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Green Supply Chain Management in Bangladesh's Textile Industry: Driving Environmental, Economic, and Social Sustainability

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Abstract

Textile industries in Bangladesh are shifting towards a sustainable future, and as a result, many firms are implementing Green Supply chain Management (GSCM). This study aims to evaluate if practicing GSCM in different areas of industry positively impacts environmental, economic, and social performance. Regarding this issue, this paper observes the scopes, drivers, and barriers of practicing GSCM and reviews it. Therefore, the research investigates, through empirical analysis based on responses from 104 textile firms, the influence of GSCM practices on environmental, economic, and social performance. Results confirm that GSCM improves environmental sustainability by reducing emissions, waste, and resource use. It enhances economic performance through cost savings and efficiency gains and also offers several social advantages, improved worker satisfaction, and community engagement. The results bring to light the potential role that GSCM can play in making the textile industry sustainable, along with suggesting policy interventions and further research on longitudinal impacts and advanced technological integration.

Keywords: Bangladesh, GSCM, Supply Chain, Sustainability, Textile

1. INTRODUCTION

Green Supply Chain Management (GSCM) is an advanced management mode considered to quantitatively take environmental impact, resource utilization efficiency, and enterprise income into account during the entire process of supply chain (Li, 2024a). The focus is to reduce or eliminate wastages using traditional supply chain management accentuating environmental thinking, like removing hazardous chemicals, end-of-pipe emissions, energy, and solid waste along the supply chain (Chin et al., 2015a). Interestingly, while GSCM is widely recognized as essential for organizations to survive and prosper in the global market and networked economy (Xu et al., 2013), some studies have found contradictory results. For instance, supplier selection and supplier evaluation, which are considered essential GSCM practices, were found to have little impact on sustainable performance in one study (Chin et al., 2015b).

In the past decade, the textile industry has come under increasing pressure worldwide to implement best practices that result in a lesser environmental footprint. Stakeholders in governments, consumers, and environmental advocates have voiced growing concerns that it is time industries took responsibility for pollution, resource depletion, and labor welfare. Government regulations and standards, along with environmental management certification (ISO 14000), are also critical driving factors (Banik et al., 2022; Gupta & Gupta, 2021). Bangladesh is considered a global leader in textile production, mainly in the Ready-Made

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Garments sector, and faces a crossroads between economic growth and sustainability challenges. While the RMG sector's contribution to the national GDP and export earnings is immense, environmental degradation and social issues cannot go unaddressed (Ahmed et al., 2023).

Accordingly, Green Supply Chain Management emerges as the game-changing remedy that can balance the economic imperative with ecological stewardship and social responsibility. Therefore, GSCM would address regulatory compliance and meet the rising demand for eco-friendly products by bringing in an environmentally friendly material sourcing process, efficient use of energy, and minimization of waste, among other practices. Bangladesh's textile sector faces several obstacles in implementing GSCM. These include financial instability, outdated technology, and insufficient awareness among industry players.

This paper investigates the GSCM in reshaping Bangladesh's textile industry by assessing scopes, drivers, and barriers. In this context, it investigates how the electronically transmitted GSCM practices, through an extensive review of existing literature and necessary empirical analysis, are affecting environmental, economic, and social outcomes. Additionally, this research has tried to find out actionable strategies for overcoming the implementation hurdles and underlined the long-term benefits of a green supply chain for attaining sustainability.

2. LITERATURE REVIEW

Several researchers have worked on identifying the scopes of implementing GSCM in textile industries, their drivers and barriers, and the impact of adopting GSCM. The following section summarizes the scopes, enablers, barriers, and their impact with reference to environmental, economic, and social factors and establishes a linkage between the pre-implementation and post-implementation scenarios using both qualitative and quantitative parameters.

Green Supply Chain Management

Green supply chain management (GSCM) integrates eco-friendly practices throughout the supply chain, taking into account every stage of a product's lifecycle—from sourcing raw materials to delivering the finished product to customers and handling its disposal or recycling at the end of its use (Ghapar et al., 2024; Srivastava, 2007). While traditional supply chains prioritize cost and efficiency, green supply chains balance these factors with environmental impact, often leading to long-term benefits such as improved brand reputation and regulatory compliance (Choi et al., 2023). Numerous research studies have identified

several important factors that can cause industries to shift towards GSCM. Governments throughout the world are enforcing stringent laws about pollution and climate change, and textile firms need to embrace green methods to comply with these laws, keep out of trouble, and lower their risk of legal issues (Gupta & Gupta, 2021). Consumers are becoming more eco-conscious and are demanding more sustainable and ethically produced textiles. (Jum'a et al., 2022) highlights that this global sustainability movement encourages firms to adopt green practices into their commercial supply chains to meet their demand and differentiate themselves in the marketplace.

