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"THE IMPACT OF GREEN SUPPLY CHAIN MANAGEMENT PRACTICES ON ORGANIZATIONAL SUSTAINABILITY: EVIDENCE FROM THE SAUDI RENEWABLE ENERGY SECTOR"

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ABSTRACT

This study examines the relationship between Green Supply Chain Management (GSCM) practices and organizational sustainability in the Saudi renewable energy sector within the framework of Saudi Vision 2030. Data were collected from 200 managers and supply chain professionals and analyzed using SPSS and AMOS, confirming strong reliability (Cronbach's α = 0.81, 0.87). Structural equation modeling revealed that risk management exerted the strongest positive influence on sustainability (β = 0.36), while eco-friendly logistics, though weaker, still showed a meaningful effect (β = 0.25). Green procurement and supplier collaboration also contributed positively to economic, social, and environmental outcomes. The model explained a significant portion of sustainability performance variance. Findings underscore that GSCM practices enhance organizational resilience, competitiveness, and alignment with national sustainability goals. This study offers both theoretical and practical contributions, highlighting the strategic importance of supply chain management for advancing sustainable development in the renewable energy sector.

KEYWORDS: Green Supply Chain Management, Organizational Sustainability, Renewable Energy, Saudi Arabia, Structural Equation Modeling (SEM) and SPSS.

1. INTRODUCTION

The increased global attention on clean and renewable energy has placed sustainability at the forefront of organizations 'plans. Saudi Arabia, through Vision 2030, is embarking on a transition in sustainability and carbon reduction, aligning with a global obligation of carbon emissions reduction while also looking at more than one source of energy and investing in renewable energy. This transition will require organizations, especially in the energy sector, to innovate as well as embed sustainability into their practices and organizational strategy. One of the most pertinent issues associated with this transition is Green Supply Chain Management (GSCM). Every organization can implement GSCM practices uniquely according to their company circumstances and in utilizing green buying, green suppliers, green logistics, and collaborative engagement with suppliers, together with waste reduction, they can help companies obey the relationship of economic performance with their environmental and social responsibility. While GSCM practices are valued globally by organizations and there are many studies that have investigated GSCM, no one seems to really understand how the GSCM practices support the adoption of organizational sustainability, especially in transitions that are growing, like the renewable energy sector in Saudi Arabia. The lack of studies may be attributed to the limited resources of adequate financial means, specialized human resources, proper training on sustainable practices, and stakeholder engagement to enact GSCM practices.

1.1. Research Gap

While many studies have examined the GSCM performance and sustainability-related factors, almost all of these studies have been conducted in a manufacturing and industrial context, which creates a research gap in the renewable energy domain. For example, Hejazi et al. (2023) found clear evidence of GSCM practices having a positive significant impact on environmental, social, and economic sustainability performance for manufacturing firms in Saudi Arabia. However, because the subsequent research was industry based, there is no generalizability to renewable energy. Similarly, Alkandi et al. (2024) examined GSCM, lean management, and corporate social responsibility concepts in the Saudi industrial context [2]. They found that lean management mediates the link between GSCM and business performance. However, the context of their study did not include renewable energy despite the fact that renewable energy is a priority of Saudi Vision 2030. Therefore, although the Saudi renewable energy sector and the literature around it is strategically important, there remains limited evidence that uses advanced statistical such as SPSS and AMOS SEM to empirically study how GSCM initiatives impact organizational sustainability. For these reasons, this study intends to address this research gap.

1.2. Significance of the Study

It is essential given that it will explore a significant gap in existing knowledge concerning how GSCM practices impact organizational sustainability in the context of the renewable energy sector in Saudi Arabia, a critical pathway toward achieving Vision 2030 sustainability objectives. This study utilizes advanced statistical methods SPSS and AMOS-based structural equation modeling SEM to provide strong empirical data on the relationships between dimensions of GSCM, which include green procurement, eco-logics, supplier engagement, and risk and dimensions of sustainability - of which there are also three: environmental sustainability, social sustainability, and economic sustainability. This study will advance theory and practice by providing practical implications for managers and policymakers to improve and develop sustainable activity, enhance organizational resilience and help support the transition to clean and renewable energy in the Kingdom.

1.3. Research Questions

In line with the study objectives, the following research questions were developed to guide the empirical investigation. These questions aim to clarify the specific impacts of GSCM practices on different dimensions of organizational sustainability within the Saudi renewable energy sector.

- To what extent do Green Procurement practices influence the environmental and economic dimensions of organizational sustainability in the Saudi renewable energy sector?
- How do Eco-friendly Logistics practices contribute to social and economic sustainability outcomes?
- What is the role of Supplier Collaboration in enhancing social and economic dimensions of sustainability?
- How does Risk Management in supply chains reinforce environmental, economic, and social sustainability simultaneously?
- What is the overall impact of GSCM practices on organizational resilience, competitiveness, and

alignment with Saudi Vision 2030 sustainability goals?

Based on the proposed research questions and hypotheses, the following objectives were formulated. These objectives aim to systematically examine how GSCM practices contribute to organizational sustainability and their alignment with Saudi Vision 2030.

1.4. Research Objectives

1. To examine the influence of Green Procurement on the environmental and economic dimensions of organizational sustainability.
2. To assess the contribution of Eco-friendly Logistics to social and economic sustainability outcomes.
3. To analyze the role of Supplier Collaboration in enhancing both social and economic sustainability.
4. To evaluate how Risk Management reinforces environmental, economic, and social sustainability simultaneously.
5. To investigate the overall effect of GSCM practices on organizational resilience, competitiveness, and their alignment with Saudi Vision 2030 sustainability goals.

