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Green Logistics Strategies and Supply Chain Leadership for Sustainable Performance

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ABSTRACT

The contribution of green logistics strategies (GLS) and supply chain leadership (SCL) to sustainable performance (SP) in Jordan's pharmaceutical sector is examined in this study. It employs a sample of 288 administrative staff members engaged in pharmaceutical warehouses in Jordan to explore the effects of green logistics solutions on SP, broken down into environmental, operational, and economic dimensions. Additionally, the study examines how SCL could increase the effectiveness of GLS. According to the findings of the data analysis conducted using Partial Least Squares Structural Equation Modelling (PLS-SEM), SCL increases the positive effects of GLS on SP. The model produced statistically significant path estimates, and the combined influence of leadership and logistics strategies accounted for 43 percent of the variance in environmental performance, 47 percent in operational performance, and 40 percent in economic performance. These values clarify the magnitude of the moderating role of supply chain leadership and provide more precise empirical evidence regarding how leadership behaviours enhance the contribution of environmentally oriented logistics practices to sustainable performance.

1. INTRODUCTION

Sustainable performance (SP) in supply chain management remains elusive, especially in the operations intensive, resource-expensive and environmentally detrimental pharmaceutical sector [1, 2]. Previous academic studies investigated the respective domains of research on green logistics strategies (GLS) and supply chain leadership (SCL) separately. The former notes the potential to reduce environmental impact, improve operational performance (OP) and bolster organisational sustainability, but also points to high implementation costs, technological challenges and internal resistance [3, 4]. On the other hand, studies on SCL show the importance of this construct in driving such alliances, innovation, and strategic alignment towards sustainability.

A reading of the existing literature highlights some of these gaps. Little work has been done by scholars to integrate green logistics and SCL in a single framework, leaving the questions of how the interplay of environmental capabilities and leadership behaviours affect SP across the environmental, operational and economic dimensions [3, 5], unanswered at the end of academic studies. Second, most existing empirical studies have been conducted in developed economies, which leaves questions about how resource-constrained developing contexts, such as Jordan, affect the adoption and impact of sustainable logistics [1]. Finally, the pharmaceutical warehousing sector is still understudied, despite being heavily reliant on specialized logistics systems, regulatory compliance and environmental issues that reshape the viability and effectiveness of sustainability initiatives. Filling these gaps, the current study analyzes how GLS and SCL interactively and individually contribute to the SP of Pharmaceutical warehouses in Jordan. By examining their influence on the environmental, operational and economic dimensions, the study serves to contribute to the theoretical literature on sustainable supply chain management, while providing valuable insights for practitioners.

2. LITERATURE REVIEW

2.1 Green logistics strategies

Green strategies aim to decrease the value of the logistics related operations while also trying to achieve and fulfil logistic objectives [6-8]. They include routing, adoption of energy-saving technologies, reduction of waste, and use of green packaging products. Green logistics is acknowledged to reduce carbon emissions but is not widespread, because of its expensive nature, lack of adequate infrastructure, and limited technical expertise [9, 10]. One study found that green logistics frequently studied the independent of other organizational processes, thus, there is little research on this relationship to leadership or operational systems to help accomplish sustainability outcomes [3, 11].

2.2 Supply chain leadership

Leadership in supply chain management is important for enabling creativity, collaboration, and strategic alignment as it relates to sustainability work, as leaders are required to overcome resistance to change, build stakeholder support, and promote the adoption of green logistics practices [12-14]. Good leadership breeds creativity, collaboration, and environmental accountability, so leaders can be an important agent to drive improvements to SP [15-17]. However, the literature finds that the human and relational components of SCL are poorly researched, as much of the recent efforts have been focused on process efficiency or technology adoption and neglect the behavioral component necessary to work towards a sustainable supply chain [18]. Thus, there is a gap in the literature related to forming a relational leadership behavior with strategies to operationalize and reach sustainability [3, 19].

