The Effect of Green Supply Chain Management Practices on Carbon Neutral Supply Chain Performance: The Mediating Role of Logistics Ecocentricity

Abstract

Purpose: Using the lens of the natural resource-based view (NRBV) theory, this study investigates the effect of green supply chain management (GSCM) practices such as green manufacturing (GM), eco-design (ED), green purchasing (GP), and investment recovery (IR) on the carbon-neutral supply chain (CNSC) performance of firms through the mediating influence of logistics ecocentricity (LE).

Design/methodology/approach: A conceptual framework that hypothesizes the relationship between GSCM practices, LE, and the CNSC performance of firms is developed. Key GSCM practices are then identified using experts' opinions. Furthermore, we collected responses from logistics companies to validate the conceptual framework using the PLS-SEM method.

Findings: Through this study, we found that GSCM practices significantly improve a firm's CNSC performance, and the relationships between GSCM practices and CNSC performance are positively mediated by LE.

Originality: This research provides valuable perspectives for managers and supply chain practitioners in their quest for sustainable and environmentally responsible supply chain operations through an extensive and novel analysis of the connection between GSCM practices, LE, and CNSC performance.

Practical Implications: The implication of the study suggests that logistics managers can benefit from the findings of this study to comprehend the impact of various GSCM techniques on LE and CNSC from the viewpoint of the NRBV paradigm.

Keywords: green supply chain management practices; carbon neutral supply chain; logistics ecocentricity; green manufacturing; investment recovery.

Quick value overview

Interesting because: This research utilizes the NRBV paradigm in a novel way to investigate the relationship between GSCM practices and the CNSC performance of companies. Specifically, the present study primarily focuses on GSCM practices like ED, GP, GM, and IR, and the way these practices mediate the relationship between LE and CNSC performance.

Theoretical value: The results of our research confirm that GSCM practices positively affect CNSC performance while LE plays a mediating role between GSCM practices and CNSC performance. Our fresh outlook on the problem helps to extend the current knowledge concerning environmentally responsible supply chain management and our understanding of the numerous interdependencies whereby the NRBV model is illustrated.

Practical value: This study is valuable to managers who are concerned with fostering an ecological supply chain. By strategically incorporating GSCM practices once the logistics manager understands their effects on LE and CNSC as part of the NRBV paradigm, sustainable practices can be deployed. Among the tangible outcomes are the optimisation of green production processes, the adoption of eco-friendly designs, and the promotion of green purchasing practices. These practices not only facilitate the accomplishment of sustainability objectives but also provide the firms that use them a competitive advantage and offer benefits to their stakeholders.

1. Introduction

Environmental pollution, climate change, and global warming have drawn much attention from academics in recent decades under the cover of nations' economic progress (Khan, 2019). Further, achieving carbon neutrality will be the world's most critical mission due to the seriousness and urgency of the climate situation (Zhang et al., 2022). In response to global climate urgency, firms concerned with their supply chains are implementing an increasing number of strategies to address environmental challenges (Sahoo & Vijayvargy, 2021). Firms can develop long-term values that are crucial for sustainability performance by integrating environmental aspects into their operations (Rasit et al., 2019). The logistics sector is one of the largest consumers of energy resources and a significant producer of CO_2 emissions (Rashidi & Cullinane, 2019). To address environmental issues, businesses lessen their adverse environmental effects by reducing GHG emissions and carbon footprints. As a result, the logistics sector faces increasing pressure to enhance its framework regarding carbon management, as it is required to boost the effectiveness of logistical operations. It will certainly quicken economic growth and lessen the damaging effects on the environment (Chien et al., 2021).

Although several countries have pledged to be carbon neutral by 2050, little research has been conducted at the corporate and supply chain (SC) levels (Zhang et al., 2022). A response to the ecological, social, and economic issues caused by SC activities is the incorporation of

green principles and practices into logistical operations (Vijayvargy et al., 2017). While very little research has been undertaken to determine the effects of logistical activities on environmental health, several studies have identified a link between logistical operations and economic development (Khan, 2019). The NRBV theory, which argues for a focus on the natural environment and contends that enterprises are bound not only by their internal resources but also by the accessibility and expense of external environmental sources, served as the theoretical framework through which this study was conducted.

Moreover, various scholars have provided evidence through studies based on carbon neutrality and firm performance (Zhang et al., 2022; Wang and Zhao, 2022). The employment of green supply chain management (GSCM) practices enhances environmental performance (Nureen et al., 2022). Therefore, to address environmental issues and maximize production effectiveness, GSCM practices have become widely used for the management of supply chains (Rasit et al., 2019). GSCM can be explained as "the integration of environmental considerations in SCM, including product design, the selection and outsourcing of materials, manufacturing processes, delivery of the final product to consumers, and managing the disposal of the product at the end of its life cycle" (Drohomeretski et al., 2014). Fang and Zhang (2018) suggest that GSCM practices have a positive association with the performance of the firm when taking its environmental, economic, and operational performance into account. Since ecological footprint reduction necessitates the elimination of hazardous substances, carbon footprint reduction is possible by boosting the accuracy of demand forecasts and investing in carbon reduction technology (Ji et al., 2014). However, Zhang et al. (2022) investigated the impacts of carbon neutrality on company performance and supply chain management. Their research complements the existing body of literature on environmental management and supply chain sustainability by providing insights into the drivers behind the commitment to carbon neutrality via various case studies of early adopters.

Furthermore, current research endeavors exhibit a greater emphasis on comprehensive GSCM practices as opposed to examining the effects of GSCM practices, such as eco-design (ED) and its associated aspects, on the overall efficacy of GSCM. Moreover, empirical research on GSCM practices in the context of developing countries, such as India, is limited (Nureen et al., 2022), given that GSCM encompasses a multitude of initiatives and practices (Ferreira et al., 2023). Moshood et al. (2021) indicate that despite being one of the most critical issues to be resolved in the SC, the low-carbon SC network has received relatively little attention. Cousins et al. (2019) suggest that ecocentricity has not received substantial empirical

investigation, which further restricts its progress and presents an opportunity for further study. Hence, this research endeavors to address this knowledge deficit by presenting robust evidence concerning the impact of GSCM practices on the efficacy of carbon-neutral supply chains (CNSC) and logistics ecocentricity (LE). The authors are unaware of any prior research that has examined the relationship between GSCM practices and CNSC performance via the mediating effect of logistics ecocentricity. This study therefore seeks to respond to the subsequent research questions:

RQ1: What is the impact of GSCM practices ("green manufacturing (GM), ED, green purchasing (GP), and investment recovery (IR)") on the CNSC performance of firms?