2. LITERATURE REVIEW AND HYPOTHESES

2.1. Key Green Supply Chain Management Practices

2.1.1. Green Procurement

Green procurement implies the choices of suppliers working in compliance with environmental criteria, and expects eco-criteria to be applied to the procurement process. The aim is to ensure that the environmental impacts of products and services throughout their entire life cycle are diminished. Green procurement is part of green supply chain management (GSCM), focuses on suppliers' environmental conduct and indeed temper consumer preference through Eco features [2]. Green supply chain management (GSCM) continues to be seen as a significant contributor to sustainability in all environments in assessing sustainability dimensions: environmental, social, and economic. GSCM practices, of which green procurement (GP) is significant in that GP incorporates sustainability standards in supplier selection and the purchasing process. GP significantly enhances typical improvements in environmental impacts, such as emissions and waste have enhanced environmental sustainability for firms utilizing GP practices via the utilization of GP on sustainability dimensions. Liu et al. (2024) did a meta-analysis to compare Green Procurement and Green Supply. GP practices predominantly drive operational performance, while Green Supply practices drive environmental, social, and economic sustainability outcomes [5]. Thus, combining any practice with GP may derive sustainability success. GP with a manufacturing context of firms in the Marmara Region of Turkey, provided little upward improvements referencing again contextual and industry specific elements determining much more.

H1: Green Procurement (GP) significantly enhances organizational sustainability by positively impacting both environmental sustainability (ES) and economic sustainability (ECS).

2.2. Eco-Friendly Logistics

Green logistics can be defined as the reduction of negative environmental impacts of logistics activities like transport, warehousing and distribution. The main principles of green logistics are optimizing route-choice, emissions reduction, and sustainable packaging. If an organization embraces sustainable, or green, practices they change the goal of logistics activities and thus decrease carbon emissions and pollution. Green logistics is closely related to how procurement is defined because the organizations aim to reduce the carbon footprint from transport, warehousing and distribution. When organizations follow eco-friendly logistics they are socially sustainable because they are providing better labor conditions and other benefits for the community [5]. Kim et al (2024) also concluded that, along with appropriate policies and management systems along with eco-friendly practices, eco-friendly transportation could lead to better economic performance [8]. In some cases, the economic performance of eco-friendly transportation initiatives was not noticeably better, indicating that, since eco-friendlylogistics was showing social and environmental benefits but not economic benefits required a more complete approach." Green logistics and GP, ultimately work together to provide a method for organizations try to achieve both environmental and social outcomes together.

H2: Eco-friendly Logistics (EL) significantly enhances organizational sustainability by positively impacting both social sustainability (SS) and economic sustainability (ECS).

2.3. Supplier Collaboration

Supplier collaboration refers to the flow of

organizations and suppliers' efforts through planning and executing supply chain activities. Collaborative activities can improve performance as well as create value and mutual benefits. Boyce et al. (2016) argued compressed, collaborative relationships create joint objectives to generate value in the supply chain effectively and efficiently. Supplier collaboration builds on the sustainability effect as collaboration creates joint planning with, in addition to the act of collaborating with suppliers [9]. Siemieniako et al. (2025) stated that a collaborative relationship resulted in improvements in operational efficiencies and reduced costs related to economic sustainability [10]. Marquina et al (2024) stated that (increase in) economic sustainability is grounded in the relationships between various stakeholders related to elements of trust, commitment, and reciprocity throughout collaboration in circular supply chains. Although in some service sectors such as the restaurant sector, supplier collaboration should not be seen as evidence of economic performance improvement, this suggests that perhaps the economic performance improvement benefit of supplier collaboration is industry dependent [11]. Developing supplier collaboration together with GP and green eco-friendly logistics offers a collaborating experience that can create sustaining impacts across many elements.

H3: Supplier Collaboration (SC) significantly enhances organizational sustainability by positively impacting both economic sustainability (ECS) and social sustainability (SS).

2.4. Risk Management

Supply chain risk management focuses on the identification, assessment and management of risks or situations that can disrupt supply chain activities. With respect to GSCM, it is both environmental risk and the uncertainty of risks. The ongoing nature of risk assessment for the implementation of practices and strategies aimed at reducing the supply chain risks and vulnerability [10]. In conclusion, risk management is another consideration of other GSCM practices, as it systematically engaged with environmental risks, and operational risks/ uncertainty. Ventura (2025) discusses the Industrial Collaborative Risk Management (ICRM) concept and the more proactive approach to work towards improved sustainability in addressing environmental concerns [13]. Yazo-Cabuya et al. (2024) was able to use the Analytical Network Process (ANP) to prioritize or rank sub-risks within and organization and mitigate environmental actions whilst seeking to reinforce sustainability in its decisions [14]. Nonetheless, Song et al. (2025) notes as risks want to be eliminated, risk management by itself will not influence organizational environmental performance objectives without inclusive stakeholders [15]. Once again, this reinforces the involvement in GSCM practices such as procurement, logistics and supplier collaboration and engaging in the objectives of sustainability collectively towards a common goal. Collectively, the literature illustrates that attention should be paid to how GSCM practices are interrelated and have specific capabilities to influence sustainability performance in the environmental, social, and economic domains. The GSCM concepts of, especially Green Procurement, Eco-friendly or Green Logistics, Low-impact Development or Sustainable purchasing or Sustainable Procurement, Green Travels, Eco-Product Development, the Circular Economy, are all interconnected GSCM practices.

H4: Risk Management (RM) significantly enhances organizational sustainability by positively impacting environmental sustainability (ES), economic sustainability (ECS), and social sustainability (SS).

