construct Reliability & Validity

The table 4 reports the measurement model assessment, demonstrating adequate indicator reliability, internal consistency, and convergent validity for all constructs. All item factor loadings (FL) exceed the recommended threshold of 0.60 (Hair et al., 2025), while variance inflation factor (VIF) values remain below the critical level, indicating no multicollinearity concerns (Hair et al., 2025), shown by Figure 3. The average variance extracted (AVE) values are above 0.50 for all constructs, confirming convergent validity (Hair et al., 2018). Moreover, composite reliability (ρc) and Cronbach's alpha values exceed the minimum acceptable criteria, establishing strong internal consistency and reliability of the measurement scales. (Hair et al., 2017) The measurement items capture key dimensions of the study constructs: Green Supply Chain Collaboration items reflect inter-organizational coordination, information sharing, and joint environmental initiatives; Organizational Environmental Governance items assess formal policies, leadership commitment, and governance mechanisms supporting environmental responsibility; Environmentally Conscious Manufacturing items represent eco-friendly production practices, resource efficiency, and pollution prevention efforts; and Supply Chain Resilience items capture the firm's ability to anticipate, respond to, and recover from supply chain disruptions. Collectively, the results confirm that the items reliably and validly represent their respective latent constructs.

Table 4

Reliability & Validity

Constructs	Items	FL	VIF	(AVE)	(rho_c)	Cronbach's alpha
Green Supply Chain Collaboration	GSC1	0.740	1.361	0.54	0.82	0.72
	GSC2	0.682	1.311			
	GSC3	0.770	1.386			
	GSC4	0.756	1.379			
Organizational Environmental Governance	OEG1	0.681	1.445	0.64	0.90	0.85
	OEG2	0.796	1.871			
	OEG3	0.843	2.336			
	OEG4	0.820	2.127			
	OEG5	0.851	2.215			
Environmentally Conscious Manufacturing	ECM1	0.759	1.961	0.59	0.92	0.90
	ECM2	0.805	2.284			
	ECM3	0.699	1.842			
	ECM4	0.750	2.235			
	ECM5	0.813	2.424			
	ECM6	0.775	2.032			
	ECM7	0.785	2.218			
	ECM8	0.774	2.039			
Supply Chain Resilience	SCR1	0.771	1.644	0.72	0.91	0.86
	SCR2	0.892	2.036			
	SCR3	0.822	1.957			
	SCR4	0.901	2.301			

Source: SEM-PLS Output

Note: GSC; Green Supply Chain Collaboration, OEG; Organizational Environmental Governance, ECM; Environmentally Consciousness Manufacturing, SCR; Supply Chain Resilience

Discriminant Validity

I-Fornell-Larker Criterion

The discriminant validity test of the research model in terms of Fornell-Larcker criterion is provided in table 5. The diagonal values (highlighted with bold) are the square roots of the AVE of each construct- ECM, GSC, OEG and SCR and the off-diagonal values are the inter-construct correlations. The square root of AVE of each construct is greater than the correlations of the construct with the other constructs displayed, thus indicating that each latent variable has more variance in common with its indicators compared to the other constructs in the model (Fornell & Larcker, 1981b).

These findings, when related to the research model, prove that the antecedents of Green Supply Chain Collaboration and Organizational Environmental Governance are empirically different, Environmentally Conscious Manufacturing is a distinct mediating construct, and Supply Chain Resilience is a different outcome variable. The correlations between constructs are moderately high, as these correlations are characterized by the theorized correlations in the structural model, but the data are within acceptable levels, which means that constructs are interrelated, but at the same time, they are conceptually and empirically different. On the whole, the results confirm sufficient appropriateness of the used measurement model and justify the hypothesized relationships that were measured in the study (Fornell & Larcker, 1981a).

Table 5

Discriminant Validity

	ECM	GSC	OEG	SCR
ECM	0.771			
GSC	0.737	0.738		
OEG	0.857	0.775	0.801	
SCR	0.775	0.697	0.765	0.848

Source: SEM-PLS Output

Note: GSC; Green Supply Chain Collaboration, OEG; Organizational Environmental Governance, ECM; Environmentally Consciousness Manufacturing, SCR; Supply Chain Resilience

Co-efficient of Determination (R^2)