RQ2: How can LE influence the GSCM practices and CNSC performance relationship?

Logistics performance is seen as a key factor in supply chain efficiency and carbon neutrality. This study applies the mediation effect method to explore the influence of individual GSCM techniques (for instance, "GM, GP, ED, and IR") and LE on CNSC performance. Our research expands upon the results of previous recent studies, Agyabeng-Mensah et al. (2021) and Cousins et al. (2019). The moderating effect approach is used in Cousins et al.'s (2019) study to investigate the influences of SC ecocentricity and SC traceability on the nexus between GSCM practices and operational cost performance and environmental performance. Alternatively, the study conducted by Agyabeng-Mensah et al. (2021) identified the effect of green logistics management practices on environmental sustainability, social sustainability, and business performance with the mediating effect of LE and supply chain traceability. Therefore, to analyze the effect of the constructs on CNSC performance, the mediating effect technique is offered through this study.

2. Literature review

2.1 Natural Resource-based View

Hart (1995) introduced the NRBV theory to include the importance of the firm's external natural ecosystem as a source. The resource-based view (RBV) promotes mobilizing internal resources to improve a firm's competitive position (Al-Khatib, 2023). However, according to the NRBV, businesses are bound by both internal and external resources, so implementing environmentally friendly practices can give businesses long-term competitive benefits (Hart & Dowell, 2011). According to Hart (1995), the three interconnected environmental techniques

that make up the NRBV foundation are product stewardship, pollution prevention, and sustainable development. The elements of the NRBV and the activities of GSCM, such as eco-design, green purchasing, and investment recovery, are interrelated with one another, as suggested by El Ayoubi and Radmehr (2023). Consequently, this study was carried out to determine how GSCM procedures affected CNSC performance through the lens of the NRBV.

2.2 Carbon Neutral Supply Chain

The COP26 conference, which ended in late 2021, reemphasized the necessity and urged organizations and SCs to work together to moderate carbon emissions to alleviate the threats to the world's climate. It has advocated for increasing the "integrity of the private sector net-zero plan" to ensure responsibility in decarbonization (Zhang et al., 2022). According to Caro et al. (2011), "a supply chain in which all firms exert their first-best emissions reduction effort levels is "carbon optimal", while a supply chain which offsets all emissions is "carbon neutral"." These efforts of the SC to achieve carbon neutrality include investment in decarbonization strategies, cooperation among supply chain players or suppliers, transparency in the SC activities, digitalization and data management in the SC, etc.

In modern supply chains (SCs), resilience and carbon neutrality are two key objectives (Wang and Zhao, 2022). As a result, several top global companies have begun to make plans to be carbon-neutral in their operations and supply networks (Zhang et al., 2022). A green and low-carbon organization, let alone a green and low-carbon supply chain, faces enormous hurdles, according to Sundarakani et al. (2010). As a result, more effort has been put into developing creative supply chain solutions to reduce CO_2. Several industries and SCs are now dealing with this difficulty. In this regard, Xu et al. (2023) provided a systematic analysis of the most recent academic research on low-carbon supply chain management (SCM) and the function of technologies and argued that comprehensive low-carbon production is becoming increasingly accepted. In addition, Jin (2021) offered performance evaluation metrics for carbon neutralization considered by GSCM, such as eco-friendly consumption, eco-friendly production, and eco-friendly supplier chain management. SCs have a rational objective for reduced emissions, as firms set carbon-negative or carbon-neutral goals, especially via efficient manufacturing and automobile electrification in logistics (Ivanova et al., 2021). Therefore, this study focused on several green SC practices that can impact the performance of CNSCs.

2.3 Green Manufacturing

Manufacturing encourages economic expansion while simultaneously contributing significantly to GHG emissions (Qu et al., 2020). Additionally, manufacturing's high-investment, energy-intensive, and environmentally damaging economic advancements have an unfavorable effect on the environment (Shao et al., 2019). Green SCs have taken the lead as the standard course for future development because traditional SCs have found it challenging to adapt to the low-carbon competitive climate. Traditional SCs neglect system-wide cooperative emission reduction in favor of individual CO_2 reduction (Liu et al., 2022).

According to Haleem et al. (2022), green manufacturing is "a method of manufacturing that reduces the consequences of environmental disasters. It is also known as green production and aims to upgrade any outmoded modes of production and opts for more sustainable manufacturing solutions that decrease waste generation instead". GM is sometimes known as lean and green, and it is a technique for examining and improving production processes (Nagle, 2022). Through careful consideration of both products and processes, this technique reduces pollution and waste. Green production reduces wasteful spending, augments public perception, and promotes innovation. GM comprises making investments in improving the manufacturing process instead of controlling technology, encouraging recycling, substituting renewable resources with finite ones, and allowing businesses to choose whether to create or purchase the product (Maruthi & Rashmi, 2015).

Failure to solve environmental concerns could also make it impossible to survive, given how slim existing profit margins are (Shete et al., 2020). To manage GM, technology's role must be further increased. This covers different aspects, including eco-friendly design as well as the elimination and recycling of waste, pollutants, and energy (Seth et al., 2018). Previous studies conducted by Andersen (2021) and Hartmann & Germain (2015) identify the likelihood that a company's capacity for innovation in the pursuit of green development will be connected with its financial and environmental success. Similarly, prior studies have highlighted the substantial benefits of the green innovation strategy, including increased performance and reflected in green manufacturing capability that enables decreased production costs, energy usage, and material recycling, ultimately resulting in enhanced organizational competence (Wang et al., 2022).