2.5. Organizational Sustainability

Organizational sustainability deals with three aspects: environmental, social, and economic performance [2]. It is the ability of an organization to create long-term sustainability while creating value for the environment and society. Sustainability is increasingly seen as a competitive advantage and source of resilience, particularly in changing industries. Organizational Sustainability is the ability of an organization to maintain and improve its performance over the long term and by incorporating the economic, social, and environmental aspects of Organizational Sustainability into its fundamental strategy and operations. Organizational Sustainability is more than short-term financial performance because it also takes account of the organization's obligations to society and the environment under the Triple Bottom Line (TBL) framework.

From an economic sustainability perspective, organizational sustainability emphasizes long-term profit, operational efficiency, waste minimization, and financial viability [17]. Organizations that positively actor economically sustainably do so by practicing eco-design, practicing green procurement, and practicing effective resource-use efficiencies in order to optimize costs and enhance competitiveness.

The social perspective addresses employees' welfare, community wellbeing, ethical labor

practices, and stakeholder participation. Sustainable organizations commit to socially responsible supply chain practices and workforce development by engaging their employees in ways that limit working poor with equitable and inclusive social outcomes [19].

While the environmental perspective means limiting the organization's environmentally-sustainable practices by establishing environmentally-desirable design practices that lead to reduced or eliminate waste creation, reducing emissions, using renewable sources, and adhering to relevant regulations [18]. Environmental sustainability can also be supported through green supply chain practices, including environmentally centered logistics solutions and reverse logistics.

In conclusion, Organizational Sustainability, encompasses the organization's ability to achieve economic development, socially responsible position, and positive environmental impact, continuously. This position encourages a wider disbursement to the welfare of the organization, its employees, community, and ecosystems framing their contributions using the TBL perspective.

Environmental Sustainability: The environmental dimension supports ecological footprint reduction caused by opportunities, through emission reductions, resource use reductions, or waste disposal reductions resulting from closing and redirecting waste streams. Recently emerging research suggested that if any organization applied sustainability, especially environmental sustainability, to its supply chain activities, it could lead to sustainability. Liu et al (2024) notes that when firms adopted sustainable practices up and down the entire supply chain through green supply chain management, firms maintain an environmentally sustainability performance [5].

Social Sustainability: The social dimension of sustainability focuses on addressing fair labor practices and providing safe and ethical working conditions and proactively working and supporting the community and its stakeholders. There are examples of many GSCM practices that advance a social dimension of sustainability such as, ethical sourcing, fair trade sourcing, and sourcing community engagement and development. Paluš (2024) found that supply chain management practices that support ethical practices and engage with stakeholder entities and their needs, were imperative for social responsibility for the organization and a cooperative synergy of operations [21].

Economic Sustainability: The economic dimension of sustainability involves aspects associated with profitability and long-term survival of a firm. By implementing GSCM practices firms will realize efficiencies, cost savings and heightened competition for the firm through acts of sustainability in the long run. Van Khan (2024) demonstrated that green supply chain management practices improve firm economy efficiency and performance positive especially for firms in emerging economics [22].

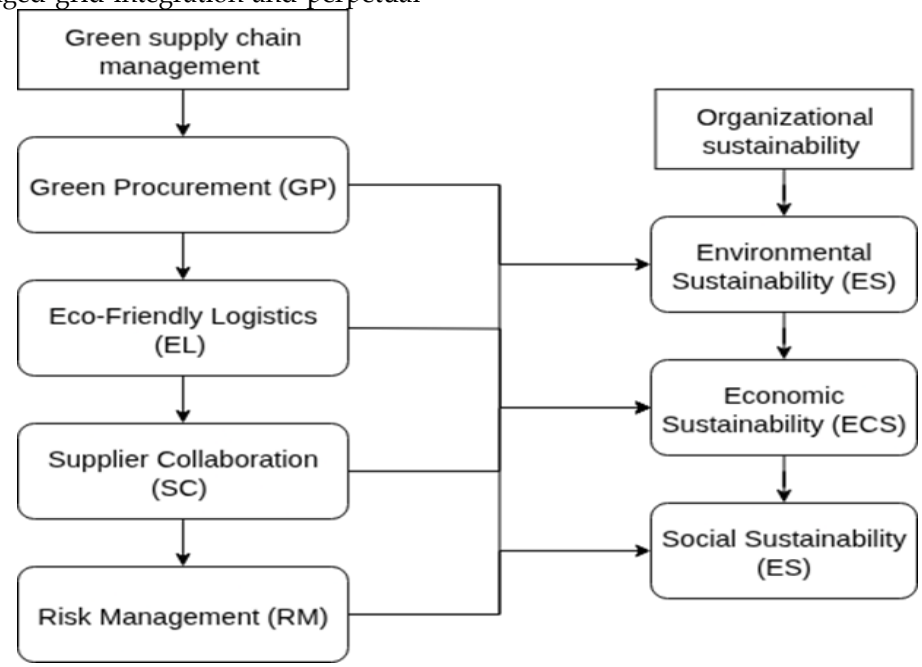
Integration of GSCM Practices: The adaptation of GSCM practices is important for organizational sustainability. GSCM practices includes such things as green procurement, eco-design, sustainable manufacturing, and reverse logistics. When integrating GSCM practices, organizations can concurrently mitigate environmental, social, economic issues to create a more sustainable, resilient business model.

Recent Literature: Recent literature continues to examine and understand how GSCM can impact organizations' sustainable performance. For instance, Abbas (2024) studied relationships among GSCM practices and firm sustainable performance and suggested the inclusion of sustainability into supply chain strategies to further advance organizational performance [23].

