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The Impact of Green Logistics Practices on the Environmental Performance of Industrial Firms in Saudi Arabia

أثر ممارسات اللوجستيات الخضراء على الأداء البيئي للشركات الصناعية في المملكة العربية السعودية

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Abstract:

This paper assesses the influence of green logistics practices on environmental performance in Saudi Arabian industrial companies. The study integrates green logistics into the Circular Carbon Economy (CCE) paradigm, linking the green industrial supply chain of Saudi Arabia to the goals of Vision 2030 and the National Industrial Development and Logistics Program (NIDLP).

A systematic literature meta-synthesis was used for this qualitative study. The research collected primary data from recent empirical studies, and variables influencing environmental performance were identified for each of the industrial sub-sectors considered. The variables included were structural equation modeling and various multi-criteria decision-making methodologies (such as Fuzzy AHP). These factors were considered to identify the barriers preventing widespread application.

The study findings revealed that although industrial companies were taking steps toward eco-design, green purchasing, and reverse logistics in supply chains, environmental performance was not adequately measured and quantified across the sectors. This study showed that the industrial subsectors were failing to improve environmental performance by at least 80%, with severe delays being caused by capital investment cost, technological obstacles, such as emission monitoring and measurement, and policy uncertainty. These gaps were found to vary by subsector, such as the petrochemical industry, FMCG manufacturing, construction industry, and high-tech manufacturing industry.

To translate green logistics intentions into environmental performance improvements, there is a critical need for the mandatory development of environmental performance measurement indices, such as those provided by Life Cycle Assessment (LCA). The study results offer a strategic multi-level intervention model for governments and industries to improve corporate supply chain management policies. By doing so, the industry may meet the Kingdom's 2030 national decarbonization and green logistics targets, thus contributing to sustainable development in emerging economies.

Keywords: Green Logistics; Environmental Performance; Saudi Green Initiative; Circular Carbon Economy; Supply Chain Management; Industrial Firms.

الملخص:

تُقيم هذه الدراسة الأثر المباشر لممارسات اللوجستيات الخضراء على الأداء البيئي للشركات الصناعية في المملكة العربية السعودية. باستخدام إطار الاقتصاد الدائري للكربون(CCE) ، يربط البحث عمليات سلسلة الإمداد الصناعية بمتطلبات الاستدامة لرؤية 2030 وبرنامج تطوير الصناعة الوطنية والخدمات اللوجستية.(NIDLP)

تم إجراء تجميع بعدي منهجي نوعي باستخدام مجموعة بيانات منتقاة من الأدبيات التجريبية المعاصرة. استخرجت المنهجية متغيرات محددة تحدد الفعالية البيئية عبر قطاعات صناعية فرعية متنوعة، مع تحليل نقاط البيانات التي تتراوح من مخرجات نمذجة المعادلة الهيكلية (SEM) إلى أطر اتخاذ القرار متعددة المعايير لتحديد العوائق الهيكلية التي تعرقل التنفيذ الشامل.

يكشف التجميع عن تشتت عميق في إدارة سلسلة الإمداد المستدامة. ورغم إظهار الكيانات الصناعية تبنياً مبدئياً للتصميم البيئي، والمشتريات الخضراء، واللوجستيات العكسية، يستمر النقص الحاد في القياس الكمي الموحد للنتائج الفعلية للأداء البيئي. تحدد البيانات فجوة تنفيذ شديدة، مقيدة بشدة بالنفقات الرأسمالية المرتفعة، والقيود التكنولوجية في تتبع الانبعاثات، والغموض التنظيمي، والتي تظهر بشكل مختلف عبر قطاعات البتروكيماويات، والسلع الاستهلاكية سريعة التداول، والبناء، والتكنولوجيا الفائقة.

