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Green supply chain management and green creativity: Implications for sustainability

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ABSTRACT

The purpose of this paper was to examine the beverage business in Iraq and the connections between green supply chain management, green creativity, barriers to green supply chain management, and sustainability in supply chain management. The objective was to investigate the interactions among these elements to affect the results of sustainability in this particular industrial sector in Iraq. The paper included 248 participants, all of whom were employees in Baghdad Soft Drinks Company, which is a private joint-stock company. Structured questionnaires based on validated scales were used to collect data. Data were analyzed using Stata structural equation modeling to examine direct and mediated effects between research variables (GSCM, GC, SSCM). The findings show that GSCM improves SSCM, and GC partially helps explain this link. BGCM is also useful in moderating the connection between GSCM and SSCM. Therefore, it is necessary to eliminate the barriers in order to maximize the impact of the environment on the Iraqi beverage industry. This article explores sustainability and how it would be used to improve the supply chain strategy using innovative approaches. It shows how Iraqi beverage companies, with the assistance of green methods, may overcome obstacles and guarantee a high degree of sustainability with long-term environmental, social, and economic impacts.

Contribution/Originality: This research is unique in addressing sustainability issues within the Iraqi industry. It highlights the positive impact of GSC by integrating creativity to tackle sustainability challenges and enhances empirical value through the SATA program. These findings contribute to academic research supporting the role of GSC in advancing GC in the soft drinks industry and achieving sustainability.

1. INTRODUCTION

Increasingly, sustainability is gaining prominence in supply chain management (SCM), where firms are under pressure to manage environmental, social, and economic issues. Sustainability in supply chain management (SSCM) reduces environmental repercussions and enhances social and economic welfare (Singh & Maheswaran, 2024). This end-to-end approach is driven by increasing consumer awareness, regulatory requirements, and operational efficiency over an extended period (López Pérez, García Sánchez, & Zafra Gómez, 2024). Green Supply Chain Management

(GSCM) is a specific form of SSCM that involves environmental considerations in supply chain activities by minimizing green procurement, sustainable manufacturing, eco-logistics, and end-of-life product management (Huang, Solangi, Magazzino, & Solangi, 2024). Recently, GSCM has gained significance due to climate change, resource depletion, and pollution (Jan, Salameh, Rahman, & Alasiri, 2024). Traditional cost-and-efficiency supply chain practices are often unsustainable from an environmental perspective, as organizations are discovering (Pathak, Verma, & Kumar, 2024). Consequently, GSCM approaches that improve ecological performance and support sustainability goals are becoming increasingly popular.

According to Chai, Liang, and Wang (2024), GSCM entails sustainable technological creativity concerning the development and adoption of environmentally friendly technologies, products, and processes. Ecological creativity helps firms become more sustainable as companies increase resource efficiency, reduce waste, and manage emissions. (De Oliveira, Menezes, & Fernandes, 2024). There are numerous advantages of GSCM and GC; however, they are also restrained by many obstacles to acceptance and success. (Shehzad, Zhang, Dost, Ahmad, & Alam, 2024). As Kumar, Mangla, and Kumar (2024) note, some of these obstacles include budgetary constraints, technical limitations, regulatory concerns, and resistance to organizational change. Several challenges must be overcome to enhance GSCM processes and maximize their benefits. Ullah, Ahmad, Kukreti, Sami, and Shaukat (2024) state that GC and barriers influence the sensitive relationship between GSCM and SSCM. These dynamics are crucial in developing sustainable supply chain strategies. Empirical research on GSCM and SSCM indicates that integrating sustainability into supply chain activities yields both positive and adverse outcomes. Most studies suggest that GSCM enhances environmental performance Goncalves et al. (2024). Organizations implementing GSCM, such as sustainable logistics and purchasing, which are ecologically responsible, have been shown to reduce waste and emissions. Bataineh, Sánchez-Sellero, and Ayad (2024) concluded that integrated GSCM could enhance environmental quality and promote sustainable development.

However, these findings from past research show that GSCM improves the environmental lifespan of supply chains (e.g., reducing waste and emissions); Abaku and Odimarha (2024). Nonetheless, there are still many aspects underexplored in this area (Rasheed, Farooq, & Qazi, 2024). GSCM approaches have been shown to improve economic (e.g., cost savings; Aroonsrimorakot and Laiphrakpam (2024), social welfare (e.g., employee well-being; Jiang, Zaman, Jamil, Khan, and Kun (2024), and environmental consequences (e.g., resource efficiency; Farrukh, Mathrani, and Sajjad (2024). Rodrigues and Franco (2023) found that environmentally friendly product creativity increased consumer satisfaction and market share, demonstrating the economic benefits of GSCM. Jianguo and Solangi (2023) listed energy-efficient production, lower operational costs, and better resource efficiency as environmentally beneficial process advances. Lee (2023) established that GSCM methods improve working conditions and community interactions, promoting social sustainability. These studies demonstrate that GSCM benefits the environment, economy, and society.

A quantitative investigation showed that GC enhances GSCM processes. Alkhatib (2023) found that the creativity of environmentally friendly products and processes enhances business environmental and operational performance. Polas, Tabash, Bhattacharjee, and Dávila (2023) have found that creative environmental businesses are financially and environmentally better off than less creative ones. This is regardless of whether businesses are environmentally conscious or not. The results indicate that GC is critical for the sustainability of the supply chain. Although the results are encouraging, the literature implies that GSCM implementation is not widely embraced (Pham et al., 2023).

According to Wen, Cheah, Lim, and Ramachandran (2023), considerable barriers are defined as financial constraints. These disadvantages include high startup costs and variable ROI. The lack of modern, environmentally friendly technology and infrastructure may limit GSCM implementation (Huang, Chen, Do, & Chung, 2022). Insufficient environmental legislation and enforcement hinder growth, as noted by Le, Vo, and Venkatesh (2022). Moreover, Fontoura and Coelho (2022) stated that business hurdles inhibit GSCM adoption and effectiveness. These

obstacles include change resistance and management indifference. Future research may reveal patterns in sustainability efforts over time and the long-term pros and cons of GSCM solutions.

Despite the existing body of literature on GSCM, GC, and barriers to GSCM, there is a research gap in understanding the role of sustainability as a dependent variable in supply chain management (SCM). Specifically, the relationship between GSCM, GC, and barriers to GSCM warrants further investigation. Previous studies have identified antecedents and consequences of supply chain managers holding different cognitive frames, particularly in the context of Iraq (Preuss & Fearne, 2022). Additionally, a systematic literature review has been conducted to analyze the triple bottom line of (SSCM) in energy production (Hmouda, Orzes, & Sauer, 2024), as well as the influence of internal and external orientations on businesses' sustainable performance, considering the impact of SSCM practices (El-Garaihy et al., 2024).