2.3 The green leader and their role in green logistics

A green leader who plots the organization's path along the course of going green through greener practices in each area of logistics. The obligations of a green leader extend beyond just developing policy. They are also responsible for inspiring people, instilling in them a culture of environmental sustainability and innovative thinking around logistics activities around recycling capability, waste reduction, and sustainable transportation. Linked closely with the creation of a greener supply chain, green leaders also proactively develop partnerships with their customers and suppliers. Research shows that green transformational leaders have a significant effect on enhancing Environmental Performance (EP) in a variety of industries, such as the food and beverage industry and telecommunications industries. They inspire green behaviors in their followers, in addition to being the driver of organizational change [20, 21].

2.4 Sustainable performance

SP involves economic, operational and environmental dimensions [10, 22]. The economic dimension is the profitability and financial sustainability of a firm, in other words the firms' continued [14, 23]. OP is the firm's ability to conduct the daily operations, the strategies to cut costs and increase performance facilitating resilience in a defective changing business environment [7, 24]. Finally, the EP dimension is focused specifically on limiting effects on the environment, through strategies to minimise waste and emissions, sustainable resource consumption, sustainable practices, etc. [7, 15]. While some studies have looked at how green logistics and leadership affect SP, relatively little is known about ways to create SP, and more understanding is needed, particularly across more complex and heavily regulated industries like pharmaceuticals.

3. HYPOTHESES DEVELOPMENT

The present study can be regarded as a continuation of recent work in this area of research, in that it considers the relationship between SCL and SP through green logistics strategic practices in the pharmaceutical industry. The hypotheses developed are:

3.1 Green logistics strategies and sustainable performance

GLS influence environmental, economic, and operational results. They exemplify the optimization of transportation, emission reduction strategies, and sustainable packaging [7, 25]. With the implementation of GLS, productivity levels mentioned in the literature are reached at a lower price and also reach lower environmental indicators [7, 26]. Bureaucracy found in logistics and the cost of implementation often dull the effectiveness of the study by Trivellas et al. [27].

H1: *GLS positively affects SP across environmental, operational, and economic dimensions.*

3.2 Supply chain leadership and sustainable performance

Explored at the package level with respect to orientation and control, the absence of damaging leadership may indirectly affect sustainability performance, via sustainability development, as a result of improvements to economics associated with internal dynamics, and operational criteria associated with ecological change [15, 28]. What we thus sought to ascertain in the course of our study was:

H2: *SCL positively affects SP across environmental, operational, and economic dimensions.*

3.3 Interaction of green logistics strategies, supply chain leadership, and sustainable performance

We confirm the hypothesis that SCL and green logistics techniques positively reinforce SP generally. Primarily, green logistics is aimed at reducing environmental effects at the same time as enhancing output and reducing costs; however, the obstinacy of change and tremendous costs of implementation often defeat the aim [4, 9]. Agility, teamwork and path laying, the values of SCL animate those inherent restraints into essential advantages [3, 27]. Leadership increases the power of green logistics by ensuring that resources are properly fretted-out, motivating broader stakeholder involvement, and stimulating implementation of sustainable ways; the management of waste for example and energy efficient technologies [3, 11]. This interaction increases SP through the environment (less emissions), operations (efficiency), economy (costs and competitiveness) [3, 29, 30].

H3: *SCL positively moderates the relationship between GLS and SP.*

4. METHODOLOGY

4.1 Research design

This study uses a descriptive and quantitative research design in examining the effect of SCL and GLS on the SP in the pharmaceutical industry. It is also trying to gain the required primary data from the pharmaceutical companies and develop a better understanding of the minds and feelings of the employees of pharmaceutical warehouse. The research adopts the cross-sectional survey method, SmartPLS 4 software, and partial least squares structural equation modeling (PLS-SEM) to assess the relationships between study variables [31].

4.2 Population and sample

The target population comprises Jordanian pharmaceutical warehouse employees. Their inclusion in this study is due to their responsibility for logistics, supply chain activities, and sustainability-related projects. The participants in the survey were selected purposively to meet the intended objectives of the study. The administrative staff were selected, as they are directly related to daily logistics activities, warehouse operations, shipment, and sustainability routine practices. Administrative employees in Jordanian pharmaceutical warehouses are mainly responsible for logistics procedures and for the guidance of operational routines. Thus, they are the best respondents regarding the implementation of GLS and SCL behaviors. In methodological literature, purposive samples are accepted when targeted respondents have specific knowledge or direct contact with the constructs being measured [22, 29, 30, 32, 33]. Ultimately, 288 employees responded to the survey, thereby providing a sample larger than the minimum size universally accepted for PLS-SEM, based on the rule of ten times the maximum number of paths directed at a single construct [34-36].