يُعد توحيد مقاييس الأداء البيئي من خلال أطر تقييم دورة الحياة (LCA) الإلزامية أمراً حتمياً لترجمة نوايا اللوجستيات الخضراء إلى تحسينات بيئية يمكن التحقق منها. توفر النتائج خارطة طريق استراتيجية متعددة الطبقات لصناع السياسات والمشغلين الصناعيين

لتحسين استراتيجيات اللوجستيات للشركات، مما يضمن الامتثال الصارم للأهداف الوطنية لخفض الانبعاثات الكربونية ودفع الخطاب النظري حول إدارة سلاسل الإمداد المستدامة في الاقتصادات الناشئة.

الكلمات المفتاحية : نمط القيادة، المهنية التمريضية، المستشفيات الحكومية، القيادة التحويلية، القيادة التبادلية.

1. INTRODUCTION

1.1 Background of the Study: Global Context vs. The Saudi Industrial Landscape

The macroeconomic drive for sustainable supply chain management (SSCM) necessitates incorporating ecological elements into traditional logistics practices. These logistics activities are driven by the need to improve environmental performance. Sustainable supply chain management has been integrated globally. It focuses on the efficient use of resources, the reduction of emissions, and the reduction of waste.

Green logistics practices have been well developed in developed countries. The regulatory frameworks of developed countries have specific targets to improve environmental performance. These targets are often accompanied by high levels of scrutiny of supply chains. This has the effect of limiting the level of Scope 1, 2, and 3 greenhouse gas emissions. Countries have introduced taxes on carbon emissions to achieve lower emissions.

The Kingdom of Saudi Arabia serves as an example of an oil-dependent economy. The economy of Saudi Arabia is experiencing rapid growth while industrial production continues to expand. Changes in the Saudi economy have resulted not only in urbanization but also environmental pollution. CO2 emissions per capita serve as an illustration of these economic changes (Mahmood et al., 2020). The Saudi government has developed an industrial strategy that is in line with sustainable supply chain management principles to address the challenge.

Saudi Vision 2030 is the plan of the government to enhance the economy of the country. The Saudi Green Initiative (SGI) represents the main aims of Vision 2030 that relate to enhancing the environment sustainability. One of the main objectives of this initiative is establishing zero net emissions of carbon dioxide by 2060, which implies the transition toward considerable changes in the industrial and logistics sectors of the country.

The National Industrial Development and Logistics Program (NIDLP) is a new set of goals that seek to strengthen the country's position as a global logistics hub while reducing carbon emissions (Hejazi et al., 2023). In an effort to improve industrial efficiency and reduce the environmental impact of the

sector, the national goals require industries to become aware of the need to integrate green logistics practices. These include, but are not limited to:

- green purchasing
- green design
- green packaging
- green return and disposal (Hejazi et al., 2023).

The shift from traditional logistics approaches to more environmentally conscious models requires fundamental changes in industry supply chain management, logistics practices, energy efficiency, production and consumption (Alkandi et al., 2024).

1.2 The Circular Carbon Economy (CCE) Framework

In order to frame this transition, this research utilizes the Circular Carbon Economy (CCE) framework. First introduced in Saudi Arabia's G20 presidency, the CCE framework elaborates the concept of the circular economy by looking at energy and emissions flows through four channels: Reduce, Reuse, Recycle and Remove. In relation to the industrial logistics industry, "Reduce" can be interpreted as route optimization, energy-efficient warehousing and use of green energy, all of which are proven to result in reduced carbon dioxide emissions in Saudi Arabia (Kahia et al., 2023). The term "Reuse" implies the use of sustainable packaging and asset sharing. "Recycle" requires an efficient reverse logistics system as well as the disposal of materials at the end of their life cycle. Finally, "Remove" makes use of effective carbon capturing systems in heavy cargo transportation. The CCE framework use in supply chain management implies that companies should not only employ green technologies but also transform their organizational environmental culture (Al Doghan et al., 2022).

1.3 Statement of the Problem

Although green logistics strategies have been given high priority as part of the Saudi macroeconomic policies, empirical evidence in the published literature is fragmented over the adoption and measurement of green logistics practices in the Saudi industrial sector. Although Saudi industrial companies are moving towards more sustainable and eco-friendly practices, they still suffer from an unavailability of a single and quantitative measurement of environmental performance.