Therefore, the gap in the current literature lies in the need to investigate the beverage business in Iraq and the connections between GSCM, GC, barriers to GSCM, and sustainability in SCM.

GSCM, GC, and SSCM are based on the resource-based view (RBV), dynamic capacities theory, and institutional theory. The resource-based view (RBV) theory (Junaid, Zhang, & Syed, 2022) assumes that organizations can gain a competitive advantage through unique resources and capabilities. GSCM incorporates GC to enhance operations and achieve sustainability. Bag, Dhamija, Bryde, and Singh (2022) explained the theory of dynamic capacity, which posits that companies must be flexible and innovative to maintain their competitive advantages in rapidly changing environments. GC enables companies to adapt to environmental and regulatory changes and fulfill sustainability objectives. Institutional theory helps analyze the influence of external and inter-organizational factors on the adoption and effectiveness of GSCM. According to this theory, regulatory, normative, and cognitive variables influence corporate behavior (Liu et al., 2022).

The pressure imposed by regulation and policy in GSCM, which is an abbreviation of (GSCM), can influence the trend of creating environmentally friendly practices. These strategies are effective subject to culture and managerial support of the organization. These dynamics are important for developing and applying long-term supply chain strategies. This research examines how GC mediates the relationship between (GSCM) practices and SSCM, as well as the impediments that affect it. This study highlights significant issues that must be addressed to improve GSCM methods. This is done by examining how GSCM affects sustainability through GC. The research fills some of the knowledge gaps in the body of literature and offers suggestions to organizations that would like to implement sustainability in their supply chains.

2. LITERATURE REVIEW AND HYPOTHESIS BUILDING

Recent SCM studies emphasize sustainability since supply chain activities affect the environment, society, and the economy (Chien et al., 2021). Sustainable supply chains improve communities' social and economic well-being and reduce environmental damage. The SSCM study includes green sourcing, manufacturing, shipping, and end-of-life product management (Jo & Kwon, 2022). Green procurement reduces supply chain impacts by buying ethical and sustainable items. Sustainable logistics reduces carbon emissions by streamlining routes and employing energy-efficient trucks (Novitasari & Agustia, 2021). The circular economy, remanufacturing, recycling, and product reuse are gaining prominence. Reusing items is an integral part of this approach. Social sustainability in supply chain management (SCM) encompasses environmental protection, as well as the rights of employees, communities, and stakeholders (Hebaz & Oulfarsi, 2021). This includes fair and equal employment legislation, employee safety and well-being, and responsible sourcing that develops adjacent communities.

Shah et al. (2021) revealed that companies require both transparency and traceability to effectively survey and govern the social consequences of their supply chains. Businesses and sectors can depend on creating value among other stakeholders and shareholders to ensure their survival (Kalpande & Toke, 2021). Sustainable supply chains enhance brand image, minimize waste and resource use, benefit environmentally and socially responsible audiences,

and reduce costs (Wang et al., 2021). Supply Chain Management (SCM) organizations should carefully manage environmental stewardship, social responsibility, and economic viability to achieve sustainable development (Abdulameer, Twfan, Al Yasari, & Amanah, 2023).

This ideology requires SCM sustainability and GSCM. GSM encompasses sustainable logistics, sustainability in sourcing, environmentally friendly production, and management of products up to the end of their lifecycle (Liu et al., 2021). These actions minimize environmental impact, increase turnover efficiency, and decrease the ecological footprint of the supply chain. SCM comprises social, environmental, and economic sustainability (Singh & Maheswaran, 2024). This includes reducing pressure on the environment and ensuring that the supply chain is fair and economical to promote its survival and sustainability. SSCM and GSCM have been linked in various studies. Researchers have concluded that the sustainability of supply chains is more effective when environmentally friendly practices are implemented (Huang et al., 2024). GSCM significantly reduces waste generation, energy consumption, and carbon emissions (Mangi et al., 2023).

GSCM also increases customer loyalty, reputation, efficiency, and cost savings. The statement indicates that improving working conditions and involving stakeholders may lead to the development of sustainable supply chains (Ur Rehman et al., 2024). According to the study, environmentally friendly methods can enhance environmental performance and support supply chain and sustainability management objectives (Pathak et al., 2024). There is both theoretical and empirical evidence to justify that GSCM has a significant impact on SSCM, although these studies provide both types of evidence. GSCM has been gaining popularity with the triple bottom line approach to balance business, society, and the environment (De Oliveira et al., 2024). Kumar et al. (2024) assume that companies adopting GSCM methods can demonstrate improved sustainability outcomes overall. Goncalves et al. (2024) revealed that environmental sustainability in sourcing and manufacturing enhances financial and environmental results. According to the findings achieved by Rasheed et al. (2024), sustainable logistics helps improve the social and environmental outcomes of organizations. These empirical studies demonstrate that GSCM enhances sustainability.

H_1: Green supply chain management significantly influences sustainability in supply chain management.

The relationship between GSCM and GC has been extensively researched (Liu et al., 2021). This paper highlights that sustainability in supply chain practices is a crucial tool for fostering innovation. Studies have indicated that GSCM practices, including eco-design, reverse logistics, and green purchasing, can promote organizational innovativeness. Fahad, Alnori, Su, and Deng (2022) found that Chinese firms adopting GSCM have produced more inventive products, implementing environmentally friendly items and processes. Additionally, De Oliveira et al. (2024) discovered that managing environmental issues through systematic handling facilitates the achievement of GC in the electronics industry via GSCM. This approach motivates employees to be creative and innovative.

Hebaz and Oulfarsi (2021) state that the development of new green technologies by manufacturing companies in the US is positively associated with the implementation of GSCM techniques. This information is important in that it can be determined what processes underlie this relationship in order to substantiate the hypothesis that GSCM influences GC (Bag et al., 2022). These empirical facts can be used to formulate this theory. In order to enhance knowledge sharing and innovativeness, business SCM normally implies close cooperation with suppliers and other stakeholders. According to Ullah et al. (2024), such a collaborative environment promotes the production of new operational and environmental solutions. GSCM operations should also follow strict environmental regulations. This encourages business investment in environmentally sustainable research and development. López Pérez et al. (2024) argue that regulatory pressure compels businesses to actively seek and adopt the latest solutions that meet regulations and provide a competitive advantage. Moreover, GSCM principles, such as aids, foster supply chain openness and transparency, as noted by Lee and Klassen (2008). This assists in the determination of productivity and creativity in business. There is a strong need to empirically confirm the hypothesis that GSCM plays a major role in GC as well as the relationship between them and their circularity. Companies with effective GSCM implement a culture of value towards sustainability and continuous improvement (Rao & Holt, 2005).