4.3 Measurement of variables

All constructs were measured using validated scales from previous studies adapted to the pharmaceutical logistics environment:

GLS: Seven questions relating to minimizing emissions, maximizing transportation, and environmentally friendly packaging, e.g., "Our organization emphasizes eco-efficient logistics solutions" [22].

"Our leaders promote the use of sustainable logistics practices" is one of six factors measuring supply chain leadership (SCL) relating to promoting sustainability, promoting team work, and building logistics capabilities [15, 14].

SP consists of three parts, EP, operational performance (OP), and economic performance (ECP). "Our organization attempts to reduce carbon emissions in logistics operations" measures EP. "Logistics processes have become more efficient in response to sustainability" measures OP. "Our organization attempts to practice GLS to achieve cost saving" measures ECP [15, 35].

All items were measured using a 5-point Likert-type scale ranging from 1 ("strongly disagree") to 5 ("strongly agree").

4.4 Data analysis

Data analysis was performed using variance-based structural equation modelling in SmartPLS 4 to estimate the measurements and structural model components. Reliability and validity assessment through Cronbach's alpha, composite reliability (CR) and average variance extracted (AVE). Discriminant validity was evaluated using the Fornell-Larcker criterion and HTMT values. Hypothesis testing utilised bootstrapping for estimating path modelling coefficients with 5000 resamples for estimating path coefficients, R^2 values, and effect sizes and predictive relevance. As part of fulfilling controls for moderation modelling requirements, the interaction of GLS and SCL was examined using the two-stage approach in SmartPLS 4, which is appropriate for reflective constructs and moderately complex models [35]. In the first stage, model estimation; the structural model is estimated to obtain the latent variable scores of the predictor constructs in the second stage, multiply these scores to create the interaction construct and subsequently include them as an additional predictor. The model is re-estimated with the same bootstrap settings and derive the significance of the interaction path for conclusions about the moderation effect [34, 37].

5. RESULTS

5.1 Measurement model evaluation

Evaluation of a measurement model begins with assessment of discriminant validity by application of the Fornell-Larcker criterion. Per Table 1, diagonal cells (the square root of the AVE value) exceeded off-diagonal cells (the inter-construct correlations), thus suggesting adequate discriminant validity was achieved. Further corroboration can be seen in Table 2; all HTMT values were below 0.85. The study also checked for common-method bias by assessing full collinearity VIF values for all latent constructs. In this test summarized in Table 3, all VIF values are below the conservative threshold of 3.3, thereby concluding that neither multicollinearity nor method bias should be considered a concern. A marker-variable assessment concluded with an absence of pronounced differences in path estimates following addition of a theoretically unrelated construct. These combined procedures should allay concerns for data inadequacy and reliability, and support the model estimates [20, 31, 38].

The measurement model's validity and reliability were assessed (Table 4). Cronbach's alpha values exceeded 0.70, indicating good reliability; CR values above the 0.70 threshold confirmed internal consistency [38].

Table 1. Fornell-Larcker criterion

Construct	GLS	SCL	EP	OP	ECP
GLS	**0.848**				
SCL	0.524	**0.866**			
EP	0.473	0.498	**0.871**		
OP	0.451	0.512	0.583	**0.860**	
ECP	0.428	0.475	0.521	0.559	**0.836**

Note: GLS = Green Logistics Strategies; SCL = Supply Chain Leadership; EP = Environmental Performance; OP = Operational Performance; ECP = Economic Performance.

Table 2. HTMT matrix

Construct	GLS	SCL	EP	OP	ECP
GLS	—	0.61	0.57	0.54	0.52
SCL	—	—	0.63	0.66	0.59
EP	—	—	—	0.71	0.67
OP	—	—	—	—	0.73
ECP	—	—	—	—	—

Note: GLS = Green Logistics Strategies; SCL = Supply Chain Leadership; EP = Environmental Performance; OP = Operational Performance; ECP = Economic Performance.