Studies have tended to provide a qualitative and subjective assessment of green logistics practices and managerial intentions, rather than objective and quantitative data, like the percentage drop in emissions,

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energy, and waste consumption. Even though green innovation is considered to be an important predictor of sustainable SME performance (Baeshen et al., 2021), there remains limited data on the exact impact on the amount of waste or emissions reduction. Additionally, the impact of green logistics adoption on the environmental performance varies in context and is highly influenced by contextual obstacles, such as costs, technology, and the level of regulation (Khayyat et al., 2024).

In the context of the Saudi industrial sector, the limited data available on specific and quantitative indicators of green logistics performance limits the ability to measure the extent to which the implementation of green logistics practices will bring about environmental performance improvements. This leaves an open research question whether green logistics practices will deliver environmental performance improvements to companies, or if it is merely a result of compliance with mimetic pressure.

1.4 Research Questions

In order to overcome the noted empirical shortcomings, the study will respond to the following research questions:

1. What is the present state of the implementation of green logistics initiatives in different industrial sectors in Saudi Arabia?
2. What is the scope of the effects of these green logistics initiatives on the environmental performance of firms?
3. What are the major structural, financial and operational hurdles in the way of the widespread implementation of green logistics in Saudi Arabia?

1.5 Research Objectives

Corresponding to the research questions, this study has particularly been devised with the following objectives:

1. To determine and classify the mainstream green logistics practices in Saudi industrial businesses in conformity with the Vision 2030 and CCE initiatives.
2. To find out the extent of effect of mentioned green logistics practices on the environmental performance rate of different targeted industrial segments.
3. To assess the structural, resource, and technological hurdles faced in the successful implementation of sustainable supply chain operations.

4. To formulate an effective-scale strategy from the viewpoint of environmental performance indicators attributed to green logistics practices in developing industrial economies.

1.6 Significance of the Study

The study aims at direct contribution to the relevant branches of the industry, for both the Saudi Arabian regulatory agencies and designers of NIDLP it provides necessary empirics to enhance environmental compliance standards and improve the tools of the Saudi Green Initiative, thus driving the nation towards its sustainability goals. For the industry itself the research offers a detailed cost-benefit analysis of green logistics implementation, which would allow businesses to integrate the principles of sustainability into their optimization practices. From the academic point of view, the study significantly contributes to the literature of the region by shifting the focus in the research from qualitative concepts to quantitative results, which may serve as the basis for further studies in the field of supply chain management in the Middle East.

2. RESEARCH METHODOLOGY AND TOOLS

2.1 Research Design and Justification

This study utilizes a qualitative systematic meta-synthesis methodology in order to assess the implications of adopting green logistics practices on environmental performance of industrial companies in Saudi Arabia. This methodology was chosen because it is capable of overcoming the empirical fragmentation faced by sustainable supply chain literature in the region. Unlike regular systematic reviews that focus only on quantitative results, this methodology interprets and integrates qualitative, quantitative, and mixed-method findings into creating an integrated theoretical framework for the particular field. As such, this technique allows for the analysis of data provided by previously published empirical studies that enables the isolation of essential variables responsible for improving environmental performance and identification of those elements that prevent full-scale application.

2.2 Data Collection and Extraction Protocol

For the purpose of this research, we considered only the primary data available in the selected databases, that is, the peer-reviewed, empirical research studies published in journals. The data were extracted in order to provide information on methodology, sample size and results.

In this regard, we extracted the studies that utilized a variety of quantitative approaches. For example, the use of partial least squares structural equation modeling (PLS-SEM) on 284 small enterprises in

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Saudi Arabia (Al Shammre et al. 2023), on 335 small and medium-sized enterprises in Saudi Arabia (Al-Shammari et al. 2022), etc., was extracted. We also extracted the use of Autoregressive Distributed Lag (ARDL) on carbon dioxide emissions between 1990 and 2018 (Kahia et al. 2023), on the impact of environmental social and governance (ESG) disclosures on the financial sustainability of the SMEs (Ammer et al. 2020), the impact of environmental social and governance (ESG) disclosures on the financial sustainability of the SMEs using the dynamic panel generalized method of moments (GMM) (Abu Hussain et al. 2024), etc. In addition, the use of fuzzy AHP for supplier selection based on supplier green innovation capability and TOPSIS-Grey method (Almalki et al., 2020).