Bangladesh's textile sector has expanded substantially, especially in the production of ready-made garments (RMG). The RMG sector accounts for approximately 80-85% of Bangladesh's total export earnings (Mollah et al., 2024). It is projected that by 2025, RMG exports from Bangladesh will reach nearly $70 billion (Ahmed et al., 2023). However, the industry's rapid expansion has severe environmental consequences, including water pollution, noise pollution, and waste generation (S. M. Tazim Ahmed & Chitra Lekha Karmaker, 2019. The sector also faces problems such as low productivity and efficiency, high lead time, high cost of quality, and low rate of 'Right First Time' (Hasan et al., 2022). The sector is struggling to keep its workers satisfied (Islam, 2023). Workers face issues related to health, safety, security, social relations, and livelihood crises. To address these pressing environmental and social challenges, the adoption of GSCM practices has indeed become crucial in the Bangladeshi textile sector (Habib & Bao, 2019).

Scopes and practices of GSCM

The purview of Green Supply Chain Management (GSCM) surpasses conventional supply chain management by incorporating environmental effects, resource efficiency, and organizational profitability across the full supply chain continuum. GSCM involves incorporating environmental considerations into supply chain operations, covering green design, procurement, manufacturing, packaging, and recycling initiatives. (Li, 2024b).

A relation between GSCM practices and GSCM drivers was investigated by (Wu et al., 2012), GSCM practices encompass activities like sustainable purchasing, collaborative partnerships, investment recovery, and environmentally conscious design. The concept of GSCM also involves factors such as organizational commitment, government participation, and the role of social networks or community support. The paper adopts a hierarchical moderated regression model to rigorously analyze the influence of regulatory and competitive pressures on organizational strategies within institutional markets. This method provides a structured approach to evaluate how external factors interact with institutional frameworks,

contributing to a comprehensive understanding of their effects on operational and strategic outcomes.

Researchers identified different approaches and scopes for implementing GSCM in various areas of the textile sector. Table 1 shows different areas and scope of implementations of the practices related to GSCM-

Table 1: Different Scopes for Implementing GSCM

Area	Scope of implementations
1. Raw Material sourcing	The use of green textile materials involves incorporating organic fibers, eco-friendly dyes, and chemicals, as well as enzymatic and other environmentally safe processing methods. These practices aim to reduce the environmental impact of textile production while promoting sustainability (Choudhury, 2017)
2. Manufacturing Process	Minimizing waste through greener production techniques and implementing waterless pre-treatment and dyeing processes (Hasanbeigi & Price, 2015a)
3. Packaging,	Using sustainable and renewable (such as cotton, silk, and paper) materials, more compact and lightweight packaging options (Asim et al., 2022)
4. Transportation and Logistics,	Ensuring green transportation, such as slow steaming, voyage optimization, and efficiency in port operations are some key factors (Saada, 2021)
5. Energy Management	Utilizing energy-efficient equipment and harnessing renewable energy sources such as solar or wind power ("Siemens Starts German Green Hydrogen Plant," 2021)
6. Waste Management,	Implementing recycling and upcycling practices for textile waste and adopting a zero-waste policy (Abrishami et al., 2024)
7. Supplier Collaboration	Working with suppliers to ensure adherence to environmental standards, supporting sustainable practices, and co-developing green innovations (Vachon & Klassen, 2008).
8. Corporate Social Responsibility	Engaging in activities beyond regulatory requirements to promote sustainability, such as community development and responsible marketing (Caniato et al., 2012).

These strategies are essential for changing an industry's supply chain from a traditional one to a sustainable and greener one. In conclusion, GSCM practices provide a comprehensive approach to sustainable supply chain management, covering various supply chain stages. Although the adoption of these practices is increasing, there is still room for improvement, especially in areas such as reverse logistics and supplier evaluation for environmental practices (Li, 2024b).