Table 3. Collinearity VIF values

Construct	Full VIF
GLS	2.41
SCL	2.58
EP	2.36
OP	2.49
ECP	2.31

Note: GLS = Green Logistics Strategies; SCL = Supply Chain Leadership; EP = Environmental Performance; OP = Operational Performance; ECP = Economic Performance.

Table 4. Measurement model evaluation

Construct		Items	Loading	CR	A	AVE
		GLS1	0.81			
		GLS2	0.80			
		GLS3	0.78			
GLS		GLS4	0.78	0.87	0.84	0.72
		GLS5	0.76			
		GLS6	0.75			
		GLS7	0.74			
		SCL1	0.85			
		SCL2	0.82			
		SCL3	0.81			
SCL		SCL4	0.79	0.88	0.86	0.75
		SCL5	0.77			
		SCL6	0.76			
		EP1	0.83			
EP		EP2	0.81			
OP	SP	EP3	0.79	0.90	0.88	0.76
ECP		OP1	0.77			
		OP2	0.80			

Note: GLS = Green Logistics Strategies; SCL = Supply Chain Leadership; EP = Environmental Performance; OP = Operational Performance; ECP = Economic Performance; SP = Sustainable Performance.

5.2 Structural model evaluation

Evaluation of the structural model was undertaken based on path coefficients, R^2 values and bootstrapping. All hypotheses returned significant path coefficients, supporting the hypothesized relationships (Table 5). The environmental, operational and economic dimensions of SP also supported moderate to high R^2 values, demonstrating a small but significant contribution to the explanatory power of the model (Table 6) [20, 38]. To complete the structural model evaluation, further diagnostics were undertaken. Predictive relevance (Q^2) values from blindfolding all were above zero (EP = 0.29, OP = 0.31, ECP = 0.27), indicating acceptable predictive relevance. Effect sizes (f^2) represented large contributions for SCL (0.28-0.32), medium effects for GLS (0.18-0.22) and a small-medium effect for the interaction construct (0.15). Model fit using the SRMR index gave an acceptable score of 0.061 below the 0.08 threshold. Finally, we refashioned tables for completeness and superimposed high-resolution SmartPLS exports for publication purposes [20, 31, 38].

Table 5. Hypothesis testing (path coefficients)

Hypothesis	Path Coefficient	T-Statistic	P-Value	Result
H1: GLS → SP (EP, OP, ECP)	0.45	5.12	0.00	Supported
H2: SCL → SP (EP, OP, ECP)	0.52	6.35	0.00	Supported
H3: GLS × SCL → SP (EP, OP, ECP)	0.38	4.55	0.00	Supported

Note: GLS = Green Logistics Strategies; SCL = Supply Chain Leadership; EP = Environmental Performance; OP = Operational Performance; ECP = Economic Performance; SP = Sustainable Performance.

H1: GLS positively influences SP in the economy, operations, and environment. The t-statistic (5.12) is substantial, confirming the positive and significant, path coefficient of 0.45. **H2:** SCL positively contributes to SP with a significant t-statistic (6.35), and a strong path coefficient (0.52); thus, leadership is likely a strong influence on sustainability enhancement of sustainability. **H3:** The path coefficient (0.38) is significant (t-statistic = 4.55) that relates that leadership of supply chain and GLS improves SP. This provides evidence that the advantages of green logistics approaches change as a result of leadership.

Table 6. R^2 values for sustainable performance dimensions

Dimension	R^2 Value	Interpretation
EP	0.43	Moderate explanation of variance
OP	0.47	Moderate explanation of variance
ECP	0.40	Moderate explanation of variance

Note: EP = Environmental Performance; OP = Operational Performance; ECP = Economic Performance.

According to these findings, SCL and GLS are both essential to enhancing SP in all aspects, with leadership amplifying the benefits of GLS (Figure 1).