We also extracted the use of qualitative data through semi-structured interviews, for example, 30 semi-structured interviews with small and medium enterprises (Shalhoob and Hussainey 2022) and 38 SMEs in Saudi Arabia, using 38 e-commerce and logistics enterprises (AlOtaibi 2023), and so on.

2.3 Inclusion of Cross-Regional Benchmarks

Although the main focus of this synthesis is the Kingdom of Saudi Arabia, the data includes very many important cross-regional studies which serve as relevant areas of comparison for the emerging economies. Data from Oman (Verma, 2024), Pakistan (Kuo et al., 2022), Jordan (Aloqaily et al., 2024), and Slovakia (Richnák & Gubová, 2021) have been used for this study so that a wider understanding of green logistics implementation barriers, including the moderating effect of GHRM and circular economy can be achieved. The cross-country data have exclusively been used only to provide certain context about the structural obstacles faced by industrial companies in Saudi Arabia in respect of the wider transition to sustainable supply chains globally.

2.4 Data Synthesis Matrix

The extraction of information was conducted using a synthesis matrix, which helped in the systematic allocation of the findings. In the case of each investigated study, information was taken with respect to applied green logistics practices (such as green purchasing, eco-design, reverse logistics), specific environmental performance metrics that were evaluated (such as reducing carbon footprint and waste), and the recognized structural inhibiting factors preventing the implementation of the practices. The availability of the matrix allowed for comparative analysis of various studies conducted and provided an opportunity for revealing the basic types of empirical data used and the corresponding methodological gaps in the field of green logistics applied in a specific industry in Saudi Arabia.

3. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

3.1 Theoretical Framework: Institutional Theory and the Resource-Based View (RBV)

The study is based on institutional theory and the resource-based view (RBV) of the firm. Institutional theory explains how the institutional environment, including the regulatory field, drives industries to implement green logistics. El-Garaihy et al. (2022) show that standard pressures, such as those from supply chain members and customers, positively drive the adoption of green supply chain practices by Saudi manufacturing companies. Moreover, within Saudi Arabia, the strict goals for environmental compliance set forth in Vision 2030 are considered an example of coercive isomorphism which pushes companies towards more sustainable approaches, or else face the sanctions of the law.

On the other hand, RBV suggests that the incorporation of green logistics into an organization gives rise to unique and irreplicable green capabilities (El-Garaihy et al., 2022). Specifically, green logistics (e.g., green purchasing, green innovation, eco-design, reverse logistics and green transportation) are viewed as capabilities for a successful organization. The RBV perspective, when applied to green purchasing, provides an explanation for how green transformational leadership can enable green innovation and corporate social responsibility and, in turn, improve environmental performance (Sobaih et al., 2022a). In essence, these capabilities are what enable industrial companies in Saudi Arabia to achieve enhanced environmental performance as well as the sustained competitive edge that is not replicable.

3.2 Synthesis of Green Logistics Practices in Saudi Industry

The empirical literature highlights the emergence of a unique range of measures for sustainable supply chain adaptations that can be seen in the Saudi industrial sector. There exist measures that are implemented in every stage of the product life cycle and are grouped in four key sub-groups.

3.2.1 Green Purchasing and Supplier Integration

Environmental purchasing is the upstream basis of sustainable supply chain management in the Saudi industrial sector, making the process of integrating environmental considerations into supplier selection and procurement more systematic. According to Almalki et al. (2020), green innovation ability is one of the most important factors in the selection of suppliers by SMEs, allowing them to reduce the risk of ecological damage and air pollution. Fuzzy AHP has shown that "Green Innovation Initiatives" is the most important criterion when selecting suppliers. Alkandi et al. (2024) make additional observations

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to prove that green purchasing supports waste reduction, recycling, and utilizing eco-friendly alternatives when sourcing materials, which has a direct impact on lean management.