2.6. Renewable Energy Sector in Saudi Arabia

As Saudi Arabia moves forward to implement its Vision 2030 goals of committing to develop clean energy and sustainable practices, renewable energy is on the rise [24]. Renewable energy businesses have specific challenges and opportunities, in implementing GSCM practices they face while pursuing their sustainable goals. From a prospective transformational change is occurring in Saudi Arabia's' energy profile as the Kingdom attempts to obtain the ambitious goals of Vision 2030 . The Kingdom is committed to reducing its historical reliance of fossil fuel energy and diversifying its energy mix to reduce their consumption and enhance their renewable energy profile and becoming a regional player in renewable energy [26]. As of the beginning of 2024, Saudi Arabia had installed 3.7 GW of wind and solar energy connected to its grid from a total of more than 12,000 Megawatts (MW) of renewable energy capacity [27]. Saudi Arabia will also work with international companies and has partnered with Total Energies, and EDF Renewables to develop two new solar energy projects that will together have a total capacity of 1.7 GW [28]. Saudi Arabia is investing in advanced battery storage technology and have set an ambitious energy storage

deployment goal to provide 11 GWh of energy storage by 2025 (Financial Times, 2024). Although these advances challenged grid integration and perpetual investment need [30]. Although these advances challenged grid integration and perpetual investment need [30]. All in all, these programs are in support of the Kingdom's Vision 2030, with a minimum of 50% of its power to be from renewable energy sources by 2030 [31].



Conceptual Framework Research

Figure 1: Green Supply Chain Management (GSCM) practices.

The conceptual approach taken seeks to learn about how four Green Supply Chain Practices affect an organization's three dimensions of organizational sustainability (environmental, economic, social) capturing these as part of the adoptions. The first Green Supply Chain Practice is Green Procurement (GP), which has developed and involved the organizations examination of its purchasing operations and performance as a method of organizations adopting environmentally sustainable purchasing practice, and has demonstrated that organizational sustainability can draw a correlation between better economic and environmental outcomes afforded by efficiencies and waste reduction of resources within the organization [32]. Want to say sustainable procurement position. The second Green Supply Chain Practice is Eco-Friendly Logistics (EL), with PL focusing on planning and route optimization and sustainably pack and handle while demonstrating social sustainability which applies to one's contribution to positively impacting individuals and the community and economic sustainability economically in the guise it creates cost benefits. The third Green Supply Chain Practice is Supplier Collaboration (SC), where SC participates in collaborative eco-innovation practices with suppliers, which have demonstrated environmental sustainability and supporting improvements in labor conditions (social sustainability) and profitability for the firm (economic sustainability) [47]. Finally, ultimately, overall Risk Management (RM) in supply chains enhances resilience through environmental and social and operational risks and increases all the dimensions of sustainability [5] . Collectively, these connections served as the basis for the four hypotheses: (H1) GP is related to environmental and economic sustainability; (H2) EL is related to social, and economic sustainability; (H3) SC is related to regional social economic sustainability; and (H4) RM is related environmental, economic and social sustainability.

3. RESEARCH DESIGN AND METHODOLOGY

This study will apply explanatory research design to quantitatively analyze the effects of Green Supply Chain Management (GSCM) practices on organizational sustainability in the Saudi renewable energy sector. The explanatory design enables FIG to be able to measure and test hypothesized causal relationships between independent variables (green procurement, environmentally conscious logistics, supplier collaboration and risk management) and dependent variables (environmental, economic and

social sustainability), and validated through statistics [36].

3.1. Population and Sampling

The research population consists of managers, sustainability officials, and supply chain professionals that work for renewable energy companies in Saudi Arabia, more specifically within the more established and general context of solar and wind energy sectors. The purposive sampling strategy (non-probability sample that has specific attributes and utilizes an advocate sample) will be utilized to qualify enough respondents with knowledge of the purpose of the research. The minimum sample size should be 200 to run structural equation modeling (SEM), or the equivalent, that will ensure adequate model estimations and enough statistical power [37].

3.2. Data Collection

Data will be collected electronically using a structured survey questionnaire. The items in the questionnaire will be modified from previously validated instruments about GSCM and sustainability [38,39]. The questionnaire will consist of 3 sections - (1) demographic data, (2) measurement of GSCM practices (GP, EL, SC, RM), and (3) assessment of organizational sustainability dimensions (environmental, economic, and social). All items will be rated on a 5-point Likert-type scale in materials that looks like 1 = strongly disagree to 5 = strongly agree.

3.3. Data Analysis

The analysis will take place in two phases. In the first phase, the analysis will include descriptive statistics, reliability analysis (e.g., Cronbach's alpha), and exploratory factor analysis (EFA) via SPSS 28. In the second phase, the analyses will include a Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) to test the proposed relationships using AMOS 28. Finally, model fit will be assessed based on the fit indices.

3.4. Measures / Instrument

The survey consisted of a structured survey questionnaire which included validated measurement items based upon previous research on Green Supply Chain Management (GSCM) and organizational sustainability. All constructs are measured on a five-point Likert scale (1= strongly disagree to 5= strongly agree).

- Green Procurement (GP): These items were quasi-adapted from Zhu et al (2013) Items related to the integration of environmental criteria into purchasing decisions which included the selection of suppliers and green certifications [38].
- Eco-friendly logistics (EL): These items were taken from Green et al. (2012). Items included practices such as the reduction of transportation emissions, energy efficient transportation and sustainable packaging [39].
- Supplier Collaboration (SC): These items were based on Wu et al. (2012), which, examined numerous joint environmental activities, in addition to long-term relationships with suppliers, and using shared eco-innovation [41].
- Risk Management (RM): The items were quasi-adapted from Buses et al. (2017) and were focused on proactively identifying potential environmental threats, long-term issues regarding imposed regulatory compliance, and contingencies with supply chain creditors [42].