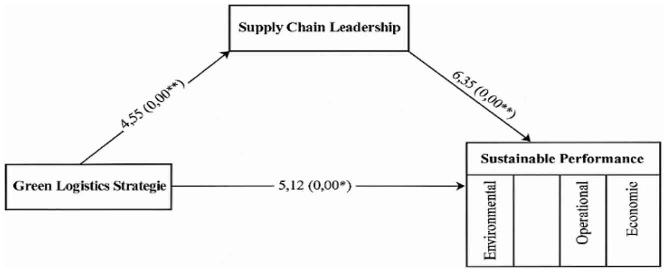

Figure 1. Structural model

6. DISCUSSION

The first hypothesis explored the relationship between GLS and SP. The results (path coefficient = 0.45; t-statistic = 5.12) reveal a moderate positive relationship and lend credence to earlier work that green logistics can enhance environmental, operational and ECP [27, 39]. Li et al. [40] confirmed that green logistics can improve operational efficiency and reduce overall environmental footprints, while Sarkis [41] also revealed 'cost efficiencies stemming from cost reduction from waste minimisation and energy-saving methods.' Other studies have yielded inconsistent results in respective industrial and geographic domains. Some have recognised little or no effect of green logistics, largely due to its high cost of implementation, insufficient infrastructure, and/or difficulties related to organizational inertia - especially in developing economies [4]. Furthermore, the overwhelming majority of evidence comes from developed countries and consequently little is known about the transferability/validity of these results to developing contexts like Jordan [42, 43]. Our work attempts to address this gap, conducting the first empirical test of the environmental, operational and economic benefits of green logistics in a developing-country pharmaceutical context. The second hypothesis involved examining the influence of SCL on SP. The results of that model (path coefficient = 0.52; t-statistic = 6.35) indicate a strong positive relationship and corroborate previous work by Mokhtar et al. [44] who suggest that leadership, in particular, plays a central role in securing organisational commitment to sustainability. Aligning with evidence that leadership behaviors emphasize the support and use of sustainability practices, nevertheless much of the prior literature has conceptualized SCL broadly without always connecting these features to definitive sustainability outcomes [45]. Others have focused on leadership styles without openly controlling for, or explicitly testing, their influence on sustainable logistics practices, in turn leading to vagueness about which leadership features shape and are favorable toward sustainability initiatives in a meaningful way [14, 46]. This study furthers this path, empirically identifying SCL as being not only important but a condition for sustainability performance to emerge in logistics demanding industries.

The third hypothesis tested SCL as a moderator of the relationship between a firm's commitments to GLS and SP. The positive interaction effect serves as evidence that a firm committing to green logistics will achieve more favorable performance when animated by strong leadership (path coefficient = 0.38; t-statistic = 4.55). This finding aligns with prior research highlighting how leadership can ease resource allocation, propel innovation, overcome behavioral inertia, and comfort when employing and integrating a green environment into the practices [17, 18]. Many prior studies have looked at leadership and at green logistics, but not interactively, missing the features through which leadership sustains and orients green logistics to produce superior performance outcomes [47]. By elaborating this observation with evidence that shows mutually reinforcing influences drawing SCL and green logistics together, this study generates evidence supporting the interaction between both constructs, leading to better knowledge about how sustainability performance is realised.

The findings are valuable, although they come with methodological limitations endemic to purposive, non-probability sampling strategies. Based on administrative employees in pharmaceutical warehouses, the headline finding and emergent implications may not be broadly transferable if the sample is indicative or representative of all stakeholder groups affecting logistics and sustainability decisions. Such use of sampling is admissible in emergencies where respondents present a knowledgeable basis about the leadership and operational practices discussed. Future suggestions would be probabilistic, confirming extension to other domains and national contexts.

6.1 Theoretical and practical implications

The study makes a theoretical contribution to the literature by addressing a lacuna in our understanding of how SCL influences green logistics through the lens of sustainability, an almost under-researched link particularly in a developing context like Jordan. The study's empirical findings elucidate how environmentally-friendly logistics practices are dissimilar in their respective environmental, operational and economic effects [1, 22, 42, 43].

In addition to this contribution, the study contributes theoretically by applying the Natural-Resource-Based View (NRBV) and Leadership Contingency Theory to the field of green logistics and green supply chain sustainability. In keeping with NRBV, we found that GLS represent strategic environmental capabilities whose essence lies in pollution prevention, resource efficiencies and operational sustainability, whose antecedents (green supply chain leadership) and consequent green qualities contribute to improvements in EP, OP and ECP dimensions. NRBV's hypothesis that environmentally-related capabilities do lead to the opportunity for sustained competitive advantages is accentuated here in resource-intensive and regulated industries such as pharmaceutical warehouses in developing countries [48-50].