3.2.2 Eco-Design and Product Lifecycle Management

Eco-design is primarily about using environmental parameters during product conception to reduce waste production and improve the possibility of recovering materials. According to Wasiq et al. (2023), investment in green innovation entails using materials that make less use of energy and pollute less in the production process in Saudi Arabia. Similarly, Baeshen et al. (2021) maintain green innovation refers to the use of technology that helps manage the environment, reduce pollution, and save energy. Empirical evidence shows eco-design leads to reduced resource depletion, confirming its status as a proactive environmental strategy.

3.2.3 Sustainable Transportation and Logistics Efficiency

Transportation constitutes a highly carbon-intensive node within the industrial supply chain. Almatar (2023) provides evidence that green mobility in Saudi Arabia is associated with the reduction of traffic congestion, climate protection, and air quality betterment. In the B2C e-commerce sector, AlOtaibi (2023) observes a shift toward environmentally friendly vehicles, such as small cars, and the use of technology to reduce delivery times, thereby minimizing the environmental impact of last-mile logistics. Furthermore, Mutambik (2024) highlights that digital transformation and sustainability innovation exploitation in the freight and logistics industry optimize resource efficiency and reduce the environmental footprint.

3.2.4 Reverse Logistics and Circularity

Reverse logistics, which includes concepts such as product recall, remanufacturing, and end-of-life recycling, is a method of initiating the supply chain cycle, allowing the principles of a circular economy to be put to practice. In the work of Ghaithan et al. (2023), it has been shown that the use of circular economy practices helps a manufacturing company in Saudi Arabia achieve sustainability goals. Furthermore, according to data from Slovakia (Richnák & Gubová, 2021) and Oman (Verma, 2024), it is evident that reverse logistics and green logistics practices greatly assist in achieving circular economy principles.

Table 1: *Matrix of Green Logistics Practices and Operational Applications*

Green Practice Category	Specific Operational Applications	Primary Empirical Sources
Green Purchasing	Supplier environmental auditing; selection based on green innovation ability; procurement of sustainable materials.	Sultan Musaad O et al. (2020); Alkandi et al. (2024)
Eco-Design & Packaging	Design for reduced material/energy consumption; use of paper instead of plastic; biodegradable packaging.	Wasiq et al. (2023); Baeshen et al. (2021); AlOtaibi (2023)
Sustainable Transportation	Route optimization; transition to small/eco-friendly vehicles; green mobility initiatives.	Almatar (2023); AlOtaibi (2023); Mutambik (2024)
Reverse Logistics & Circularity	Waste minimization; resource optimization; end-of-life product recovery and recycling.	Ghaithan et al. (2023); Richnák & Gubová (2021); Verma (2024)

According to Table 1, the operationalization of green logistics practices represents a departure from conventional cost-driven supply-chain systems to those which are ecologically integrated. The use of green purchasing mechanisms is imperative for businesses, which means they now must impose strict environmental compliance regulations on their suppliers, thereby changing the dynamics of procurement. Eco-design and sustainable packaging emerge as key operational strategies for minimizing wastage at all phases of the product life cycle. Moreover, establishing reverse logistics systems represents a daunting operational task for manufacturing firms to implement circular economy principles.

3.3 Evaluation of Environmental Performance Impacts

The main goal of implementing green logistics is to achieve real ecological gains. Yet, as stated in literature, the ways these gains are measured and reported vary a lot from entity to entity. As shown in Table 2, the assessment of environmental performance consists of several perspectives but often does not involve standard ways of measurement.