Barriers of GSCM in the textile industry

Although GSCM has become a critical strategy for achieving sustainability in the textile industry, many firms still struggle to implement it on a large scale due to various barriers. Researchers used different structures to establish the barriers, mainly the 'Decision-Making Trial and Evaluation Laboratory (DEMATEL)' method and the 'Interpretive structural Modeling (ISM)' method. An analysis of 14 barriers, derived from both literature reviews and expert opinion surveys, highlighted the absence of effective governmental policies and inadequate infrastructure as the most critical obstacles to achieving sustainability. These issues were identified as requiring the highest level of attention from decision-makers to drive meaningful progress (Gardas et al., 2018). (Majumdar & Sinha, 2019) addressed the barriers to green textile supply chain management in Southeast Asia using the ISM approach, arranging the barriers in seven levels of hierarchical structure, where the complexity of green process and system design was pointed as the most rudimentary barrier. It is not wise to address all the barriers all at once and try to overcome them, as different industries have different sets of goals and motivations for pivoting into GSCM, which is highly influenced by the economic point of view. So, it is better to handle these obstacles and improve the application of GSCM techniques by organizing them into distinct categories (Susanty et al., 2023). In this process (Jianguo & Solangi, 2023) identified Technological, Financial, and Information and knowledge-related challenges as the most significant ones.

Technological Challenges

Many textile companies depend on traditional manufacturing processes that are not conducive to sustainable practices. In order to incorporate new technology Organizations must integrate it into their current systems, which can be difficult and expensive. (Hasanbeigi & Price, 2015b) provides a comprehensive summary of processes in the textile industry, consolidating key details about 18 emerging technologies designed to lower energy consumption and environmental emissions. It includes insights into energy savings,

ecological advantages, associated costs, commercialization progress, and references for further exploration.

Financial Challenges

Switching to green technologies is often a high up-front cost, but securing sufficient capital may be difficult for many companies, especially small and medium-sized enterprises (SMEs). ROI It is also long-term returns of investment in sustainable practices may not be conducive to the immediacy associated implementation of GSCM, creating skepticism with sustainability benefits (Muduli et al., 2013).

Information and Knowledge-Related Challenges

Lack of awareness of the stakeholders of the GSCM practices and their benefits results in companies struggling to find or develop the necessary expertise to implement GSCM effectively. Effective GSCM requires accurate data on environmental impacts, resource usage, and supply chain practices. Inadequate data management systems can impede decision-making (Eltayeb et al., 2011).

Qualitative and Quantitative Parameters in Supply Chain Management

The operationalization of GSCM is a broader area and requires further examination from qualitative and quantitative perspectives. In tandem, the qualitative talks about either around change in organizational culture or awareness level and Corporate Social Responsibility (CSR). These are more intangible, speculative, and difficult-to-measure dimensions but a way of attempting for the long-lasting experience of GSCM practices. (Wang et al., 2020) The study examined the connections between corporate social responsibility (CSR), green supply chain management (GSCM), and firm performance, highlighting the role of big-data analytics capability. It found that big-data analytics strengthens the positive links between CSR, GSCM, and overall performance in China's manufacturing sector.

Quantitative parameters, however, provide measurable data on GSCM effectiveness. These were energy consumption, water usage and waste generation alongside land use changes (deforestation), carbon emissions or production costs. In this regard, the textile industry of Bangladesh specifically had been characterized by shortcomings in these areas prior to committing itself to GSCM. The lack of green practices led to extensive water wastage, chemical pollution, and energy overconsumption (Iqbal et al., 2019; Oprea et al., 2020).

Research Framework and Hypothesis Development

The implementation of GSCM has been an essential practice from a worldwide perspective driven by many environmental and social challenges, as well as rules and regulations for environmental safety and sustainability. Also, the benefits of practicing the GSCM drive industries to implement it, (Emon, 2024) highlighted the key benefits of executing GSCM: 1. Environmental Sustainability, 2. Economic performance, and 3. Social Well-Being. Evaluating the current literature study, we selected the key areas where practicing GSCM will have the most impact, and we developed a research model (Fig 1) and developed three hypotheses.

H1 : Implementing GSCM practices has a positive effect on the environmental performance of Bangladesh's textile industry.

H2 : Implementing GSCM practices has a positive effect on the economic performance of Bangladesh's textile industry.