According to a study's findings, businesses' sustainability performance can be greatly improved with a rise in green manufacturing (Ahmad et al., 2022). To achieve sustainable

performance across all business operations, academics have praised integrating GM into production processes and recommended that GM can play a significant role in growth considering sustainability performance (Cankaya and Sezen, 2019). Therefore, the following hypothesis is proposed:

H1: GM has a significant positive influence on CNSC performance.

2.4 Eco Design

The guidelines for effective ED, according to Luttropp and Lagerstedt (2006), include avoiding the use of toxic materials, making an effort to reduce product weight, minimizing the use of energy and resources during production, transportation, and use, providing repairs and updates to products with dependent systems, designing products that are easily repairable, recyclable, and collapsible, and encouraging long product lives for those with significant environmental impacts.

Given that transportation is one of the major supply chains' environmental pollution sources (Gurtu et al., 2017), properly designed logistics systems will undoubtedly and significantly improve sustainable supply chain management (SSCM) performance (Ji et al., 2016). Koh et al. (2023) asserted that to accomplish carbon neutrality through SCs, it is crucial to put in place a comprehensive approach that considers every stage of a product or service's lifecycle, from the sourcing of raw materials to end-of-life disposal and circular economy practices. Past literature indicates that EDs enhance the effectiveness of sustainable SCs (Thamsatitdej et al., 2017). Adikaram and Amarasena (2023) reported that ED practices positively influence the environmental performance of firms. Therefore, we hypothesize:

H2: ED has a significant positive influence on CNSC performance.

2.5 Green Purchasing

Academics and practitioners value GSCM as a promising strategy to enhance a company's environmental performance (Tseng et al., 2019). According to Blome et al. (2014), GP is the strategy of putting into practice procurement procedures that take the environment's impact into account. According to Zsidisin and Siferd (2001), it is critical to re-evaluate the problems as well as the standards for choosing and obtaining materials and assessing the progress of suppliers.

Collaboration with suppliers is a crucial component of GP. According to Raut et al. (2019), to achieve significant sustainability performance, suppliers and vendors must be informed of environmental standards and sustainability goals in addition to business information. To achieve GSCM, Liu et al. (2020) reported that big data analytics (BDA) removes information asynchronization and enhances information exchange among suppliers, which supports environmental collaboration. Esfahbodi et al. (2023) reported that GP positively influences the environmental performance of firms. Amjad et al. (2022) conducted their study to identify the impact of GSCM practices on firm performance and sustainable development and found that GP has a positive significant relationship with the environmental performance of firms. Through understanding the role of GP in influencing the environmental performance of the firm, the following hypothesis is proposed:

H3: Green purchasing has a significant positive influence on CNSC performance.

2.6 Investment Recovery

According to Knap (1980), investment recovery (IR) is "the management of the reuse and disposal of the surplus materials equipment and products which are generated by an enterprise in the pursuance of its primary business(es)". Zhu and Sarkis (2004) indicate that IR and ED are important parts of GSCM. IR involves the sale of surplus goods and stocks, scrap and used materials, and surplus capital equipment (Bhardwaj, 2016). In essence, IR may benefit environmental health (El Ayoubi and Radmehr, 2023). Assumpço et al. (2019) asserted that controlling and managing stock levels through IR could lower costs and decrease the wasteful production of resources and goods. Reverse logistics that involves the reuse of materials and products requires IR (Bokade and Raut, 2013).

A sample of 272 textile businesses in Pakistan shows that IR considerably mediates the connection between a firm's overall performance and intraorganizational green practices (Jawaad and Zafar, 2020). Amjad et al. (2022) conducted their study to identify the impact of GSCM practices on firm performance and sustainable development and established that IR has a positive significant relationship with the environmental performance of firms. In addition, according to the studies of (Cankaya and Sezen, 2019; Esfahbodi et al., 2023), IR has a positive significant relationship with the environmental performance of the firm. Therefore, the following hypothesis is proposed:

H4: IR has a significant positive influence on CNSC performance.

2.7 Logistics Eco-centricity

Supply chain logistics play a significant role in environmental damage and wasteful resource utilization (Zaman and Shamsuddin, 2017). Logistic eco-centricity (LE) is a company's propensity to interact with traditional and nontraditional external stakeholders, work together, and learn from them to enhance logistical procedures and meet sustainability goals (Pagell and Wu, 2009). To become carbon neutral, suppliers and partners must work together. Companies should collaborate with their suppliers to find opportunities to cut emissions, adopt sustainable procedures, and exchange best practices (Gong et al., 2018).

More efficient implementation of GSCM practices, such as green logistics management practices, is encouraged by LE, which suggests that companies learn from their competitors, nongovernmental organizations (NGOs), and the organizations with whom they work. This will facilitate their idea-gathering and ability to think creatively (Cousins et al., 2019). This knowledge might help the company project the image proposed by the NRBV theory strategy of sustainable development (Hart, 1995).

Discussions with community representatives who are more sympathetic to societal environmental issues are encouraged by LE. According to Johnson et al. (2018), operating in an ecosystem where companies deal with environmental stakeholders might give businesses the chance to learn innovative things about environmentally friendly methods of material packaging and transportation. To progress in social sustainability and environmental sustainability, businesses may find it helpful to incorporate suitable environmental practices into logistics procedures (Nkrumah et al., 2020). This suggests that LE may speed up the adoption of environmentally friendly logistics management techniques to accomplish a notable boost in sustainability performance. Theoretical and conceptual attention has been given to eco-centricity (Johnston and Linton, 2000), according to a number of academics, but little empirical treatment has been given to it (Cousins et al., 2019). Agyabeng-Mensah et al. (2021) provided evidence that green logistics management practices have a significant positive impact on LE, which further influences environmental and social sustainability and firm performance. In light of the findings of Liu et al. (2023), enhancing logistics performance can enhance environmental quality, and introducing green practices within the logistics industry may contribute to further enhancing the environment and reducing carbon emissions. Therefore, this study attempts to

explore the effect of GSCM practices (such as ED, GM, GP, and IR) on LE. On the other hand, Cousins et al. (2019) examined the moderating impact of supply chain ecocentricity on the relationship between GSCM practices and the environmental performance of a firm. Similarly, Siregar and Pinagara (2022) identified the moderating influence of supply chain eco-centricity on the relationship between GSCM practices and the operational cost and environmental performance of a firm, and they found that supply chain ecocentricity moderates the relationship between GSCM practices and environmental performance and operational costs, even when there is a low level of ecocentricity. These results are supported by Epoh and Mafini (2018), who found that the involvement of external parties could improve the environmental performance of a firm. Through a thorough review of the literature, it was found that there exists a lack of empirical evidence on logistic ecocentricity with regard to CNSC performance. Therefore, this study uses LE as a mediator that could support eco-friendly behaviors and help supply chains work in a carbon-neutral manner. Based on the above discussion, the following hypotheses are proposed:

H5: Green manufacturing has a significant positive influence on LE.

H6: Eco-design has a significant positive influence on LE.

H7: GP has a significant positive influence on LE.

H8: IR has a significant positive influence on LE.

H9: LE has a significant positive influence on CNSC performance.

H10: LE significantly mediates the relationship between GM and CNSC performance.

H11: LE significantly mediates the relationship between ED and CNSC performance.

H12: LE significantly mediates the relationship between GP and CNSC performance.

H13: LE significantly mediates the relationship between IR and CNSC performance.

Based on the previously discussed literature and formulation of the hypotheses, a conceptual research framework is developed and presented in Figure 1.
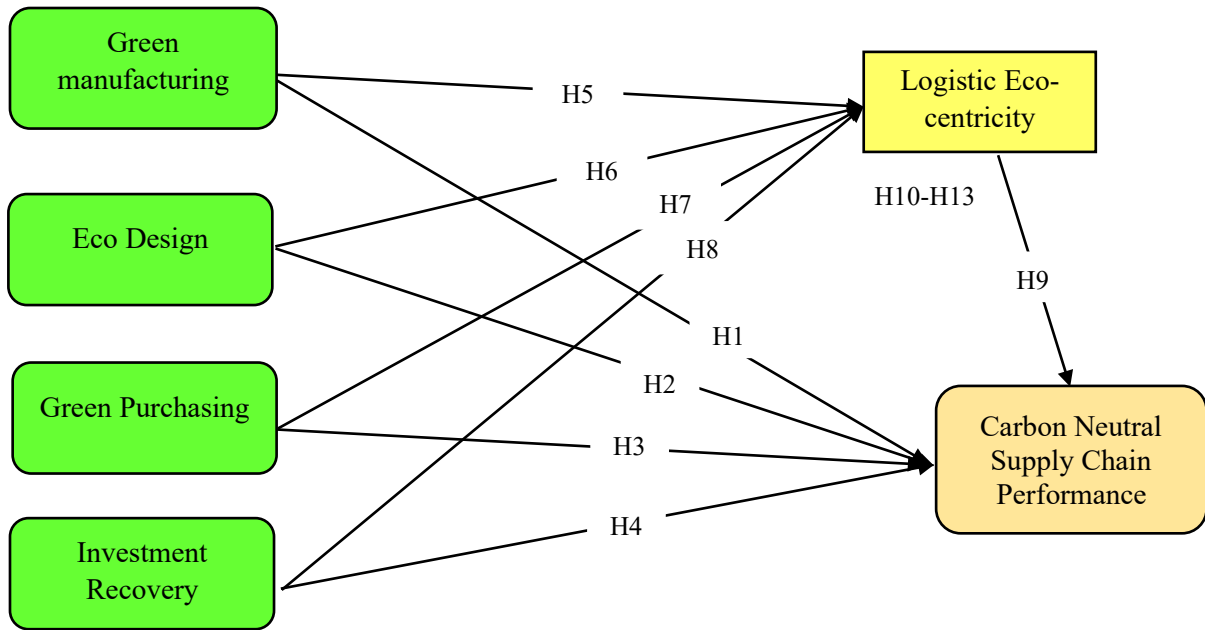
Figure 1: Conceptual framework