Table 2: *Cross-Sector Evaluation of Environmental Performance Dimensions*

Environmental Dimension	Observed Empirical Pattern & Metrics	Representative Sources
Carbon Footprint Reduction	Reductions in CO2 emissions linked to green energy use and environmental patents; reliance on ARDL modeling.	Kahia et al. (2023); Mahmood et al. (2020)
Waste Minimization	Reduction in solid waste and hazardous materials; implementation of circular economy principles.	Ghaithan et al. (2023); Wasiq et al. (2023); Hejazi et al. (2023)
Energy Efficiency	Decreased consumption of electricity, oil, and gas; optimization of energy use through green innovation.	Al Doghan et al. (2022); Alshebami (2023)
Resource Optimization	Efficient allocation of raw materials and water; integration of Industry 4.0 and lean manufacturing.	Ghaithan et al. (2021); Al-Shammari et al. (2022)

Cross-sector evaluation of environmental performance dimensions (Table 2) reveals an apparent gap in the current empirical landscape between qualitative assessment of managerial intent and quantitative analysis of actual environmental impact. A notable exception is Kahia et al. (2023), who found that a 1% increase in the utilization of green energy is associated with a decline in carbon emissions of 0.185% in per capita emissions. Instead, the remaining empirical studies (e.g. Al Doghan et al., 2022; Alshebami, 2023) rely on qualitative perception survey findings to conclude that the usage of environmental resources (e.g. water, electricity and natural gas) has generally declined. There is a distinct lack of empirical findings reporting on quantified volumetric data.

Waste minimization and efficiency of resources are another key dimension of environmental performance. Several studies (e.g. Ghaithan et al., 2023; Ghaithan et al., 2021) provide clear evidence of the theoretical advantages associated with a circular economy and Industry 4.0 approaches, which can facilitate waste generation minimization and resource allocation in various industries such as the petrochemical and the plastic industries. Still, there is a general absence of empirical research reporting on standardized cross-sector measurements of waste generated or efficiency of resources allocated, and the lack of unified reporting systems in the environmental reporting field means that there is no benchmark for measuring environmental performance of waste reduction and resource efficiency.

3.4 Taxonomy of Structural Implementation Barriers

There are difficulties involved in the move to sustainable practices within supply chain management. With respect to eco-friendly logistics, Saudi Arabian firms are presented with a number of different hurdles.

Table 3: *Taxonomy of Green Logistics Implementation Barriers*

Barrier Category	Concrete Empirical Evidence	Representative Sources
Economic Constraints	High initial capital expenditures; financial constraints limiting SME investment in green technologies.	Khayyat et al. (2024); Shalhoob & Hussainey (2022); Alsahlawi et al. (2021)
Technological Limitations	Deficits in technological readiness; complexity of AI and digital transformation adoption.	Badghish & Soomro (2024); Ghaithan et al. (2021)
Regulatory Ambiguities	Lack of clear government regulations and robust policy support; systematic complexity of disclosure standards.	Khayyat et al. (2024); Shalhoob & Hussainey (2022)
Organizational Resistance	Lack of environmental culture; insufficient training; resistance to change.	Al-Ajlouni (2023); Al-Shammari et al. (2022)

The classification of obstacles to structural implementation as described in Table 3 illustrates the complicated friction points which make complete introduction of green logistics impossible. Economic problems represent the greatest obstacle in this regard for SMEs. According to Shalhoob and Hussainey (2022), these types of companies face high costs and low profit margins that hinder the application of ESG practices. Besides, Alsahlawi et al. (2021) indicated that financial issues increase the negative influence of the environmental disclosures on stock prices because investors view such financially restricted firms undertaking eco-friendly initiatives as more risky ones.

Technological difficulties and vagueness of regulations create additional structural obstacles. As Badghish and Soomro (2024) indicate, the complexity of the AI technology presents a problem for SMEs, while Ghaithan et al. (2021) argues that a lot of petrochemical companies use the old technologies of Industry 3.0 showing that the technological readiness is far behind the needs. Moreover, Khayyat et al. (2024) point out that the government regulations need to be clarified and the policy support should be stronger in order to promote the implementation of green logistics. Finally, the organizational resistance, which is fueled by the absence of the environmental culture and insufficient

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training (Al-Ajlouni, 2023), complicates the establishment of the internal green capabilities that are essential for sustainable supply chain realization.