H3 : Implementing GSCM practices has a positive effect on the social performance of Bangladesh's textile industry.

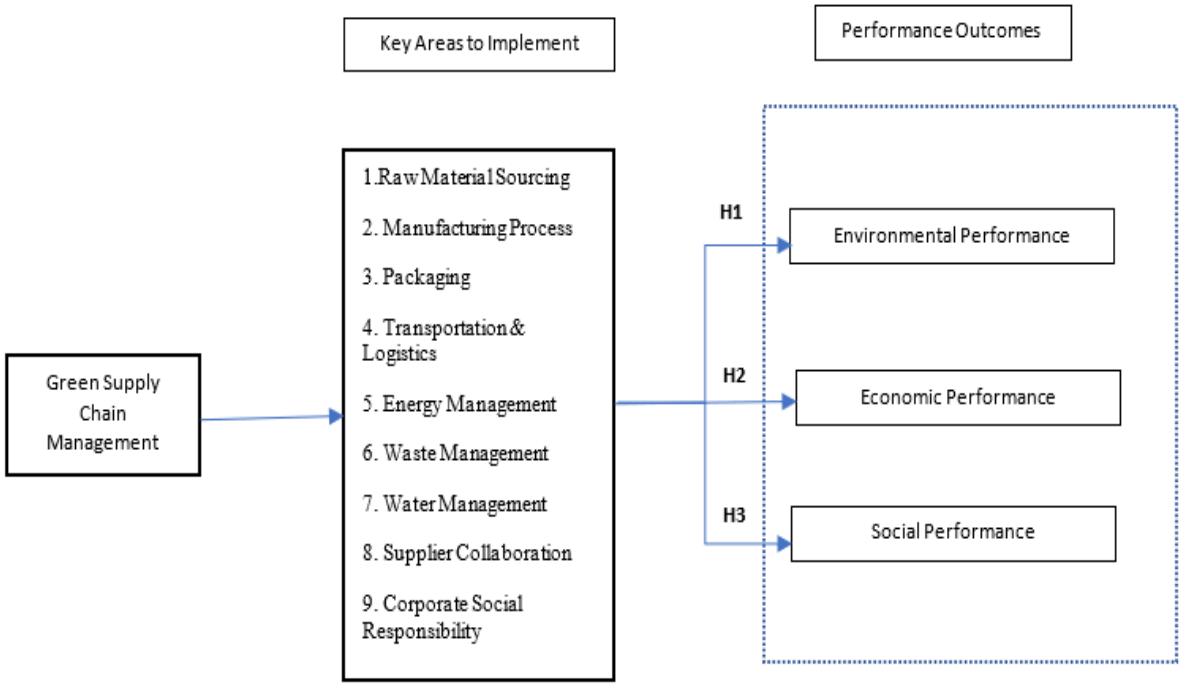

Figure 1: Research Framework

3. METHODOLOGY

Sample and Data Collection

This study's population is the textile manufacturing industry In Bangladesh, which has implemented GSCM fully or partially. We collected 104 datasets from different textile industries in Bangladesh, and the sample respondents in this study are employed supply chain managers and production managers in different textile manufacturing firms in Bangladesh. We conducted an online survey and collected data from industry experts to gather the necessary data. We used a questionnaire survey method, a popular method where we set structuring questions for data collection and then use them to analyze the relationship among the variables and check the hypothesis. We used a 5-point Likert scale to measure respondents' attitudes on particular questions. For example, it ranges from 1 to 5 for a specific question like “Does practicing CSR positively improve social performance?” where 1 reflects “Not at all” and 5 reflects “Always”.

Data Analysis Procedure

We analyzed the data differently to test all three hypotheses with different independent and dependent variables. Here, the areas of GSCM implementations were determined according to Table 1, and they influenced the different performance outcomes.

A Pearson chi-square test has been conducted to check H1, H2, and H3.

H1 : The null hypothesis posits that GSCM practices like using sustainable materials, adopting renewable energy, implementing green energy-saving methods, employing sustainable packaging, recycling waste, and monitoring carbon emissions have no effect on environmental performance. On the other hand, the alternative hypothesis suggests that these GSCM practices significantly influence environmental performance.