3. Research methodology

3.1 Research setting, hypotheses authentication, and questionnaire construction

The stages that the present research went through are depicted in Figure 2. The study is centered on extensive interviews with GSCM sustainability experts. The first part of the interview asked the experts, from LE's and CNSC's perspectives, about different GSCM practices, including GM, GP, ED, and IR. The interviews contributed to understanding how GM, GP, ED, and IR would help to enhance LE and how LE would influence CNSC in a spillover effect. The second part of the study included asking the experts to test the study's hypotheses about the importance of GM, GP, ED, and IR when acquiring and implementing LE successfully leading to CNSC. The experts were convinced that the GSCM practices could help to make LE work and bring it a step closer to CNSC. Furthermore, we asked the experts their position on the hypotheses formulated as they were supported by the previous literature. The experts were finally asked to give feedback concerning the clarity of the questions and the difficulties they had in answering them after responding to the preliminary questionnaire that the study used for the surveys. We collected the necessary data from the relevant organisations relevant to the study's constructs and analyzed them.
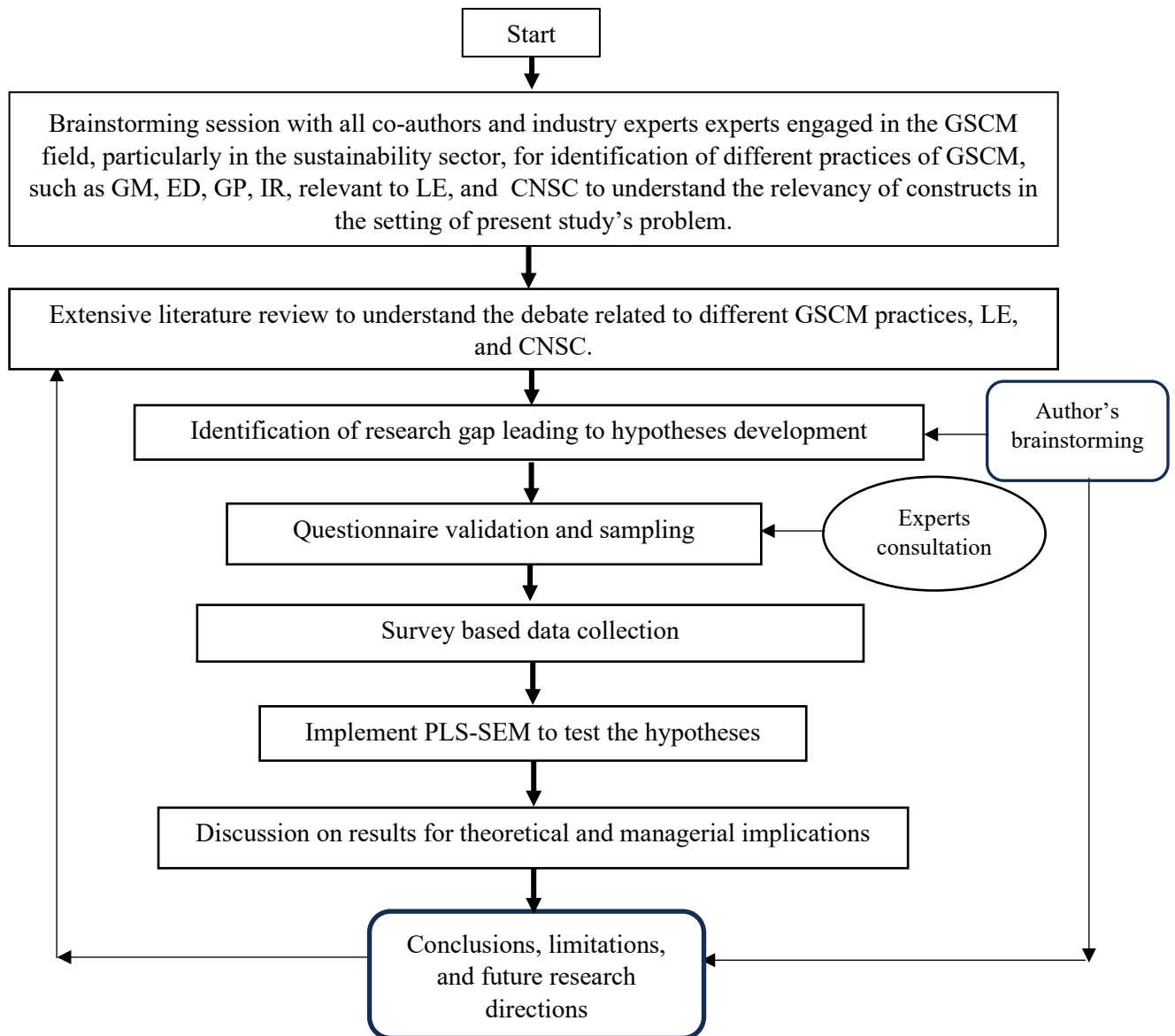
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│ Brainstorming session with all co-authors and industry experts experts engaged in  │
│ the GSCM field, particularly in the sustainability sector, for identification of    │
│ different practices of GSCM, such as GM, ED, GP, IR, relevant to LE, and  CNSC to    │
│ understand the relevancy of constructs in the setting of present study's problem.   │
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│ Extensive literature review to understand the debate related to different GSCM      │
│ practices, LE, and CNSC.                                                            │
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Figure 2: Research flow

3.2 Research survey

First, we postulated the conceptual framework, which was developed from the literature review and authors' brainstorming. After this, the framework was used as a basis for this research. In doing so, we developed the questionnaire to define and validate the constructs, i.e. GP, GGM, ED, IR, LE, and CNSC from the literature. Furthermore, for the alignment and definition of these constructs from the questionnaire, we contacted GSCM experts, especially in the sustainability area, who were familiar with these GSCM practices as well as LE and CNSC concepts. Their expertise helped to finalize the 24 questionnaire items for the validation of constructs, see Table 1. During the finalization of the questionnaire, the experts were given feedback related to the selection of the right items adapted from the literature for defining the

constructs, so that the most relevant items could be used to define the constructs. Also, the experts helped to rephrase the items for easy understanding. The experts' recommendations helped the 4 items of each GM, GP, ED, IR, LE, and CNSC. Furthermore, we assigned codes to all the questionnaire items for better presentation, see Table 1. We collected data from a broad spectrum of companies, particularly Indian logistics firms, in a growing market to ensure that our findings were more generalizable and avoided bias. The data was collected in two timelines, i.e. August 2022 to October 2022, and November 2022 to January 2023, see Table 2. In India, it is difficult to collect data, especially without any professional relationships within the sector. Therefore, we used different social media platforms to contact the experts. The chain-referring method was used to obtain the network structure while keeping the pertinent data intact (Kolaczyk, 2009). This is an iterative procedure that consists of collecting data from the vertices connected to the vertices that were obtained during the previous iteration (Chan, 2020). Moreover, it is a cost-efficient way of collecting samples. Academic researchers can collect a large amount of data in a cost-efficient way by gathering data from the nodes connected to the samples obtained during the previous iteration. We used the chain-referring strategy to contact logistics companies that were interested and informed them of the pointers of GSCM practices and their desire to achieve CNSC. We contacted businesses, and then, the employees were contacted through random sampling. We used random sampling to ensure that each sample had an equal possibility of being chosen. With the use of this strategy, we obtained a sample that was "statistically" true of the population. We reached the respondents through the use of random sampling to obtain their opinions. The respondents were involved in transformation sustainability efforts at different levels of their company's hierarchy. The participants were familiar with different GSMC practices that are needed to implement for improving LE and CNSC. Therefore, we can conclude that these participants aligned with the goals of the present study. After following this thorough process, 224 responses were collected, see Table 2.