4. RESULTS

The thorough meta-analysis of the collected empirical studies makes clear the considerable diversity in the implementation of green logistics practices in the Saudi industry. The findings suggest that converting sustainable supply chain intentions into observable environmental achievements is highly dependent on the particular characteristics of operations, capital intensity, and governmental rules applicable to specific sub-industries. To explain the differences in the results, they are included in the corresponding industrial scenarios, forming the comparative Performance Matrix.

4.1 Sub-Sector Analysis and Industrial Scenarios

Scenario Alpha: Petrochemicals and Heavy Manufacturing

The petrochemical and heavy manufacturing companies exhibit great promise when it comes to the implementation of the principles of green logistics thanks to the application of industry 4.0 tools and lean manufacturing. As it follows from Ghaithan et al. (2021), the digital characteristics of industry 4.0, particularly those connected to real-time data sharing, provide companies with opportunities to use resources effectively which allows them to reduce resource use, GHG emissions, and plastic waste in the petrochemical industry of Saudi Arabia. Moreover, as explained by Althnayan et al. (2022), Environmental Transformational Leadership (ETL) influences the sustainability performance of the petrochemical organization indirectly by promoting Environmental Organizational Citizenship Behavior (EOCB) which is aimed at the decline in resource usage at both individual and organization levels. Yet, even with such advantages, the sector continues to experience challenges due to its dependence on the consumption of fossil fuels and the management of hazardous wastes.

Scenario Beta: Fast-Moving Consumer Goods (FMCG) and Food Processing

The eco-design, sustainable packaging, and eco-friendly human resource management practices are at the forefront of both the FMCG and food processing sectors. Sobaih et al. (2022b) provide robust evidence about the association between green transformational leadership and pro-environmental behaviors among 1,050 employees working in the food industry in Saudi Arabia. This, in turn, results in the reduction of waste and saving energy as well as water. Alkandi et al. (2024) emphasize the significance of green purchasing and internal environmental management in the industrial sector to

ensure lean management and high performance of business with minimum waste and energy consumption.

Scenario Gamma: Small and Medium-Sized Enterprises (SMEs) and E-commerce

The economic and technological challenges experienced by small and medium-sized enterprises (SMEs) significantly impact their ability to fully embrace green logistics practices. The study by Wasiq et al. (2023) shows that adoption of green innovation in Saudi SMEs helps to improve environmental performance through lower solid waste production, lower greenhouse gas emissions, and reduced consumption of resources (water, energy, gas). However, qualitative interviews conducted by Shalhoob and Hussainey (2022) demonstrate that SMEs are not familiar with ESG practices, which causes serious difficulties as they are often unable to obtain enough funds to implement the necessary changes. In the B2C e-commerce industry, AlOtaibi (2023) notes the gradual move of companies towards green cars (small cars), but high costs of raw materials and the focus on profits instead of sustainability continue to pose problems for them.

Table 4: *Comparative Performance Matrix of Green Logistics Outcomes by Industrial Sub-Sector*

Industrial Sub-Sector	Primary Green Logistics Focus	Capital Intensity & Tech Readiness	Measurable Environmental Outcomes	Execution Lag Severity
Petrochemicals	Industry 4.0 integration, real-time data for resource allocation.	High / Advanced	Reduction in GHG emissions and plastic waste generation.	Low to Moderate
FMCG & Food	Eco-design, green purchasing, green HRM.	Moderate / Intermediate	Waste reduction, water and energy conservation.	Moderate
SMEs & E-commerce	Sustainable packaging, green mobility (small cars).	Low / Deficient	Marginal reductions in resource use; high reliance on qualitative estimates.	High

The comparative view shown in Table 4 shows how big the difference is between implementations of green logistics in industries that are functioning in Saudi Arabia. While the oil and gas industry is well aware of the benefits of introducing Industry 4.0 technologies to track emissions, it is not widely applied. FMCG companies have some green logistics practices; however, they are left with no other

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option but to promote in their organizations the environmental culture and behavior. It should be noted that the rather slow adoption of green logistics by SMEs creates an important problem as SMEs suffer from both financial constraints and unclear regulations that are very important in estimating the success of their environmental performance.