Such a shift in organizational culture positions GC as a strategic issue, fostering creativity and aligning organizational objectives with sustainable development themes. Tseng, Chiu, Tan, and Siriban-Manalang (2013) suggest integrating these two concepts by stating that GC and GSCM can positively influence each other. It was also determined that GSCM investments enable organizations to develop small-scale concepts, thereby increasing their capacity for larger innovations. This finding is significant. The interactive process between GC and GSCM is illustrated through an iterative approach, indicating that GC can be maintained through GSCM practices. In many cases, this approach encourages ongoing innovation. Scientific evidence supports that GSCM impacts GC. This paper demonstrates that GSCM can be a key factor contributing to organizational creativity.

H_2: Green supply chain management significantly influences green creativity.

Studies by GC and supply chain sustainability indicate that sustainable solutions promote GC that has a positive impact on sustainability Jianguo and Solangi (2023). GC entails using technology, methods, and products that are new in reducing environmental degradation factors and enhancing resource utilization. Their findings demonstrate that the investment researched will boost the involved company's effectiveness in environmental performance (Junaid et al., 2022). Alkhatib (2023) declared that innovative producers of environmentally friendly products experience less waste and emissions, thus having a low ecological footprint. As Huang et al. (2022) have observed, green process creativity uses energy-efficient manufacturing technology. This lowers operational costs and is more sustainable. Such developments highlight the necessity of introducing supply chain technologies that are environmentally friendly to enhance environmental sustainability. In this respect, Ahmed et al. (2023) mentioned that successful organizations are obligated to encourage innovative behavior in the workplace, foster a creative workforce, and manage the volatile nature of the environment.

GC also improves supply chain social and economic sustainability, according to research (Fahad et al., 2022). GC creates safer, healthier products, improving consumer well-being and pleasure (Junaid et al., 2022). Green procedures also improve working conditions and reduce health hazards, thereby enhancing social sustainability (Liu, Zhang, Tarbert, & Yan, 2022). GC has the ability to act as a boost to the economy through product and process differentiation, attracting new customers interested in eco-friendly services and goods, and the emergence of new markets (Jo & Kwon, 2022). Companies with GCs tend to be leaders in sustainability, which can enhance their branding and market position (Hebaz & Oulfarsi, 2021).

The described multidimensional advantages of GC reveal the role it plays in the sustainability of the supply chain. These empirical findings confirm the idea that GC influences supply chain sustainability significantly (Kalpande & Toke, 2021). GC in supply chains substantiates the dynamic capacities hypothesis, which implies that businesses must change and innovate to sustain competitive advantages (Liu et al., 2021). Green technologies assist organizations in achieving sustainability through environmental and regulatory demands. As Le et al. (2022) state, GC enhances environmental, social, and economic sustainability. López Pérez et al. (2024) add that higher GC levels correlate with better environmental performance, operational efficiency, and financial gains for enterprises. In one study, Jan et al. (2024) found that green product and process creativity improve the level of sustainability in the supply chain. The findings indicate that GC plays a vital role in supply chain management, emphasizing the importance of innovative approaches to achieve sustainability goals.

H_3: Green creativity significantly influences sustainability in supply chain management.

The connection between GSCM, GC, and SCM results has been associated with numerous empirical studies (Bag et al., 2022). These works provide a solid foundation for understanding how to conceive GC as a mediator (Fontoura & Coelho, 2022). GSCM operations are enhanced through the application of green technology, environmentally friendly goods, and sustainable processes. Eco-friendly technologies, diligent procurement, and green logistics contribute to improved environmental performance of organizations. As Le et al. (2022) concluded, firms with high levels of GSCM and GC minimize waste and emissions.

The mediating role of GC, the focus of Pham et al. (2023), tested whether GC could increase the environmental sustainability of GSCM. Based on the research, GC improves social and economic effects, increasing the degree of environmental performance and sustainability of supply chains. GC enhances such outcomes (Polas et al., 2023). Lee (2023) suggested that green product improvements led to consumer satisfaction and market share, and green process creativity led to operational efficiencies and cost savings. They both obtained benefits without affecting their environment. These advantages lead to sustainable SCM. According to Rodrigues and Franco (2023), enterprises that adopted both GSCM and GC recorded higher social sustainability outcomes, such as improved employment relationships and social engagements, compared to those adopting only GSCM (Bataineh et al., 2024). In this study, it was found that GC mediates the relationship between GSCM approaches and the sustainability of the supply chain, both in terms of environmental, social, and economic impacts. There are a number of empirical studies to rely on when asserting the importance of GC in GSCM and SCM (Ullah et al., 2024).

The dynamic capabilities model and the resource-based view demonstrate how GSCM can be enhanced through GC. The Resource-Based View (RBV) posits that resources such as creativity enable a firm to attain a competitive advantage (Shehzad et al., 2024). GC makes the processes of GSCM more sustainable. Based on research findings, GC relates GSCM and SCM by converting green practices into sustainable gains. Chai et al. (2024) found that GC enhances the eco-friendly and efficiency benefits of GSCM. Jan et al. (2024) and Alabdily, Khalil, Abdulameer, and Amanah (2024) findings indicate that GC plays a crucial role in the relationship between the GSCM system and overall SCM. Sustainable supply chain objectives are reliant upon GC.

H_n: Green creativity significantly mediates the relationship between green supply chain management and sustainable supply chain management.

Several empirical studies have identified obstacles to GSCM and their significant moderating effects on GSCM implementation and SCM performance (Novitasari & Agustia, 2021). These obstacles include financial restrictions, technical disparities, regulatory support, and organizational resistance to change. The high costs associated with adopting GSCM and its uncertain ROI may hinder its adoption and effectiveness (Chien et al., 2021). Without proper implementation, GSCM may not yield the expected benefits, and a radical deployment of green technology and infrastructure might be necessary (Shah et al., 2021). A study conducted by Wang and Yang (2021) indicates that the absence of effective environmental regulations and controls can adversely affect GSCM operations. Resistance to change and managerial support are organizational constraints that influence the outcomes of GSCM and SCM, as demonstrated through empirical research (López Pérez et al., 2024).