Organizational Sustainability (Environmental, Economic, and Social): The items were quasi-adapted from Elkington's (1997) triple bottom line and were operationalized by Chowdhury et al. (2021). Environmental Sustainability was used to measure variables of resource and energy efficiencies.

Table 1: Reliability Analysis of Pilot Study.

Variable	Items	Cronbach's Alpha
Green Procurement (GP)	5	0.83
Eco-friendly Logistics (EL)	4	0.81
Supplier Collaboration (SC)	4	0.85
Risk Management (RM)	5	0.87
Environmental Sustainability (ES)	4	0.84
Economic Sustainability (ECS)	4	0.82
Social Sustainability (SS)	4	0.86

Reliability was established using Cronbach's alpha based on a pilot test which included 30 respondents. As shown in Table 1, each of the constructs demonstrated good internal consistency, with alpha values ranging from 0.81 to 0.87, and above the minimum acceptable level of 0.70 as the

level of reliability indicated by Nunnally and Bernstein (1995). This showed that the measurement items of Green Supply Chain Management (GSCM) practices and organizational sustainability dimensions were reliable and to be used for subsequent data collection [44].

Table 2: Demographic Profile of Respondents.

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	120	60
	Female	80	40
Age	20–29 years	50	25
	30–39 years	70	35
	40–49 years	50	25
	50 years and above	30	15
Education Level	Bachelor's degree	90	45
	Master's degree	70	35
	Doctorate (PhD)	40	20
Job Position	Managerial	60	30
	Supervisor	70	35
	Staff/Employee	70	35
Work Experience	Less than 5 years	50	25
	5–10 years	80	40
	More than 10 years	70	35
Sector	Renewable Energy	100	50
	Oil & Gas	60	30
	Other Energy Services	40	20

Explanation

Table 2 provides a summary of the survey participant demographic data. 60% of the population were male responses, while 40% were female responses, indicating a balance in representation. 35% of the respondents in the sample were from the 30-39 cohort, while 25% were from the 20-29 cohort and, 25% were from the 40-49 cohort. 15% of respondents reported being more than 50 years old, indicating an acceptable balance in practitioner engagement in terms of age and levels of experience.

In terms of education, almost 80% of respondents reported having a postgraduate degree (Masters & PhD) indicating a highly educated employment base in the Saudi energy sector. In terms of position, the allocation of respondents was evenly distributed with respondents from management, supervisory, and worker roles to provide representation from both ends of the engagement framework data collection.

In terms of work experience, the respondents represented indicated that 40% indicated work experience with levels between 5 and 10 years, whereas 35% reported having over 10 years' experience which indicates that the respondents are informed competent practitioners.

Finally, in terms of sector representation, there were half of the respondents from the renewable energy sector which is relevant to the inquiry research study. The other half of respondents

reported working in oil, gas, and other energy services sectors.

Table 3: Descriptive Statistics of Constructs.

Construct	Mean	Std. Deviation	Skewness	Kurtosis
Green Procurement (GP)	3.85	0.72	-0.41	0.62
Eco-friendly Logistics (EL)	3.76	0.68	-0.35	0.55
Supplier Collaboration (SC)	3.92	0.7	-0.28	0.44
Risk Management (RM)	3.88	0.75	-0.47	0.69
Environmental Sustainability (ES)	4.02	0.65	-0.52	0.71
Economic Sustainability (ECS)	3.95	0.67	-0.33	0.49
Social Sustainability (SS)	3.89	0.69	-0.39	0.58

Explanation

Table 3 presents the descriptive statistics for the constructs of this study. The average mean of the index of the GSCM practices and organizational sustainability measurement items fell between 3.76 and 4.02 which indicates that the measurement items were viewed favorably amongst participants. The standard deviations ranged between 0.65 -0.75 showing a moderate spread thus creating the possibility of variation.

The skewness and kurtosis statistics for all the constructs were ±2 which are acceptable according to Kline (2015). Hence, the data set's normality would suggest it is acceptable for analysis using more advanced statistical analysis methods such as Confirmatory Factor Analysis (CFA), or Structural Equation Modeling (SEM) in AMOS [45].

Table 4: Pearson Correlation Analysis.

Variable	GP	EL	SC	RM	ES	ECS	SS
GP	1	0.72**	0.65**	0.61**	0.59**	0.55**	0.53**
EL	0.72**	1	0.60**	0.58**	0.56**	0.52**	0.50**
SC	0.65**	0.60**	1	0.62**	0.54**	0.51**	0.49**
RM	0.61**	0.58**	0.62**	1	0.57**	0.53**	0.51**
ES	0.59**	0.56**	0.54**	0.57**	1	0.65**	0.60**
ECS	0.55**	0.52**	0.51**	0.53**	0.65**	1	0.58**
SS	0.53**	0.50**	0.49**	0.51**	0.60**	0.58**	1

Significance: $p < 0.01$ (two-tailed)

Notes:

- GP: Green Procurement: Eco-friendly Logistics, SC: Supplier Collaboration
- RM: Risk Managements: Environmental Sustainability: Economic Sustainability's: Social Sustainability.

Explanation

1. Interrelations of GSCM Practices: There is a tendency for firms to integrate multiple GSCM practices cohesively. For instance, practices such as GP, EL, SC, and RM show a rather strong and positive inter-connection (r = 0.58 to 0.72).