Table 1: Questionnaire construction

Constructs	Literature resource	Finalized items after correction/acceptance	Item codings
Carbon Neutral Supply Chain (CNSC)	Zhang et al. (2022)	Do you think your firm invests in decarbonization?	CNSC1
		Do you believe that carbon neutrality in the supply chain can be driven by the leadership of a single company?	CNSC2
		Do you believe that participants in the supply chain get information and best practices for decarbonization from other sources?	CNSC3

		Do you believe in the digitization of the supply chain, which allows data management for decarbonization and facilitates the integration of multitier supply chains?	CNSC4
Green Manufacturing (GM)	Machingura et al. (2023)	Our business sees waste products as an asset.	GM1
		The environmental effect of the goods is monitored throughout all phases.	GM2
		The environmental inspection is conducted to assess the internal management practices of suppliers.	GM3
		We strongly encourage our supplier(s) to undertake environmental initiatives.	GM4
Eco Design (ED)	Adikaram and Amarasena (2023)	The products are designed with the intention of minimizing both material and energy use.	ED1
		Our goods are designed with the 4 R's ("reduce, recycle, recover, and reuse") in mind.	ED2
		The goods are designed with the goal of reducing or eliminating the need for potentially harmful materials.	ED3
		We design waste minimization operations.	ED4
Green Purchasing (GP)	Zhu et al. (2013); Laosirihongthong et al. (2013)	The environmental criteria for acquired components are included in the design specifications we supply to our vendors.	GP1
		We choose goods that are environmentally friendly, such as those made from recycled materials or that can be reused.	GP2
		We utilize a questionnaire to learn about our suppliers' ecological practices, procedures, and performance.	GP3
		Our suppliers are obligated to establish and keep up an "environmental management system" (EMS).	GP4
Investment Recovery (IR)	Zhu et al. (2013)	We implement a system of recycling for used and faulty products.	IR1
		Materials and goods that have reached the end of their useful lives are collected and recycled by our firm.	IR2
		We sell waste and old materials.	IR3
		We sell surplus capital equipment.	IR4
Logistic Eco-Centricity (LE)	Agyabeng-Mensah et al. (2021)	To promote sustainability in logistics, we encourage patronage of green logistics management practices.	LE1
		We use the feedback from authorities to develop green logistics management practices and regulations that boost economic, social, and environmental well-being.	LE2
		We work with nongovernment organizations (NGOs) and other nonprofits to find sustainable approaches to logistics' environmental, social, and economic challenges.	LE3
		The sustainability of logistics is improved by the incorporation of external input into green logistics practices.	LE4

Furthermore, using a *t*-test, we identified the nonresponse bias. We used t-tests and no statistically significant differences were found ($p > 0.05$) between the initial and later respondents on the means of any of the theoretical constructs (Armstrong and Overton, 1977). Table 2 offers a summary of the details of the sample characteristics of this study's participants.

Table 2: Sample characteristics

Subject	August 2022 to October 2022	November 2022 to January 2023	Total response
Respondent designation			
Logistics manager	35	53	39.28%
Logistics coordinator	20	19	17.41%
Supply chain analyst	21	36	25.45%
Warehouse manager	25	15	17.86%
Total employees in different hubs			
0-100	10	13	10.27%
101-250	37	30	29.91%
251-500	28	51	35.27%
501-1000	20	15	15.63%
Above 1000	6	14	8.92%
Yearly revenue (million USD ($))			
Below 5	7	4	4.91%
5-10	23	26	21.88%
10-25	38	55	41.52%
Above 25	33	38	31.69%
Qualification			
Graduation	62	65	56.70%
Post-graduation	24	39	28.13%
Others	15	19	15.17%
Experience (in years)			
Below 5	5	3	3.57%
5-10	20	44	28.57%
11-20	60	37	43.30%
Above 20	16	39	24.56%

4. Analysis and Results

We evaluated our conceptual framework by looking at cross-sectional data with the use of SmartPLS 4.0 software, which is based on the variance in structural equation modeling. Despite recent objections, we studied the views of certain researchers, and after doing so, we concluded that the variance-based PLS-SEM approach would be the most effective way to authenticate the conceptual framework (Hair et al., 2020). PLS-SEM is appealing because it adheres to a causal-predictive paradigm. This technique emphasizes testing the predictive ability of a model that has been meticulously constructed based on theory and logic (Chin et al., 2020). Furthermore, PLS-SEM allows researchers to assess extremely intricate models

including several constructs and indicator variables, while demanding much lower sample sizes in comparison to factor-based SEM approaches. PLS-SEM provides a great degree of flexibility in estimating complex interactions between different components of a model, such as higher-order models (Sarstedt et al., 2019). The current study used reflective constructs to authenticate the framework. Reflective measurement approaches establish direct connections between the concept and the indicators, seeing the indicators as imperfect representations of the underlying construct (Bollen 1989). When discussing reflective constructs, it is important to consider four key criteria: indicator reliability, internal consistency, convergent validity, and discriminant validity (Sarstedt et al., 2021), which are discussed in the later part.

4.1 Common Method Bias (CMB)

In the setting of PLS-SEM, common method bias (CMB) is a phenomenon that results from the measuring approach used in SEM research rather than the causal network in the model under investigation (Kock, 2015). The implicit social acceptance of a particular reaction to a questionnaire item may also contribute to CMB by making the indicators have some common variance (Kock, 2015). The full collinearity test was developed by Kock and Lynn (2012), where variance inflation factors (VIFs) are calculated for all latent factors in a model using this method. If all of the VIFs from a thorough collinearity test are less than or equal to 3.3, we can consider the model CMB-free (Kock, 2015). This prompted us to look into the VIF values of our internal model, and we found that they all fall below the critical threshold of 3.3, in the range of 1.671 to 3.047. Thus, we may deduce that the CMB in our study is lower.

4.2 Measurement Model

We started by examining the predictability model by gauging the construct's internal consistency reliability. First, we estimated outer loadings for each variable in the measurement set. The threshold values for various indicators of the assessment measurement model are adapted from the studies of Hair et al. (2016), such as loadings > 0.7; Cronbach's alpha > 0.7; rho_a > 0.7, average variance extracted (AVE) > 0.5, and composite reliability > 0.7.