It is shown by Pathak et al. (2024) that organizational inertia and lack of interest among senior management might be reasons why green initiatives are slow to progress and fail to deliver benefits to GSCM in terms of supply chain performance. Shehzad et al. (2024) reported that cultural resistance within businesses and supply chains hinders the implementation of GSCM. The findings indicate that these barriers can exacerbate challenges in applying GSCM and diminish its impact on SCM outcomes (Goncalves et al., 2024). Green chain management inhibitors significantly influence the relationship between GSCM and SCM when examined through both theoretical and practical evidence. The Resource-Based View (RBV) and institutional theory highlight the impact of barriers on the effectiveness of GSCM initiatives (Rodrigues & Franco, 2023).

According to the institutional theory, culture and management, combined with other legislative, commercial, and organizational variables, elevate GSCM adoption and success Stockton-on-Tees Borough Council (2024). Ullah et al. (2024) found that obstacles may change the course and intensity of GSCM-SCM interpersonal relationships. As Polas et al. (2023) demonstrated, regulatory and financial constraints limit the benefits of GSCM on the environment. Fahad et al. (2022) found that the influence of GSCM on the efficacy of the operational process and its sustainability was low due to technological and organizational constraints (Liu et al., 2022). Such empirical evidence is highly relevant to the idea that obstacles to green chain management alter the correlation between green practices and overall supply

chain management (SCM), supporting the notion that efforts should be made to reduce such barriers to emphasize practices of green supply chain management (GSCM).

H_5: Barriers of green chain management significantly moderate the relationship between green supply chain management and sustainable supply chain management.

Figure 1 summarizes the relationship between the study variables as a model that will be tested successively.

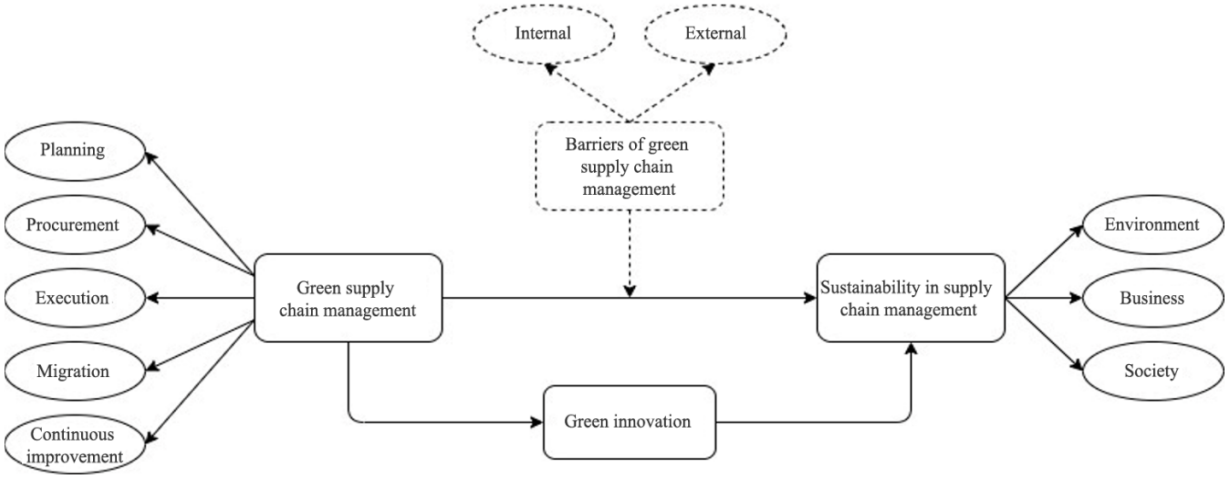

Figure 1. Research model.

3. METHODOLOGY

The research has investigated the relationships between green supply chain management (GSCM), green creativity (GC), and barriers to GSCM and sustainability in SCM within the beverage sector of Iraq. The statistics examined in the study consist of data from 248 industry staff. The study selected participants from Iraqi beverage companies, specifically the Baghdad Soft Drinks Company Private Joint Stock Company, using convenience sampling. The selection of the participants was made with references to their positions in SCM and to the activities presented by them to have the representation not only within the organizational levels but also among the functions. Perceptions and attitudes on GSCM, GC, BGCM, and SSCM were measured using structured questionnaires that were to be administered electronically or face-to-face. The GSCM, GC, BGCM, and SSCM measurement scales were based on established research studies. The scales were chosen due to their reliability and validity in measuring the constructs of supply chain sustainability. The beverage industry and the culture of Iraq were considered by modifying items of each scale, as stated in the study Table 1.

Table 1. Variables, instruments.

Variables	No. of items	References
(GSCM)	25	Singh, Singh, and Kumar (2020)
GC	14	Wang et al. (2021)
Barriers of (GSCM)	09	Ojo, Mbowa, and Akinlabi (2014)
Sustainability in SCM	11	Kholaif and Ming (2023)

The statistical analysis was carried out using Stata SEM. SEM was selected to analyze the direct and mediated effects of GSCM, GC, BGSCM, and SSCM, since it has the capability of simultaneously analyzing complicated associations among latent variables and observable measures. To test the hypothesized correlations between the variables via confirmatory factor analysis (CFA) to determine the validity and reliability of the measurement model, the hypothesized variables were investigated using path analysis. These variables were incorporated into the analysis to enhance the reliability and accuracy. The sample demographics and attributes were summarized using preliminary descriptive statistics. The goodness-of-fit of the measurement model was also evaluated through CFA to ensure that

each latent variable has been well captured by its indicators. The structural model was then considered to establish how the research hypotheses regarding the direct effects of GSCM and GC on SSCM, the mediating effects of GC, and the moderating effects of BGSCM are supported.

4. MATERIALS AND METHODS

4.1. Research Context and Sample

This research was conducted at Baghdad Soft Drinks Company, one of the prominent industrial corporations in Iraq within the soft drinks industry. The study population included 51 executive managers working in its branches across Iraq and 3,527 employees. Thompson (2012) used a limited population formula to determine the sample size, assuming a confidence level of 95%, a 5% margin of error, and a population proportion of 0.5 to maximize variance. To increase the likelihood of obtaining an adequate number of valid responses, questionnaires were administered to a sample size larger than the calculated number.