The study contributes to Leadership Contingency Theory by showing how the efficacy of SCL is contingent upon the availability of green capabilities and environmentally-related operating conditions. The literature argues that leaders who enact work behaviours relevant to sustainability objectives are more effective at mobilising an organisation's resources, stimulating green innovation and increasing the extent to which green logistics capabilities generate SP [49-51]. This comprehensive theoretical framework conceptualises leadership as a contingency that promotes the impact of environmental capabilities on performance and provides insight into how leaders' enactment of behaviours interacts with structural conditions to facilitate sustainability in complex logistical environments. The findings present a number of practical implications for managers of pharmaceutical warehouses. Pharmaceutical warehouse operators may benefit from investing in leadership development programs that encourage sustainability-oriented leader behaviours, bridging training with green logistics planning, environmental decision-making and collaborative problem-solving exercises. Building this competence assists leaders who support with scaffolding the application of green logistics. Pharmaceutical warehouse managers should dedicate resources to institutionalizing operational green practices ranging from adopting energy- and water-efficient technical solutions, improving the logistics operation in ways that improve transport path planning solution generation, waste reduction workflow, eco-efficient packaging and so forth. Finally fostering a sustainability-oriented culture in turn gently oriented employees towards green initiatives, linking rewards toward good performance against sustainability metrics and developing desirable EP metrics can yield improvements in environmental, operational and ECP whilst fostering resilience of pharmaceutical warehouses operating in environments that are highly dependent on local natural resources and also formally regulated.

6.2 Limitations and future research

Several limitations of this study should be acknowledged. First, this study examines GLS in pharmaceutical warehouses in Jordan, so the results cannot be generalised to other countries or cultural or industrial contexts. Women's work behaviours related to leadership, sustainability adoption and existential land transport logistics in general are, for example, a function of national culture [42, 43]. Future studies could explore the relationships we examined in different countries to determine their comparability across countries. Second, this study uses a single-informant design – that is, we collected data in all cases only in a single report from a survey from administrative employees. Using a single informant opens up the likelihood of common-method variance or bias based on respondents' subjective informant ratings of all survey items. Addressing this possible bias by using multi-informant or multi-source data in the form of managerial reports, trace data or environmental audits would enhance measurement validity [52]. We focus on self-reports as sampling methodology, given that many other studies in logistics and sustainability research ask respondents who are typically fore-members and thus experts in logistics work and leaders' work behaviours. Third, we used a cross-sectional design that prevented us from inferring causal relationships within our data. Longitudinal designs provide additional evidence of the assumed temporal ordering of effects and stronger evidence of causal effects over longer terms. Examining how leaders influence the emission of GLS might be particularly fruitful in using this approach. Future studies that use introductory techniques for applying longitudinal or mixed-method research might be more salient for understanding the pace at which GLS are emplaced and the ways that leadership(s) and infrastructures influence or modulate emergent green-logistical paradigms. Finally, while we focused on GLS and SCL, other factors may also shape SP that we could not include in our modelling: Regulatory enforcement, infrastructures, or supplier fodder, would be potentially important to investigate in future research.

7. CONCLUSION

This study shows that both green logistics practices and SCL enhance SP in pharmaceutical warehouses. Green logistics practices enhance environmental, operational and ECP whilst SCL boosts the effects of green logistics on performance and provides further behavioural backing for such strategies. The strong direction effect found shows that environmental capabilities have more positive performance effects when matched by leadership behaviours which help overcome resistance and inertia, hence the need to ensure effective leadership in resource rich industries. We address important gaps in the literature by presenting empirical data in a developing country context as well as demonstrating how leadership and green logistics practices interact to affect SP. To extend the current findings, we suggest the proposed model be tested using data from other industries and national settings to support the generalizability of results. Longitudinal study designs hold promise for revealing more insights about how sustainability practices develop over time and how leadership affects the long-term success of green logistics practices in industry. We suggest examining complementary factors such as technological readiness, regulatory influence, and supply chain-related dimensions for a more holistic view of SP drivers.

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