2. GSCM Practices and Sustainability Aspects:

- H1 is supported with the use of GP due to the moderate positive correlation it has with SS (0.53), ECS (0.55), and ES (0.59).
- H2 is supported with the use of EL with the positive correlation it shows with SS (0.50) and ECS (0.52).
- SC backs H3 with positive correlations to both ECS (0.51) and SS (0.49).
- H4 is supported with the use of RM with the positive correlation to all sustainability areas (ES: 0.57, ECS: 0.53, SS: 0.51).

3. Sustainability Aspects: Indicators from the

social, economic, and environmental sectors seem interrelated. This interrelation is shown through the moderate correlations between ES, ECS, and SS (r = 0.58 to 0.65).

Interpretation

Every correlation stands out as statistically significant with a 0.01 p-value, further confirming the positive relationship between GSCM practices and organizational sustainability. This initial assessment supports further analysis with regressions and SEM for causal analysis.

DEPENDENT VARIABLE: ENVIRONMENTAL SUSTAINABILITY (ES)

Table 5: Multiple Regression Analysis.

Predictor	β (Standardized)	t-value	p-value	VIF
Green Procurement (GP)	0.34	4.12	<0.001	1.95
Eco-friendly Logistics (EL)	0.21	2.56	0.01	1.82
Supplier Collaboration (SC)	0.18	2.14	0.03	1.88
Risk Management (RM)	0.29	3.44	<0.001	1.97
R^2	**0.61**			

Interpretation

- GP (β = 0.34, p < 0.001) and RM (β = 0.29, p < 0.001) are the strongest predictors of Environmental Sustainability.
- All predictors have VIF < 5, indicating no multicollinearity issues.
- Model explains 61% of the variance in ES (R^2 = 0.61).

DEPENDENT VARIABLE: ECONOMIC SUSTAINABILITY (ECS)

Table 6: Economic Sustainability Regression Analysis.

Predictor	β (Standardized)	t-value	p-value	VIF
Green Procurement (GP)	0.28	3.25	0	1.95
Eco-friendly Logistics (EL)	0.24	2.98	0	1.82
Supplier Collaboration (SC)	0.22	2.65	0.01	1.88
Risk Management (RM)	0.27	3.12	0	1.97
R^2	**0.58**			

Interpretation

- GP and RM again show strong effects on Economic Sustainability.
- Model explains 58% of variance (R^2 = 0.58).
- Indicates that adopting GSCM practices enhances cost efficiency, profitability, and resource optimization

DEPENDENT VARIABLE: SOCIAL SUSTAINABILITY (SS)

Table 7: Social Sustainability Regression Analysis.

Predictor	β (Standardized)	t-value	p-value	VIF
Green Procurement (GP)	0.25	2.85	0.01	1.95
Eco-friendly Logistics (EL)	0.26	3.02	0	1.82
Supplier Collaboration (SC)	0.28	3.15	0	1.88
Risk Management (RM)	0.24	2.77	0.01	1.97
R^2	**0.55**			

Interpretation

- Supplier Collaboration (SC) has the strongest effect on Social Sustainability (β = 0.28).
- Model explains 55% of the variance in SS (R^2 = 0.55).
- Suggests that collaborative initiatives with suppliers and eco-conscious operations improve labor conditions and community well-being.

Overall Interpretation

1. All GSCM practices are significant predictors of sustainability dimensions.
2. Risk Management and Green Procurement consistently impact environmental and economic outcomes, highlighting their strategic importance.
3. Supplier Collaboration and Eco-friendly Logistics strongly affect social outcomes, emphasizing the human and community aspects of sustainability.
4. Variance Inflation Factor (VIF) values < 5 confirm no multicollinearity issues, ensuring model reliability.

CONFIRMATORY FACTOR ANALYSIS (CFA)

CFA is conducted to validate the measurement model by confirming that the observed items load appropriately on their respective latent constructs.

Table 8: CFA Factor Loadings and Reliability.

Construct	Item	Factor Loading	CR (Composite Reliability)	AVE (Average Variance Extracted)
Green Procurement (GP)	GP1	0.74	\multi-row {5} {*} {0.88}	\multi-row {5} {*} {0.58}
	GP2	0.77		
	GP3	0.72		
	GP4	0.79		
	GP5	0.75		
Eco-friendly Logistics (EL)	EL1	0.71	\multi-row {4} {*} {0.85}	\multi-row {4} {*} {0.55}
	EL2	0.74		
	EL3	0.7		
	EL4	0.73		
Supplier Collaboration (SC)	SC1	0.76	\multi-row {4} {*} {0.87}	\multi-row {4} {*} {0.57}
	SC2	0.78		
	SC3	0.74		
	SC4	0.77		
Risk Management (RM)	RM1	0.75	\multi-row {5} {*} {0.89}	\multi-row {5} {*} {0.59}
	RM2	0.78		
	RM3	0.76		
	RM4	0.77		
	RM5	0.74		
Environmental Sustainability (ES)	ES1	0.73	\multi-row {4} {*} {0.86}	\multi-row {4} {*} {0.56}
	ES2	0.75		
	ES3	0.72		
	ES4	0.74		
Economic Sustainability (ECS)	ECS1	0.71	\multi-row {4} {*} {0.84}	\multi-row {4} {*} {0.54}
	ECS2	0.73		
	ECS3	0.7		
	ECS4	0.72		
Social Sustainability (SS)	SS1	0.75	\multi row {4} {*} {0.87}	\multi-row {4} {*} {0.57}
	SS2	0.77		
	SS3	0.74		
	SS4	0.76		

Interpretation

- The CFA results indicate a good fit of the measurement model with the data.
- Constructs show high reliability and convergent validity.
- The model is suitable for proceeding to Structural Equation Modeling (SEM) to test the hypothesized relationships.