The stratified random sampling method was employed to ensure proportional representation of both managers and employees across various branches of the company and administrative and operational units. Specifically, managers and employees were provided with 60 and 220 questionnaires, respectively. A total of 264 responses were received, comprising 54 managers and 210 employees. After subtracting 16 invalid or broken questionnaires (4 managers and 12 employees), the valid questionnaires for statistical analysis totaled 50 managers and 198 employees, resulting in a response rate of 94%.

4.2. Instruments and Measures

The two-part structured questionnaire was used to gather data over six months, from November 2024 to April 2025. The demographic section was the initial part, collecting demographic data such as age, gender, academic qualification, and years of experience. The latter section evaluated the variables of the study through the analysis of valid measurement scales for green supply chains, creativity, and sustainability. The ratings for all items were on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

A pilot test was conducted on a subsample of 60 individuals from the target population to identify the determinants of sustainability in the Iraqi soft drinks industry. The pilot study facilitated minor linguistic adjustments to the tool, ensuring that participants could read and understand it easily within the context of the Iraqi manufacturing environment.

4.3. Ethical Considerations

The study adhered to the ethical standards of the Baghdad Soft Drinks Company and the University of Kerbala, Faculty of Administration and Economics, which advised on the academic aspects of the study. Prior to data collection, the Research Ethics Committee of the university approved the study. Participation was voluntary, and the objectives and procedures of the study were explained to all participants. Each participant provided informed consent and was assured of strict confidentiality. No personal identities of the participants were required, and no information was de-anonymized or stored insecurely to ensure participants' privacy.

5. DATA ANALYSIS AND RESULTS

Table 2 indicates the consistency and validity of the study factors in sustainability in SCM research. These findings show that each of the constructs has good internal consistency and reliability, with Cronbach's Alpha values ranging between 0.850 and 0.920. The composite reliability scores, ranging between 0.858 and 0.923, represent strong measurement models. The average variance extracted (AVE) scores of 0.516 to 0.566 indicate that each concept significantly explains the variance in the measured indicators, demonstrating convergent validity. These results

confirm that the measurement tools used in the study are effective for measuring GSCM, GC, impediments to green chain management, and sustainability in SCM.

Table 2. Variables: Reliability and Validity.

Variable	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
(GSCM)	0.889	0.921	0.516
GC	0.920	0.858	0.541
Barriers of (GSCM)	0.850	0.923	0.523
Sustainability in SCM	0.880	0.911	0.566

Table 3 presents the Confirmatory Factor Analysis (CFA) of each latent variable and indicator (Factor loading OIM Coef), standard errors (Std. Err.), z-value, significance level (P > |human|), and confidence interval ([95% Conf. Interval]). The table begins with GSCM, with the factor loadings of each indicator showing their relationship to the latent construct. Each factor loading (0.149-0.706) is statistically significant ($p < 0.001$), indicating that all indicators are valid measures of their GSCM dimension. GSCM4 and GSCM18 have loadings of 0.169 and 0.631, respectively, and are part of the GSCM construct. The high factor loadings across all indicators suggest that GSCM has high convergent validity, meaning the items effectively explain the activities of a green supply chain.

There are significant relationships between the GC indicators (GC2 = 0.730, GC8 = 0.508, and GC12 = 0.720) and the latent variable ($p < 0.001$). These findings demonstrate that GC measures are valid and effectively reflect the new program of sustainable supply chain efforts. Indicators of GC with high factor loadings are considered reliable and valid in this study. Specifically, BGCM6 (0.652) and BGCM8 (0.722) show strong correlations with the latent variable Barriers to Green Chain Management (BGCM) ($p < 0.001$). These results suggest that these indicators are effective in identifying financial and technological barriers that hinder green supply chain operations, owing to their high factor loadings. According to Table 3, the SSCM indicators (SSCM2 = 0.625, SSCM8 = 0.706, and SSCM10 = 0.650) also exhibit significant correlations with the latent variable ($p < 0.001$). The convergent validity of supply chain sustainability outcomes is strong, underscoring their importance in measuring sustainability across environmental, economic, and social dimensions.

Table 3. Confirmatory factor analysis.

Measurement	OIM Coef.	Std. Err.	z	P>|z|	[95% Conf. interval]	
GSCM1	1.000	(Constrained)				
GSCM2	0.563	0.043	10.887	0.000	0.381	0.545
GSCM3	0.590	0.047	10.553	0.000	0.149	0.568
GSCM4	0.169	0.084	8.875	0.000	0.256	0.831
GSCM5	0.216	0.039	74.487	0.000	0.252	0.777
GSCM6	0.224	0.066	3.072	0.000	0.425	0.713
GSCM7	0.513	0.081	8.466	0.000	0.166	0.755
GSCM8	0.706	0.081	8.833	0.000	0.205	0.795
GSCM9	0.584	0.081	8.390	0.000	0.153	0.744
GSCM10	0.610	0.050	9.341	0.000	0.513	0.708
GSCM11	0.583	0.078	9.000	0.000	0.273	0.744
GSCM12	0.579	0.041	69.461	0.000	0.204	0.720
GSCM13	0.541	0.082	8.390	0.000	0.168	0.754
GSCM14	0.461	0.094	7.597	0.000	0.230	0.763
GSCM15	0.674	0.057	9.153	0.000	0.563	0.626
GSCM16	0.526	0.075	10.461	0.000	0.280	0.898
GSCM17	0.557	0.086	8.257	0.000	0.216	0.781
GSCM18	0.631	0.045	61.505	0.000	0.077	0.183
GSCM19	0.085	0.087	9.284	0.000	0.348	0.910
GSCM20	0.668	0.053	9.737	0.000	0.564	0.612
GSCM21	0.403	0.078	9.860	0.000	0.273	0.875