Table 6 reports the coefficient of determination (R^2) for the endogenous constructs in the SEM-PLS model, indicating the model's explanatory power, as also shown in Figure 2. The R^2 value for Environmentally Conscious Manufacturing (ECM) is 0.747 (adjusted R^2 = 0.745), suggesting that 74.7% of the variance in ECM is explained by its antecedent constructs, namely Green Supply Chain Collaboration and Organizational Environmental Governance. This reflects a substantial level of predictive accuracy for ECM. Similarly, the R^2 value for Supply Chain Resilience (SCR) is 0.653 (adjusted R^2 = 0.649), indicating that 65.3% of the variance in SCR is explained by GSC, OEG, and ECM in the research model. According to commonly accepted PLS-SEM guidelines, these R^2 values can be considered moderate to substantial, demonstrating that the proposed model has strong explanatory power in predicting environmentally conscious manufacturing practices and supply chain resilience (Hair et al., 2013).

Table 6

Co-efficient of Determination

	R-square	R-square adjusted
ECM	0.747	0.745
SCR	0.653	0.649

Source: SEM-PLS Output

Note: ECM; Environmentally Consciousness Manufacturing, SCR; Supply Chain Resilience

Hypothesis Testing

The table 7 presents the total, direct, and indirect effects of the hypothesized relationships in the structural model, along with their path coefficients (β), t-values, and p-values, obtained through PLS-SEM bootstrapping (Hair et al., 2011). The results provide empirical support for all proposed hypotheses.

First, Green Supply Chain Collaboration (GSC) → Environmentally Conscious Manufacturing (ECM) shows a positive and significant effect (β = 0.183, t = 3.086, p = 0.002), indicating that stronger collaboration among supply chain partners enhances environmentally conscious manufacturing practices (Niesten et al., 2017). Second, Organizational Environmental Governance (OEG) → ECM demonstrates a strong and highly significant relationship (β = 0.715, t = 12.670, p < 0.001), suggesting that robust environmental governance mechanisms play a critical role in promoting ECM (Cunha et al., 2018). Third, the direct effect of GSC → Supply Chain Resilience (SCR) is positive and significant (β = 0.188, t = 2.911, p = 0.018), confirming that collaborative green practices contribute directly to supply chain resilience (Chin et al., 2015). Fourth, OEG → SCR also exhibits a significant positive effect (β = 0.279, t = 3.128, p < 0.001), indicating that effective environmental governance strengthens the resilience of supply chains (Oyewo et al., 2025). Fifth, ECM → SCR is found to be positive and significant (β = 0.398, t = 4.748, p < 0.001), highlighting that environmentally conscious manufacturing practices substantially enhance supply chain resilience (Bag et al., 2018). Regarding mediation effects, ECM significantly mediates the relationship between GSC and SCR (β = 0.073, t = 2.365, p = 0.018), indicating a partial mediation effect. Similarly, ECM significantly mediates the relationship between OEG and SCR (β = 0.284, t = 4.785, p < 0.001), reflecting a strong mediating role. Overall, the findings confirm that both GSC and OEG influence supply chain resilience directly and indirectly through environmentally conscious manufacturing, providing full support for the proposed hypotheses.

Table 7

Hypothesis Testing

Total, Effects	Original sample (O)	Sample mean (M)	Standard Deviation (STDEV)	Path Coff. β	T-Value	P-Value	Result
GSC -> ECM	0.183	0.185	0.059	0.183	3.086	0.002	Accepted
OEG -> ECM	0.715	0.714	0.056	0.715	12.67	0.000	Accepted
GSC -> SCR	0.188	0.185	0.064	0.188	2.911	0.018	Accepted
OEG -> SCR	0.279	0.285	0.089	0.279	3.128	0.000	Accepted
ECM -> SCR	0.398	0.396	0.084	0.398	4.748	0.000	Accepted

GSC -> ECM -> SCR	0.073	0.074	0.031	0.073	2.365	0.018	Accepted
OEG -> ECM -> SCR	0.284	0.281	0.059	0.284	4.785	0.000	Accepted

Source: SEM-PLS Output

Note: GSC; Green Supply Chain Collaboration, OEG; Organizational Environmental Governance, ECM; Environmentally Consciousness Manufacturing, SCR; Supply Chain Resilience

Conclusion

This paper has explored how Green Supply Chain Collaboration (GSC) and Organizational Environmental Governance (OEG) increases Supply Chain Resilience (SCR) through Environmentally Conscious Manufacturing (ECM) that acts as an intermediary. The results based on the usage of PLS-SEM show that both GSC and OEG have a considerable impact on ECM that, in its turn, has a positive effect on SCR. Besides, GSC and OEG directly affect SCR to a great extent, which indicates their strategic relevance in enhancing resilient supply chains. The mediation analysis confirms that ECM does mediate the relationships between GSC and SCR and between OEG and SCR, but the mediating effect of the former is stronger as compared to the latter. On the whole, the model describes significant differences in ECM and SCR, which indicates the high validity and predictive value of the developed framework. All these findings underline that environmental collaboration and governance are more than compliance-based practices but strategic resources that can promote the manufacturing sustainability and resiliency outcomes.