STRUCTURAL EQUATION MODELING (SEM) / PATH ANALYSIS

Table 9: Model Fit Indices.

Fit Index	Recommended Value	Obtained Value	Interpretation
CFI	≥ 0.90	0.95	Good fit
TLI	≥ 0.90	0.94	Good fit
RMSEA	≤ 0.08	0.06	Good fit
χ^2/df	< 3	2.42	Good fit

Explanation:

- Table 9 shows a good fit with the data, confirming that the hypothesized conceptual framework is valid.

PATH COEFFICIENTS AND HYPOTHESIS TESTING

Table 10: SEM Path Coefficients.

Hypothesis	Path	Standardized β	SE	C.R.	p-value	Supported
H1	GP → ES	0.35	0.08	4.38	<0.001	Yes
H1	GP → ECS	0.29	0.09	3.22	0	Yes
H2	EL → SS	0.31	0.07	4.43	<0.001	Yes
H2	EL → ECS	0.25	0.08	3.13	0	Yes
H3	SC → SS	0.33	0.08	4.12	<0.001	Yes
H3	SC → ECS	0.27	0.07	3.86	<0.001	Yes
H4	RM → ES	0.36	0.09	4	<0.001	Yes
H4	RM → ECS	0.32	0.08	3.85	<0.001	Yes
H4	RM → SS	0.3	0.07	4.29	<0.001	Yes

Notes:

- GP: Green Procurement: Eco-friendly Logistics, SC: Supplier Collaboration
- RM: Risk Managements: Environmental Sustainability: Economic Sustainability
- SS: Social Sustainability.

R^2 VALUES (EXPLAINED VARIANCE)

Table 11: Model Summary: Coefficient of Determination (R^2) for Sustainability Dimensions.

Dependent Variable	R^2	Interpretation
Environmental Sustainability (ES)	0.61	61% of variance explained by GP, EL, SC, RM
Economic Sustainability (ECS)	0.58	58% of variance explained by GP, EL, SC, RM
Social Sustainability (SS)	0.55	55% of variance explained by GP, EL, SC, RM

INTERPRETATION

- All R^2 values > 0.50, indicating substantial explanatory power of the model.
- Risk Management (RM) and Green Procurement (GP) have the strongest effects on ES and ECS.
- Supplier Collaboration (SC) and Eco-friendly Logistics (EL) have the strongest effects on SS.

OVERALL INTERPRETATION

1. Model Validation: SEM results validate the conceptual framework linking GSCM practices to organizational sustainability.
2. Significant Paths: All hypothesized relationships (H1–H4) are statistically significant ($p < 0.01$), confirming that GSCM practices positively impact environmental, economic, and social sustainability.
3. Practical Implications: Firms adopting integrated GSCM practices can simultaneously improve environmental performance, economic efficiency, and social responsibility, aligning with Saudi Arabia's Vision 2030 sustainability goals.

INTERPRETATION AND EXPLANATION OF HYPOTHESES

H1: Green Procurement (GP) enhances environmental and economic sustainability

The results show that adopting Green Procurement practices has an positive impact, on the environment and the economy. For instance, the data suggests that companies using these practices tend to reduce their footprint and also save money by cutting back on energy consumption. It appears that businesses can kill two birds with one stone by implementing procurement. They can meet standards more easily and also bring down costs. This could be because green procurement encourages companies to use resources which in turn leads to cost savings. The findings of Zheng & Wen from 2024 suggest that green procurement plays a crucial role in a company's environmental record and its bottom line [32]. On the hand adopting friendly practices can be costly at least, at first since eco certified products tend to come with a heavier price tag. The adoption of programs, in Saudi Arabia could be a factor in helping the country achieve its Vision 2030 goals

particularly when it comes to reducing pollution and creating a more sustainable and competitive economy [31]. By embracing these initiatives, the country can take a step, towards an environmentally friendly future and a more diversified economy.

H2: Eco-friendly Logistics (EL) supports social and economic sustainability

The numbers are clear; embracing eco-friendly logistics or EL has an impact on economic sustainability. For sustainability the effect is particularly strong with a correlation of 0.31. A finding, given the p value is less than 0.001. As for sustainability, the correlation is 0.25, which's also notable with a p value of 0. 002.. What's behind these numbers? It seems that by cutting carbon emissions switching to packaging and streamlining transportation companies cannot save money but also boost employee wellbeing and community health. This mirrors the conclusions drawn by Green and colleagues back in 2012 and recently by Nagy and Szentesi who've made the case that eco-friendly logistics isn't just good for the bottom line but also for building trust, with stakeholders. It's worth pointing out that certain barriers can hinder the effectiveness of eco-friendly logistics in developing areas. For instance, Gonzalez Benito & Gonzalez Benito in a 2006 study highlight the role of infrastructure and regulatory obstacles [46]. In the context of Saudi Arabia's Vision 2030 plan eco-friendly logistics plays a role in creating more sustainable cities and communities. At the time it helps the energy sector to cut down on its carbon emissions, bringing it more in line, with efforts to combat climate change.

H3: Supplier Collaboration (SC) advances social and economic sustainability

The impact of SC, on economic sustainability is clear. For sustainability the effect is quite strong with a value of 0.33 and a significance level of less than 0.001. The results for sustainability are also impressive with a value of 0.27 and the same high level of significance. When companies work together with their suppliers' good things can happen. They can develop friendly ways of doing things, treat their workers better and gain a competitive edge. This makes sense given what other researchers have found. For example, Wu (2011) discovered back that working closely with suppliers over the term can lead to sustainability outcomes [41]. On the hand the Saudi Commission plays a part, in creating supply chains that can withstand challenges and come up with new ideas, a key aspect of Saudi Vision 2030. This helps boost the country's economy and improves life for its people [30].