Measurement	OIM Coef.	Std. Err.	z	P>|z|	[95% Conf. interval]	
GSCM22	0.149	0.083	9.000	0.000	0.252	0.833
GSCM23	0.671	0.039	72.133	0.000	0.113	0.347
GSCM24	0.669	0.036	77.559	0.000	0.104	0.379
GSCM25	0.586	0.073	9.292	0.000	0.138	0.555
GC1	1.000	(Constrained)				
GC2	0.730	0.037	77.810	0.000	0.182	0.418
GC3	0.682	0.063	9.893	0.000	0.215	0.706
GC4	0.586	0.038	76.466	0.000	0.205	0.367
GC5	0.666	0.041	68.751	0.000	0.112	0.388
GC6	0.430	0.037	78.394	0.000	0.230	0.647
GC7	0.289	0.038	78.711	0.000	0.314	0.458
GC8	0.508	0.039	75.948	0.000	0.311	0.714
GC9	0.713	0.052	10.460	0.000	0.610	0.656
GC10	0.615	0.057	8.758	0.000	0.504	0.720
GC11	0.452	0.051	7.223	0.000	0.353	0.547
GC12	0.720	0.056	10.317	0.000	0.609	0.663
GC13	0.720	0.066	8.831	0.000	0.591	0.682
GC14	0.527	0.055	7.772	0.000	0.420	0.629
BGCM1	1.000	(Constrained)				
BGCM2	0.569	0.049	8.938	0.000	0.474	0.660
BGCM3	0.700	0.066	9.889	0.002	0.577	0.705
BGCM4	0.492	0.052	7.611	0.000	0.390	0.589
BGCM5	0.494	0.058	8.241	0.004	0.412	0.673
BGCM6	0.652	0.053	9.962	0.000	0.548	0.749
BGCM7	0.584	0.068	6.916	0.000	0.450	0.711
BGCM8	0.722	0.047	12.410	0.000	0.630	0.647
BGCM9	0.606	0.058	11.389	0.000	0.569	0.727
SSCM1	1.000	(Constrained)				
SSCM2	0.625	0.051	9.553	0.000	0.526	0.718
SSCM3	0.685	0.048	10.978	0.000	0.590	0.619
SSCM4	0.558	0.048	8.992	0.000	0.465	0.646
SSCM5	0.666	0.052	9.870	0.000	0.564	0.762
SSCM6	0.642	0.053	9.429	0.000	0.539	0.740
SSCM7	0.623	0.053	9.057	0.000	0.519	0.722
SSCM8	0.706	0.055	9.901	0.000	0.598	0.653
SSCM9	0.592	0.054	8.522	0.000	0.487	0.692
SSCM10	0.650	0.054	9.398	0.000	0.545	0.748
SSCM11	0.673	0.053	9.816	0.000	0.569	0.617

Table 4 contains the fitness of the variables of the current study, including GSCM, GC, Barriers of GSCM, and SSCM. These statistics confirm that their latent measures in the measurement model are assessed by their indicators, as required in the reliability and goodness-of-fit of the measurement model. According to the GSCM table, each indicator has composite dependability statistics ranging from 0.511 to 0.822. This indicates a high reliability of all components, exceeding the recommended threshold of 0.50. GSCM19 (0.822) and GSCM18 (0.783) demonstrate strong reliability and are effective in tracking GSCM practices. The composite dependability scores for GC range between 0.545 and 0.926. Indicators such as GC11 (0.926), GC13 (0.906), and GC12 (0.871) are highly dependable and reflect the adoption of new sustainability approaches in supply chains. The BGCM indicators show composite reliability values from 0.620 to 0.860. Notably, BGCM7 (0.860) and BGCM6 (0.837) exhibit high reliability and are used to identify impediments to green supply chain activities. Lastly, SSCM indicators possess composite reliability scores between 0.657 and 0.910. SSCM10 (0.910) and SSCM3 (0.884) are particularly reliable, indicating the sustainability of supply chains across environmental, economic, and social dimensions.

Table 4. Measurement items for fitness statistics.

Variable	Indicator	Original sample
Green supply chain management	GSCM1	0.655
	GSCM2	0.705
	GSCM3	0.726
	GSCM4	0.658
	GSCM5	0.562
	GSCM6	0.555
	GSCM7	0.595
	GSCM8	0.606
	GSCM9	0.783
	GSCM10	0.575
	GSCM11	0.524
	GSCM12	0.625
	GSCM13	0.672
	GSCM14	0.707
	GSCM15	0.599
	GSCM16	0.624
	GSCM17	0.637
	GSCM18	0.783
	GSCM19	0.822
	GSCM20	0.660
	GSCM21	0.696
	GSCM22	0.585
	GSCM23	0.511
	GSCM24	0.749
	GSCM25	0.656
Green creativity	GC1	0.683
	GC2	0.698
	GC3	0.552
	GC4	0.545
	GC5	0.676
	GC6	0.666
	GC7	0.765
	GC8	0.724
	GC9	0.649
	GC10	0.717
	GC11	0.926
	GC12	0.871
	GC13	0.906
	GC14	0.856
Barriers of (GSCM)	BGCM1	0.823
	BGCM2	0.680
	BGCM3	0.620
	BGCM4	0.740
	BGCM5	0.795
	BGCM6	0.837
	BGCM7	0.860
	BGCM8	0.778
	BGCM9	0.665
Sustainability in SCM	SSCM1	0.657
	SSCM2	0.859
	SSCM3	0.884
	SSCM4	0.796
	SSCM5	0.843
	SSCM6	0.874
	SSCM7	0.776
	SSCM8	0.808
	SSCM9	0.825
	SSCM10	0.910
	SSCM11	0.809

Table 5 presents the chi-square test fit statistic of the structural equation model (SEM) in comparison with the saturated and baseline models. The likelihood ratio chi-square value of 7750.722 for the model against the saturated model indicates a good fit. The p-value of this statistic (0.000) demonstrates that the model significantly differs from

the saturated model, suggesting that the SEM is appropriate for the data. Additionally, the chi-square (chi2_bs) value of 3205.039, obtained with the baseline model, reflects the SEM's ability to reveal correlations among variables. The p-value of 0.000 used to compare the baseline and saturated models further confirms the SEM's capacity to explain the relationships and interactions among GSCM, GC, impediments to green chain management, and sustainability in this study.

Table 5. Chi-square test.

Fit statistic	Value	Description
Likelihood ratio	7750.722	Model vs. Saturated
p > chi²	0.000	
chi2_bs(2728)	3205.039	Baseline vs. Saturated
p > chi²	0.000	

Table 6 indicates the saturated and estimated R-SQ of the structural equation model of goodness of fit of this study. The Saturated Model column displays a baseline SRMR (Standardized Root Mean Square Residual) of 0.040, indicating that the model is fit when all parameters are freely determined. However, the Estimated Model column shows that the SEM is fit with estimated parameters, with an SRMR of 0.068. The increase from the saturated model implies a mismatch between the estimated model and the saturated model's perfect fitness, but the SRMR value remains within an acceptable range for model fit assessment. The third column's R-square values indicate how much variance each endogenous variable explains in the SEM. With modest explanatory power, GSCM explains 25.1% of its indicators' variance. GC explains 54.8% of the variance, indicating a greater impact on sustainability outcomes. Green supply chain issues are exacerbated by green chain management hurdles, which account for 56.9% of the variance.