Table 3: Consistency and reliability measures summary

Constructs	Item code	Loadings	Cronbach's alpha	rho_a	Composite reliability	AVE
Green Manufacturing (GM)	GM1	0.880	0.882	0.883	0.919	0.739
	GM2	0.829				
	GM3	0.869				
	GM4	0.859				
Eco Design	ED1	0.853	0.871	0.874	0.912	0.721

Construct	Item	Loading				
(ED)	ED2	0.862				
	ED3	0.851				
	ED4	0.832				
Green Purchasing (GP)	GP1	0.844	0.872	0.873	0.912	0.722
	GP2	0.838				
	GP3	0.846				
	GP4	0.871				
Investment Recovery (IR)	IR1	0.883	0.904	0.904	0.933	0.776
	IR2	0.885				
	IR3	0.883				
	IR4	0.873				
Logistic Eco-centricity (LE)	LE1	0.879	0.905	0.905	0.933	0.778
	LE2	0.875				
	LE3	0.887				
	LE4	0.887				
Carbon Neutral Supply Chain (CNSC)	CNSC1	0.898	0.917	0.918	0.942	0.802
	CNSC2	0.903				
	CNSC3	0.874				
	CNSC4	0.905				

All of the constructs and their associated item loadings were found to be statistically significant in the PLS analysis (greater than 0.7, see Table 3). We also found that the correlations between the items were higher than the threshold (Cronbach's alpha > 0.7, see Table 3). Finally, the values of AVE are also greater than the threshold (AVE > 0.5, see Table 3). The findings from Table 3 indicate the stability, reliability, and internal consistency of the model.

After that, we assessed the discriminant validity of the measurement model, which compares how well independent factors predict latent ones. The discriminant validity may be evaluated and represented using two separate measures. The Fornell-Larcker criterion comes first, followed by the heterotrait-monotrait (HTMT) criteria. There is an argument for using these measures to assess discriminant validity in the literature. Nonetheless, research by Henseler et al. (2015) shows that HTMT is a more trustworthy criterion for evaluating discriminant validity. As a result, the current study employed the HTMT ratio as a means of assessing the measurement model's discriminant validity. In this case, we need a lower cutoff than 0.9. All values in Table 4 were found to be less than 0.9, as shown by the findings, and indicate that the model possesses discriminant validity.

Table 4: Discriminant validity (HTMT criteria)

	CNSC	ED	GM	GP	IR
ED	0.810				
GM	0.747	0.775			
GP	0.758	0.824	0.733		
IR	0.661	0.659	0.648	0.533	
LE	0.836	0.837	0.754	0.757	0.697

4.3 Structural Model

The model's predictive power for one or more intended constructs may be determined by examining the model's results. To evaluate the error estimates, the inquiry employed nonparametric bootstrapping using 5,000 subsamples. To assess the model's fitness, the standardized root mean square (SRMR) values were used. If there are more than 100 people in the population, this ought to be lower than 0.08 (Cho et al., 2020). The present research's SRMR score, which is below the 0.08 cutoff, can be found in Table 5. The SRMR results, therefore, demonstrated the model's quality of fit. Table 5 displays the R^2 and Q^2 values. R^2 must be greater than 0.1 to be considered acceptable (Hair et al., 2016). A blindfold was used to analyze the Stone-Geisser (Q^2) score. For this model, it was discovered that Q^2 corresponds to the values 0.245, 0.240, and 0.226 (see Table 5). The fact that Q^2 had a value greater than 0 demonstrated that the route model had sufficient predictive power (Nath and Agrawal, 2022).

Table 5: Model robustness summary

Variables	R^2	Q^2	SRMR
CNSC	0.675	0.532	0.042
LE	0.658	0.504	

It was also possible to establish whether the independent variables substantially influenced how accurately the dependent variable was predicted by computing the f^2 effect size for each of the individual variables. Table 6 displays the magnitude of the f^2 impact for each independent variable. The size of these is somewhere between modest and medium, per the criteria defined by Hair et al. (2017). In order to provide statistical significance of the routes and acceptance of the hypothesis, the value of various standard coefficients, such as must be greater than zero and the p-value less than 0.05.

All of the study's assumptions, as evidenced by the findings in Table 6, were found to be correct. The results of the PLS-SEM method and the SmartPLS bootstrap approach included the direct effect, total indirect impact, specific indirect effect, and overall effect. These outputs allowed for the execution of a mediation evaluation, which could be found in the SmartPLS results reports (Hair et al., 2017). According to the findings shown in Table 6, there was a substantial positive direct connection between GM, ED, GP, IR, and CNSC. Moreover, the indirect association between GM, ED, GP, IR, and CNSC was favorable, suggesting that LE had a beneficial mediating effect on their interaction. Nitzl et al. (2016) claim that significant partial mediation occurs when the indirect effect is both considerable and positive, while partial mediation occurs when both effects are strong but the direct consequences are minimal. According to the results presented in Table 6, LE could partially mediate the connection between GM, ED, GP, IR, and CNSC.

Table 6: Hypothesis testing summary

Association path	Hypothesis	Standard Coefficient (β)	t-statistics	p-value	Accepted/Rejected
Direct effect					
GM → CNSC	*H1*	0.141	2.041	0.041	Accepted
ED → CNSC	*H2*	0.182	2.108	0.035	Accepted
GP → CNSC	*H2*	0.170	2.438	0.015	Accepted
IR → CNSC	*H4*	0.119	2.038	0.042	Accepted
GM → LE	*H5*	0.174	2.229	0.026	Accepted
ED → LE	*H6*	0.346	3.939	0.000	Accepted
GP → LE	*H7*	0.203	3.389	0.001	Accepted
IR → LE	*H8*	0.231	2.987	0.003	Accepted
LE → CNSC	*H9*	0.342	3.941	0.000	Accepted
Mediation effect					
GM → LE → CNSC	*H10*	0.060	2.060	0.039	Accepted
ED → LE → CNSC	*H11*	0.118	3.103	0.002	Accepted
GP → LE→ CNSC	*H12*	0.070	2.683	0.039	Accepted
IR → LE→ CNSC	*H13*	0.079	2.010	0.044	Accepted

5. Discussion and implications

For logistics companies to achieve LE and CNSC, the current study identified GM, ED, GP, and IR as key resources. The present research also applies the NRBV lens to analyze the mediating role of LE in the relationships between GM, ED, GP, IR, and CNSC. Using the PLS-SEM method, we tested our hypotheses about the interplay between all of the different conceptual framework constructs. All hypotheses tested, including those involving a direct and a mediation effect, were confirmed.