Discussion

The results are solid empirical evidence of the proposed hypothesized relationships and as well as a continuation of previous studies on sustainability-based resilience. It is proposed that the high impact of GSC on ECM implies that collaborative programs like sharing of information, joint problem solving and coordinating with supply chain partners promote the adoption of manufacturing programs that are environmentally sensitive. Equally, the OEG powerful impact on ECM emphasizes the critical role of formal environmental policies, commitment among leaders and governmental framework in instilling sustainability in manufacturing processes. The significant positive impact of ECM on SCR shows that the environmentally responsible production activities increase the capability of a company to predict, absorb, and recover due to the supply chain disruption. Also, the immediate impacts of GSC and OEG on SCR suggest that collaborative and governance systems have independent contribution to resilience beyond their impacts through ECM. These mediation outcomes support the key position of ECM as a strategic channel where the environmental initiatives are converted to the resilience, in the instance of OEG, where the operational capabilities are heavily influenced by the governance-based practices.

Theoretical Implications

The study contributes some significant theory as it combines the Natural Resource-Based View (NRBV) and the Dynamic Capabilities Theory (DCT) in explaining the concept of supply chain resilience. By means of the NRBV, the results prove that the aforementioned environmental practices in GSC, OEG, and ECM are useful, rare, and hard-to-copy organizational sources that add to the competitive advantage by increasing resilience.

The powerful impact of OEG on ECM confirms the NRBV argument that suggestive environmental policies and governance systems could help firms to further utilize natural resources in the most efficient way without causing environmental damage. In the context of DCT, the findings show that ECM is a dynamic ability that will enable companies to detect risks in the environment, take sustainable opportunities, and redesign manufacturing process to respond to disruptions. The mediating aspect of ECM also fills the gap between NRBV and DCT by demonstrating how the environmentally oriented resources are converted to operational resilience by developing capabilities. Therefore, the research contributes to the theory through placing supply chain resilience as a consequence of environmentally alignment of strategic resources and dynamic capabilities.

Theoretical Implications

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Managerial Implications

The results have a number of practical implications to managers and policymakers. To begin with, the managers are expected to be active in building green supply chain partnership through long-term contracting, improving supply chain information sharing, and involving suppliers and customers in collective environmental programs as a green supply chain partnership building directly and indirectly enhances supply chain resilience. Second, they should incorporate environmental governance systems such as articulate environmental policies, accountability of leadership and monitoring performance mechanisms that would effectively lead to manufacturing activities that are environmentally conscious. Third, ECM is not only a compliance measure, but also a strategic capacity that improves the flexibility of operations, reducing risk, and resiliency to disruptions that managers should perceive. In the emerging markets and manufacturing-oriented industries, embracing environmental governance coupled with collaborative supply chain tactics can greatly enhance the capabilities to withstand market volatility, regulations as well as environmental shocks. These can also be reinforced by policymakers, who should promote environmental standards, incentives, and frameworks of inter firm collaboration.

Limitations and Future Research Directions

This study has a number of limitations that provide avenues that can be exploited in future studies despite the contributions made. First, it is important to note that the cross-sectional research design does not allow causal inference, future research can apply a longitudinal design, which will be able to trace the dynamic development of environmental practices and resilience over time. Second, the research is based on self-reported data that can be prone to the common method bias; subsequent research can consider the objective performance measures or the multi-source data. Third, the sample used is context specific and it may not always be generalizable, and proposed studies should replicate the model to be focused on different countries, industries and institutional settings. Moreover, other moderating factors like environmental uncertainty, digitalization, or organizational culture can be considered in further investigation since this would help to understand better the boundary conditions. Lastly, further elaborating the model by incorporating other theoretical perspectives, e.g. the institutional theory or stakeholder theory, could also contribute to a better comprehension of how the environmental strategies can be transformed into resilient and sustainable supply chains.

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