Table 6. R^2 for model goodness.

Variable	Saturated model	Estimated model	R^2
SRMR	0.040	0.068	
(GSCM)			0.251
GC			0.548
Barriers of (GSCM)			0.569

The outcome of the route analysis Table 7 depicts the connection between GSCM, (GC) hurdles to BGCM, and sustainability in SCM. The direction and strength of these associations are shown in the standard error (Std. Err.), z-value, level of significance (P > |human|), and confidence interval ([95% Conf. Interval]) of each path coefficient (OIM Coef.). The results also indicate that GSCM significantly affects GC (coefficient = 0.612, z = 4.391, p < 0.000). Sustainability has a positive relationship with GSCM (coefficient = 0.588, z = 4.005, p < 0.001). This suggests that green supply chain practices contribute to sustainability. The association is strong, with a confidence interval (0.349, 0.466), indicating a notable effect of GSCM on SSCM.

The positive effect of GC on supply chain sustainability is also evident, with a path coefficient of 0.519 (z = 3.548, p < 0.001). This finding indicates that supply chain sustainability initiatives are motivated by GC practices. The confidence interval (0.269, 0.769) is broad but supports the effect of GC on SSCM. The mediation between GSCM and sustainability occurs through GC, with a mediation path coefficient of 0.492 (z = 3.360, p < 0.001). This mediation suggests that GSCM methods foster creativity and improve sustainability outcomes. A strong relationship exists between GSCM and SSCM, as indicated by a confidence interval of (0.255, 0.728). The moderate coefficient of 0.517 (z = 11.430, p < 0.001) demonstrates that impediments to green chain management moderate the relationship between sustainability and GSCM. This implies that GSCM initiatives should address financial or technological bottlenecks

to enhance sustainability. The confidence interval (0.292, 0.895) is narrow, highlighting the significant mediating role of BGCM in the interaction between GSCM and SSCM.

Table 7. Path analysis.

Variable	OIM Coef.	Std. Err.	z	P>|z|	[95% conf. interval]	
(GSCM) significantly influences SSCM.	0.588	0.208	4.005	0.000	0.349	0.466
(GSCM) significantly influences GC	0.612	0.274	4.391	0.000	0.227	0.671
GC significantly influences SSCM.	0.519	0.128	3.548	0.000	0.269	0.769
GC significantly mediates the relationship between GSCM and SSCM.	0.492	0.121	3.360	0.000	0.255	0.728
Barriers of GSCM significantly moderate the relationship between GSCM and SSCM.	0.517	0.148	11.430	0.000	0.292	0.895

6. DISCUSSION

It is important to question the complex interdependence between green supply chain management, green creativity, and supply chain management methods in an era where environmental sustainability is the primary issue of concern among companies. Not only does this research reveal that both GSCM and GC play an important role in achieving sustainable supply chain results, but it also provides in-depth information on how these two factors interrelate to achieve positive results for society, the economy, and the environment. This discussion demonstrates that GSCM is viewed as a way of enhancing sustainability, GC is viewed as a mediator, and the potential obstacles to green chain management can be viewed as a moderator. The current work integrates both empirical and theoretical understanding (the theory of dynamic capabilities and the resource-based view) to provide a clear image of the strategic applicability of sustainable supply chain practices and the potential challenges that contemporary businesses could encounter in their pursuit of sustainability.

The recognition of the original theory that explains the essential role of GSCM in SSCM indicates that environmental issues should be integrated into supply chain operations. The outcomes affirm a substantial level of evidence that GSCM improves environmental performance. Emissions, waste, and resources can be reduced by firms through green sourcing, production, transportation, and post-production (take-back) of products. The theory also shows that GSCM is an environmental, economic, and sustainable initiative. GSCM enhances brand awareness, work effectiveness, and waste minimization (Huang et al., 2022). The power of GSCM is that it lowers the degree of employment and stakeholder engagement, resulting in social sustainability (Alkhatib, 2023). Evidence confirms that GSCM is an important concept in improving supply chain sustainability. The second hypothesis confirms that GSCM and its practices emphasize the necessity of a sustainable supply chain in motivating company innovation. GSCM practices include eco-design, reverse logistics, and environmental purchasing, which enhance positive environmental performance and sustainable products and processes. These results confirm existing research and demonstrate the efficiency of such efforts. Global supply chain management (GSCM) promotes creativity by involving suppliers and stakeholders, ensuring environmental compliance, and highlighting the supply chain. This association implies that organizations oriented toward GSCM have higher chances of innovating and gaining a competitive edge. Supply chain management needs to be sustainably integrated.

The third hypothesis that GC has a significant influence on the sustainability of the SCM stresses the need for new solutions. This is consistent with past studies on green product and process enhancements that would result in improved environmental performance and operational efficiency (Rodrigues & Franco, 2023). Through GC, companies produce green products, practices, and technologies. The advantages of these are low emissions, less waste, and economic and social benefits. Green product development helps reach environmentally conscious consumers, increasing market share and customer loyalty. Green process creativity conserves money in terms of energy and materials. The social sustainability of GC is enhanced because the products created and working conditions are safer

and healthier. This demonstrates how GC is applicable to supply chain sustainability. Assuming these premises, it shows how GSCM and GC boost SSCM. GSCM approaches help integrate environmental issues into supply chain operations, but GC improves them. Theories such as dynamics and resource-based view (RBV) state that GC is a strategic resource and dynamic capability that enhances GSCM's sustainability impact. Strong GSCM processes and GC improve environmental, economic, and social sustainability. GC increases the sustainability of GSCM. Sustainability requires firms to focus on GSCM and GC.

The fourth hypothesis emphasizes the creative role of green practices in mediating the relationship between GSCM and SCM, highlighting its contribution to shifting GSCM practices toward a sustainability perspective. According to the dynamic capabilities hypothesis, firms must be innovative to remain competitive and address environmental issues (Le et al., 2022). This study reveals that green capabilities (GC) enhance the environmental and operational performance of GSCM. GC in GSCM assists firms in creating green products and processes that meet regulations and exceed customer sustainability goals. Green practices and creativity reduce carbon footprints, improve resource productivity, and enhance market competitiveness (Kumar et al., 2024). The mediating role of GC in enabling GSCM to achieve full sustainability serves a strategic purpose. However, the relationship between GSCM and SCM is affected by barriers, as outlined in the fifth hypothesis. These obstacles include high start-up costs and low ROI, which can slow GSCM adoption and success. Additionally, the lack of advanced technology and infrastructure can pose significant barriers to green program implementation (Rodrigues & Franco, 2023).