H2 : We take a null and an alternative hypothesis. The null hypothesis posits that GSCM practices like using Sustainable materials, Green Transportation, Greener Production Techniques, Green Energy Saving Processes, and waste recycling processes have no impact on economic performance. On the other hand, the alternative hypothesis suggests that these GSCM practices significantly influence economic performance.

H3 : We take a null and an alternative hypothesis where the null hypothesis posits that GSCM practices like Supplier Collaboration Practice and practicing CSR have no impact on social performance. On the other hand, the alternative hypothesis suggests that these GSCM practices significantly influence social performance.

4. RESULTS

Hypothesis-1 Test

Table 2: Calculation of chi-square for H1

Observed Value						
GSCM implementation	Always	often	Sometimes	Rarely	Not at all	Total
Sustainable Materials	28	27	29	14	6	104
Renewable Energy Usage	29	42	22	10	1	104
Green Energy Saving Process	31	41	28	3	1	104
Sustainable Packaging Process	33	38	28	4	1	104
Waste Recycling Management	37	31	26	6	4	104
Carbon Emission Monitoring	35	38	19	11	1	104
Total	193	217	152	48	14	624
Expected Value						
GSCM implementation	Always	often	Sometimes	Rarely	Not at all	
Sustainable Materials	32.166667	36.16667	25.3333333	8	2.33333333	
Renewable Energy Usage	32.166667	36.16667	25.3333333	8	2.33333333	
Green Energy Saving Process	32.166667	36.16667	25.3333333	8	2.33333333	
Sustainable Packaging Process	32.166667	36.16667	25.3333333	8	2.33333333	
Waste Recycling Management	32.166667	36.16667	25.3333333	8	2.33333333	
Carbon Emission Monitoring	32.166667	36.16667	25.3333333	8	2.33333333	
(O-E)^2/E						
GSCM implementation	Always	often	Sometimes	Rarely	Not at all	
Sustainable Materials	0.5397237	2.323349	0.53070175	4.5	5.76190476	
Renewable Energy Usage	0.3117444	0.94086	0.43859649	0.5	0.76190476	
Green Energy Saving Process	0.0423143	0.645929	0.28070175	3.125	0.76190476	
Sustainable Packaging Process	0.0215889	0.092934	0.28070175	2	0.76190476	
Waste Recycling Management	0.7262522	0.738095	0.01754386	0.5	1.19047619	
Carbon Emission Monitoring	0.2495682	0.092934	1.58333333	1.125	0.76190476	
Degree of Freedom	(6-1)*(5-1)					
	20					
X^2	31.60687204					
Level of significance	0.05					
p-value	0.047671681					

With a significance level set at 0.05 and a p-value falling below this threshold, the null hypothesis is rejected. This leads us to accept the alternative hypothesis, which states that GSCM practices play a significant role in improving environmental performance.

Hypothesis-2 Test

Table 3: Calculation of chi-square for H2

Observed Value						
GSCM implementation	**Always**	**Often**	**Sometimes**	**Rarely**	**Not at all**	**Total**
Sustainable material	36	39	17	7	5	**104**
Green Transportation	33	38	21	5	7	104
Greener Production Technique	37	47	17	2	1	104
Green Energy Saving Process	35	33	26	1	9	104
Waste Recycling Process	23	48	27	4	2	104
Total	128	166	91	12	19	416
Expected Value						
GSCM implementation	Always	often	Sometimes	Rarely	Not at all	
Sustainable material	32	41.5	22.75	3	4.75	
Green Transportation	32	41.5	22.75	3	4.75	
Greener Production Technique	32	41.5	22.75	3	4.75	
Green Energy Saving Process	32	41.5	22.75	3	4.75	
Waste Recycling Process	32	41.5	22.75	3	4.75	
(O-E)^2/E						
GSCM implementation	Always	often	Sometimes	Rarely	Not at all	
Sustainable material	0.5	0.150602	1.453296703	5.333333	0.013158	
Green Transportation	0.03125	0.295181	0.134615385	1.333333	1.065789	
Greener Production Technique	0.78125	0.728916	1.453296703	0.333333	2.960526	
Green Energy Saving Process	0.28125	1.740964	0.464285714	1.333333	3.802632	
Waste Recycling Process	2.53125	1.018072	0.793956044	0.333333	1.592105	
Degree of Freedom	(5-1)*(5-1)					
	16					
X^2	30.45906268					
Level of significance	0.05					
p-value	0.015762402					

With a significance level set at 0.05 and a p-value falling below this threshold, the null hypothesis is rejected. This leads us to accept the alternative hypothesis, which states that GSCM practices play a significant role in improving economic performance.