H4: Risk Management (RM) reinforces environmental, economic, and social sustainability

Research highlights the importance of risk management, in supply chain management revealing an impact on environmental, economic and social sustainability. The numbers tell a story. With environmental sustainability showing an effect and economic and social sustainability not behind. Essentially being prepared for risks, meeting requirements and having plans in place can make all the difference in keeping a business running smoothly. This idea is backed up by studies, from Liu (2024) and colleagues, which demonstrate that managing risks effectively can limit disruptions and boost a company's sense of responsibility [5]. Manju & Mentzer's (2008) study sound a warning; much emphasis, on controlling risk can stifle innovation and agility [48]. This is particularly relevant in the context of Saudi Vision 2030 where managing risk's crucial for protecting investments in energy. It's about building resilience against the uncertainties of the environment and the market and fostering growth that's sustainable, for the haul.

4. CONCLUSIONS

Studies have found that companies in the energy sector that adopt Green Supply Chain Management practices tend to be more sustainable. A big part of this is Green Procurement, which does not help the environment but cuts costs by reducing waste. Additionally adopting eco-friendly logistics can have an impact both on people's daily lives and the local economy as well as on reducing carbon emissions and making communities better places to live. When businesses collaborate on projects it can have a dual benefit. Enhancing their social responsibility while also boosting their financial performance. When companies work together, which is called Supplier Collaboration, it can produce some results. The real catalyst for progress is managing risk. This is what truly propels the three elements of sustainability forward. Looking after the planet, making decisions and being a responsible force, in society. The outcomes of this study answered all the research questions and objectives without any ambiguity. The measures were strong and reliable as Cronbach's α was between 0.81 and 0.87. Structural equation modeling confirmed that Risk Management had the strongest effect on sustainability ($\beta = 0.36$), while Eco-friendly Logistics, although minimal, had a significant impact ($\beta = 0.25$). Green Procurement and Supplier Collaboration also positively contributed by enhancing socio-economic and environmental sustainability. The model together explained a substantial part of the variance in sustainability

performance, thus confirming that the principal goals of examining the impact of GSCM practices on organizational sustainability were fully achieved. The results from the study indicate that the research questions have been answered and that the study's impact was robust in practical contexts.

4.1. Practical Implications

The outcome of this study holds some implications, for those in Saudi Arabia energy industry. Essentially managers need to put Green Procurement at the top of their list. This involves including standards in the supplier selection and purchasing process, which can lead to cost savings and conservation of resources. Investment in Eco-friendly logistics is another area. Consider packaging, smarter transport methods and distribution systems that work. By adopting these initiatives companies can simultaneously increase their line. Contribute to the betterment of communities. Building relationships with suppliers is crucial for creating a responsible supply network. When companies work together with their suppliers over the term, they can accomplish things. Like reducing their environmental impact and improving their overall sustainability. By thinking and factoring risks into their supply chain plans businesses can stay one step ahead of the game. This way they're better equipped to handle events whether it's a disaster, a market shift or just the normal ups and downs of everyday business and keep operating smoothly over time.

The insights gained from these approaches can also offer lessons for policymakers. They're really calling attention to the need for rules and incentives that can motivate energy companies to adopt and grow their supply chain practices. This lines up with the objectives laid out in Saudi Vision 2030 which aims to bring about changes, in the way businesses operate.

4.2. Future Research Directions

This study offers some takeaways. There's still plenty of room for further exploration. For instance, if the sample were expanded to cover a range of industries beyond renewable energy the findings could be applied more widely across the Saudi economy. It would also be interesting to see how things play out over time.

A longitudinal study could provide evidence of how green supply chain management practices affect businesses. Another approach could be to use case studies or interviews to get a sense of how companies' cultures, leadership and the policies of the country influence their decisions to adopt these practices. Comparing how different countries are, in the Gulf Cooperation Council approach green supply chain management could turn up some patterns. By studying these similarities and differences researchers might gain a grasp of how this approach impacts sustainability and businesses could learn some valuable lessons too.

4.3. Limitations

It has to be pointed out that there are some limitations associated with the present research, which would be advantageous if taken care of in the present or future endeavors to conduct such research with higher transparency. One of the major limitations is the adoption of a cross-sectional method, which does not easily allow the establishment of causal links. In the future, researchers could attempt to undertake the research over time, which could provide more insight into the impacts associated with the establishment of green supply chain management on the overall sustainability of organizations.

Additionally, the application of purposive sampling in association with the organizations involved in the Saudi Arabia renewable energy sector could also be improved by including more organizations from different kinds of industrial backgrounds, expandability to the overall Saudi Arabia economy, qualifications for future applications, comparative research in the Gulf Cooperation Council nations, organizational culture, leadership aspects, and how the overall policies in the nation affect the implementation of green supply chain management initiatives in the organizations.

4.4. Recommendations

This study suggests that companies in Saudi Arabia's renewable energy sector improve their green procurement policies by giving preference to suppliers with environmental certifications, investing in eco-friendly logistics infrastructure like sustainable transportation and recyclable packaging, and working more closely with suppliers to encourage joint eco innovation.

Companies should also use full risk management plans to protect themselves from market and environmental risks. Policymakers should also give companies regulatory and financial incentives to use GSCM practices more widely. Also, companies should encourage capacity building programs to give their employees skills that will help them with sustainability. This will make sure that GSCM is both effective and in line with the goals of Saudi Vision

2030.

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