Resistance by the organization to GSCM is moderate, whether culturally or management-based. Once these challenges are overcome, firms will be able to leverage the impact of GSCM on SCM to the maximum and even initiate sustainability projects. The receptiveness to these ideas indicates that there is an influence of GC, barriers, and GSCM on supply chain sustainability. Both the institutional theory and the resource-based view explain such dynamics. The boundary of the legislative environment, market demand, and the organizational environment, including culture and leadership, significantly control GSCM adoption and performance in the institutional theory. Another RBV implication is that firms may gain a competitive edge through the utilization of unique resources and capabilities, such as GC in general, to transcend limitations and improve GSCM.

The present research practically contributes empirical support to these theoretical assumptions and emphasizes the need for companies to investigate the mediating effect of GC along with the moderating effect of barriers. GC appears to be an alternative that firms need to invest in to develop greater environmental performance and address the constraints of GSCM. These measures would assist firms in developing more resilient and sustainable supply chains that can achieve long-term sustainability goals.

All of the five hypotheses have been approved, which proves the fact that GSCM and GC can revolutionize the process of supply chain sustainability management. GSCM has a high level of correlation with sustainability, and GC mediates its environmental, economic, and social implications. The obstacles on the way to the realization of the maximum effects of GSCM should not be merely overcome but addressed deliberately. Based on empirical data and theoretical ideas, this paper highlights the need to introduce innovative approaches and break systemic obstacles. These insights can be useful in helping companies negotiate sustainability and assist in the enhancement of supply chain operations, thereby increasing the resilience of the global economy.

7. CONCLUSION

This paper highlights the significance of Green Supply Chain Management (GSCM) and Green Coordination (GC) in enhancing the sustainability of supply chains, particularly within the beverage industry in Iraq. The empirical study demonstrates that GSCM positively impacts sustainability outcomes and that GC mediates the relationship between GSCM and supply chain sustainability. Additionally, the research identifies obstacles to green chain management that hinder the success of GSCM in achieving sustainable supply chain management (SCM). The findings suggest that GSCM practices can improve sustainability performance by promoting environmentally

friendly innovation and reducing barriers. These results have important implications for both theory and practice, emphasizing the need for business organizations to adopt environmentally friendly strategies and innovative approaches to navigate modern supply chains. Furthermore, the study clarifies the active connections between GSCM, GC, and sustainable SCM. It also provides a valuable guideline for future research and practice aimed at attaining long-term supply chain sustainability.

7.1. Implications of the Study

The research theory is connected to numerous SCM and sustainability domains. GSCM processes are necessary to achieve supply chain sustainability, as explained in the paper. GSCM enhances SSCM in an experimental manner, which confirms theoretical approaches that emphasize green supply chain practices to achieve environmental, economic, and social advantages. This indicates that sustainable operations could increase competitiveness and survival. Theoretical value is added to GSCM through (GC), which connects GSCM and SSCM. By endorsing the creativity of sustainable practices, companies can augment the benefits of green supply chain activities and improve and transform the setting. It is possible to learn how creativity can mediate the green supply chain approach to increase sustainability performance. The research also demonstrates the role played by green chain management hurdles in mitigating the GSCM-SSCM relationship. This theory highlights the factors involved in attaining a green supply chain in businesses, which are subtle. These financial, technological, and organizational challenges could be addressed by scholars and practitioners to enhance supply chain sustainability plans and policies.

This study can aid businesses and political leaders in improving the sustainability of the supply chain. The results emphasize the connection of GSCM to organizational strategies. However, taking environmental responsibility seriously in the entire supply chain activities assists companies in not only complying with regulatory requirements, reducing adverse effects on the environment, and satisfying consumer needs regarding sustainable products and undertakings. Practically, efficiency and waste reduction decrease costs, enhance profitability, and increase competitiveness in the market. GSCM is a sustainability-driven concept; therefore, firms need to invest in research and development to create and introduce green-friendly products and processes. Promoting creativity and sustainability allows businesses to stand out, appeal to the environmentally conscious market, and be recognized as good corporate citizens. To make a successful application, barriers to green supply chain management must be addressed. Challenges such as financial limitations, technology, and resistance to change can be overcome to help organizations enhance their green supply chain initiatives. The practical implications focus on strategic planning, stakeholder involvement, and cooperation with supply chain partners to surmount these limitations.

7.2. Limitations and Future Research Directions

Although contributions have been made and some conclusions drawn, there are certain limitations that should be acknowledged. Firstly, cross-sectional data does not permit establishing causality in the research. Epidemiology, path analysis, and mediation/moderation tests indicate relationships; however, longitudinal research could reveal how these constructs vary over time and their overall impact on sustainability. The study focuses on a single industry or location, which may limit its applicability. To improve external validity, future research should consider examining these correlations across different industries, geographies, and cultures. Secondly, GSCM, GC, green chain management impediments, and sustainability measurement are based on survey data. The common method bias remains a concern despite thorough evaluation of reliability and validity. Triangulation of findings and a deeper understanding of these complex aspects could be achieved in future studies through the use of objective performance measures and case studies.

This discussion indicates a number of interesting research alternatives. To start with, longitudinal research may be conducted to determine the nature of changes in (GSCM) practices, GC, impediments, and sustainability outcomes over time. Such studies would shed light on the temporal impact and causal relationships, as they would help

stakeholders in the supply chain understand the dynamics of these variables and how they interact with one another. Second, cross-industry and cross-national comparative studies on green supply chain adherence and effectiveness could be carried out. Knowledge of industry-specific sustainability concerns and opportunities would allow for an individual approach to improving environmental performance in industries and implementing specific strategies and laws. The way suppliers, customers, and regulators influence (GSCM) practices and sustainability can be studied in future research. Sustainable SCM stakeholder engagement and collaboration initiatives may be informed by stakeholder views, motives, and behaviors. Qualitative case studies and mixed-method approaches can also help identify situational factors that influence the execution and success of green supply chain initiatives. This type of research would be able to capture dynamics in organizations, leadership approaches, and culture at work on SSCM.

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Institutional Review Board Statement: The study protocol was approved by the IRB of Kerbala University, Iraq. Informed verbal consent was obtained from all participants, and all data were anonymized to protect participant confidentiality
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
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