Hypothesis-3 Test

Table 4: Calculation of chi-square for H3

Observed Value						
GSCM implementation	**Always**	**Often**	**Sometimes**	**Rarely**	**Not at all**	**Total**
Supplier Collaboration Practice	25	50	24	3	2	104
Practicing CSR	40	36	16	7	5	104
Total	65	86	40	10	7	208
Expected Value						
GSCM implementation	**Always**	**often**	**Sometimes**	**Rarely**	**Not at all**	
Supplier Collaboration Practice	32.5	43	20	5	3.5	
Practicing CSR	32.5	43	20	5	3.5	
(O-E)^2/E						
GSCM implementation	**Always**	**Often**	**Sometimes**	**Rarely**	**Not at all**	
Supplier Collaboration Practice	1.730769	1.139535	0.8	0.8	0.642857	
Practicing CSR	1.730769	1.139535	0.8	0.8	0.642857	
Degree of Freedom	(5-1)*(2-1)					
	4					
X^2	10.22632251					
Level of significance	0.05					
p-value	0.036783083					

With a significance level set at 0.05 and a p-value falling below this threshold, the null hypothesis is rejected. This leads us to accept the alternative hypothesis, which states that GSCM practices play a significant role in improving social performance.

5. DISCUSSION

The objective of this paper is to evaluate the effects resulting from the practice of GSCM in Bangladesh's textile industries. Since industries are geared towards adopting ways that ensure sustainability in operations, this research will find out if GSCM adoption is being abandoned from an industrial perspective. We presented and tested the hypothesis on grounds of environmental, economic, and social performance based on GSCM adoption.

The findings confirmed that GSCM practices are statistically perceived to exert a positive impact on environmental performance, further influenced by the use of sustainable materials and renewable energy through the adoption and implementation of better methods of waste management. The analysis showed that GSCM practices positively affect economic performance. For instance, the green energy-saving processes and greener techniques of

production applied in the study significantly reduced operating costs, hence increasing profitability.

The qualitative analysis carried out in this study indicated that GSCM practices have a positive effect on social performance. Firms implementing GSCM demonstrated increased worker satisfaction, community involvement, and greater social responsibility.

6. CONCLUSION

This study specifically evaluates the effects of GSCM practices on environmental, economic, and social performances in the textile firms operating in Bangladesh. The results have subsequently confirmed that the adoption of green supply chain management practice like assisting in sustainable materials usage, renewable energy absorption, waste management, and cooperation with supplier finds a huge reduction in carbon footprint emissions, water conservation, and overall improvement of the waste recycling rate in environmental sustainability.

Economically, GSCM practices spur cost efficiency, profitability, and operational effectiveness, establishing them as doing business and perhaps as a long-term investment asset for companies. Socially, methodologies enhance employee satisfaction by improving the community and standards of corporate responsibility that concretely set its view of creating societal benefit.

However, the study also detected significant barriers in the form of financial constraints, technological limitations, and lack of knowledge, especially for smaller firms. Such challenges need specific policy interventions, capacity-building programs, and closer collaboration among stakeholders. The findings herein prove GSCM as a potential game changer for achieving sustainable development in the textiles sector of Bangladesh. To this effect, addressing the identified barriers coupled with promoting several benefits from GSCM practices shall be imperative if wide diffusion is to be achieved. Longitudinal effects, larger sample sizes, and more sophisticated technologies that could accelerate the shift toward sustainable supply chain practices are some aspects that future studies should focus on.

With GSCM embedded into their core strategies, the competitive advantages of textile firms in Bangladesh will increase, hence making significant contributions towards international sustainability.

7. LIMITATION

While the study provides valuable insight, it also analyzes the categorial data, which do not represent continuous measurements but reflect levels of agreement or frequency. Potential mediating variables could be better explained by analyzing grassroots technologies that enhance capabilities, big-data analytics, or automation. It can also determine a synergistic relationship between environmental and economic performance to test if improving environmental practices positively influences economic performance. It is also recommended that in the future, research should be done on further increasing the sample size and study the longitudinal effect of GSCM on performance metrics.

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