Therefore, the standard coefficients provide considerable support for hypotheses H1 to H4, which, when seen through the lens of NRBV theory, imply that there is a positive relationship between GM, ED, GP, IR, and CNSC (see Table 6). Standard coefficients also give strong support for the validation of Hypotheses H5–H9, which demonstrate a positive link between GM, ED, GP, IR, and LE when seen through the lens of NRBV theory (see Table 6). Standard coefficients also reveal that the hypotheses are correct. The NRBV theory predicts that there is a positive link between LE and CNSC, and all of the standard coefficients agree with H9, demonstrating that this relationship exists (see Table 6). The finding that LE has a significant mediating impact on the relationship between GM, ED, GP, IR, and CNSC is supported by the standard coefficients, which all lend weight to the idea that LE has such an influence (see Table 6). Agyabeng-Mensah et al. (2021) found that LE had a favorable mediation impact between GSCM practices and environmental performance. These findings are in agreement with the findings of the aforementioned researchers. All of the hypotheses that have been verified are consistent with the findings of earlier research, which are previously covered in the section on the literature.

5.1 Theoretical implications

The present research contributes to the theory by examining the relationship between different GSCM practices, LE, and CNSC performance, which have not been investigated together in the previous literature. When studied earlier, these constructs were investigated separately and without a theoretical foundation. We succeeded in filling the existing gap in the NRBV theoretical framework by investigating all the relationships between different GSCM practices, LE, and CNSC performance together. Another theoretical contribution of the study is the empirical elucidation of the relationships between these variables. The findings of the study expand our theoretical knowledge since they empirically confirm that "strong causal links with GSCM practices, LE and CNSC" in companies that follow the NRBV principles, and the latter can be used "as practices in its logistics functions". The research results benefit theoretical advancements by explaining how logistics companies use the GSCM practices and principles, LE, and CNSC in the formation of their ways of work that result in advantageous outcomes. Also, the findings help improve our comprehension of the affectedness of variables and the links that exist between them. The study also contributes to the theory by highlighting the importance of the discussed concepts for changing external environments, such as the necessity of making logistics operations carbon-neutral.

Overall, the theoretical implications that the research has on the NRBV theory are broader than the immediate findings presented in the study. The research provides a theoretical foundation where future researchers can continue investigating the links and events that have not been considered. The research enables scholars to develop further the NRBV framework to understand what organisations can do to get a sustainable competitive advantage in terms of environmental initiatives, such as GSCM, LE, and CNSC. In other words, the research develops the NRBV theory by providing insights into the theoretical implications of how environmental initiatives and practices and, in particular, logistics work together to produce a competitive advantage.

5.2 Managerial implications

The findings of this study are useful for managers in comprehending the effects of various GSCM techniques on LE and CNSC from the perspective of the NRBV paradigm. To achieve more CNSC-oriented results, such as net-zero, lowering carbon emissions, and more environmental outcomes across logistical operations, practitioners/managers/superintendents may employ LE as an integrated method in GSCM activities. The findings indicate that GSCM procedures are swiftly adjusting to provide environmental advantages in industrial enterprises, therefore emerging as a novel strategic approach. The study findings indicate that the combination of GSCM approaches with LE is expected to grow more widespread in both Indian logistics firms and logistics organizations worldwide. Practitioners consider GSCM methods and LE to be important factors in achieving CNSC, as shown by their favorable impact on the three components of the NRBV. The conclusive results obtained from actually testing the hypothesis validate this. Furthermore, due to the beneficial influence of GSCM practices on LE, a firm that is either considering or has already implemented GSCM practices will not quickly become outdated. This is because of their enhanced performance in a context where LE is used in logistical operations.

These findings support the notion that LE has a role in mediating the relationship between GSCM practices and CNSC. These findings indicate that implementing GSCM methods and LE within the framework of the NRBV paradigm may contribute to the attainment of CNSC. This information is vital for organizations that have a presence in the market. Therefore, it is crucial for logistics business management to comprehend the significance of GSCM methodologies and LE in supporting CNSC. This is the process by which we ultimately achieve the climatic outcomes that are significant. The implementation of GSCM practices and

rules provides a rationale and impetus for embracing CNSC activities, and it is the responsibility of the management to acknowledge this.

6. Conclusions

This study incorporates the knowledge of logistics industry veterans at work for Indian companies that have implemented GSCM techniques in their operations in pursuit of LE and CNSC outcomes. Experts in the logistics field are specifically interviewed for this study. If the study's results are taken into account, the research findings might be used as a reference for logistics firms considering the usage of GSCM methods to obtain LE and CNSC-driven advantages within the assumptions of NRBV theory. Additionally, the outcomes revealed how the NRBV concept may be integrated into the GSCM practice action plan. The research shows that using all of the GSCM practices addressed in this study concurrently may greatly improve LE and CNSC results; hence, doing so is strongly encouraged for logistics companies.

Current research provides a comprehensive overview of how GSCM procedures affect the LE and CNSC of logistics firms. Additionally, there are several caveats to this research, such as the fact that various GSCM procedures were examined independently to determine their effect on LE and CNSC. Nevertheless, GM, ED, GP, and IR are only a few examples of GSCM activities that have their own specialized sets of tools and methods. However, as LE has a facilitating role in the association between the various GSCM techniques and CNSC, studying the impact of LE's moderating effect on the same linkage is important. The current literature does not give a hierarchy of GSCM practices in the framework of NRBV theory. Therefore, future studies may examine other ranking techniques to arrange the respondents' views on a range of GSCM practices and activities into a hierarchical framework that meets the limits of the NRBV paradigm.

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