5. DISCUSSION OF RESULTS

The analysis thus far has uncovered a gap between the top-down macro goals of the Saudi Green Initiative and the current reality of the implementation of green logistics at the level of the individual enterprise. In this last section, we consider the determinants of this gap in the SGI case, including the nature of social and political influence, a shortage of measurement criteria, and what might be understood as a phenomenon of "Execution Lag" for the industry in Saudi.

This empirical fragmentation begins, in part, as a function of the divergence of coercive institutional pressures from the actual economic requirements for the business firm. In the SGI, as in Vision 2030, goals regarding decarbonisation are set from above, but their operationalisation in detailed sectoral terms remains, in many respects, a process of ongoing development. This lack of clarity leaves space for performative compliance.

As with the case study data above, industrial firms including SMEs use rhetoric about green supply chain management as a way to demonstrate corporate legitimacy and win government contracts, even while they fail to make real changes in their operations that would yield actual environmental progress. Mimetic isomorphism reaches its limits when corporations merely take on the appearance of environmental sustainability as a form, rather than the requisite capabilities for actual environmental sustainability as a process.

One cause for this cosmetic compliance is a lack of data. Enterprises rely primarily on subjective managerial judgment rather than on specific data on carbon emissions. This lack of data is not only the result of poor data, but also of technological deficiencies as well as poor metrics. For green logistics to be fully realized, there must be real-time tracking of information across the entire supply chain; however, most firms lack the digital tools needed to measure such things as indirect (Scope 3) carbon emissions or specific amounts of material sent to a landfill. A general lack of state-mandated lifecycle assessments allows businesses to highlight the most favorable metrics without taking into account the most negative environmental impacts of their activity.

This lack of technology and metrics brings about an effect that we call the "Execution Lag." High upfront investments in environmental supply chain infrastructure run headlong into the need for short-term gains in the typical corporate model of financial management. As the ROI for environmental sustainability is long-term in its returns, the industrial sector is characterized by an Execution Lag in the form of an upstream delay to implementation. A company will not invest in the necessary technology until the government makes it financially necessary to do so, that is, until coercive pressures begin to replace normative ones.

The conceptual application to the case studies suggests that the execution lag is not constant. Large companies in the petrochemical sector have reduced this time lag by virtue of their participation in global markets, which require carbon footprint accounting, and their ability to invest in digital infrastructure and automation technologies, such as Industry 4.0 solutions. The companies with a primarily domestic market and small business organizations are in a situation of having to deal with local market dynamics where the financial losses that a carbon-heavy supply chain would incur are currently not sufficient to force rapid logistics innovation. The case study also suggests one more aspect of the execution lag: the maturity of the industry in which a company is a participant. A company will be less willing to adopt circular supply chain models if there is no secondary market that can purchase material that has already been used, and the same is true for the availability of subsidies for green technologies.

The downstream, upstream execution lag is a very large threat to the implementation of Vision 2030 as a whole. If companies are operating with no common definition of carbon emissions, then the ecological footprint of the industrial sector as a whole will not be consistent with the country-wide effort to reduce carbon emissions to zero. A radical transformation from voluntary, subjective, and qualitative environmental improvement to mandatory and objective environmental management will be necessary if the gap is to be bridged. A shift from linear to circular supply chains should not rely on the goodwill of the enterprise alone, but should have a strong coordination of resources and government enforcement in addition to widespread carbon footprint monitoring capabilities at every link in the supply chain.

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6. RECOMMENDATIONS

In order to eliminate Execution Lag and achieve convergence in industrial logistics with net-zero goals of Vision 2030, a multi-layered strategic framework has been suggested through this research. This prescriptive strategy serves as a guide for policymakers, industrial stakeholders, and academic professionals.

6.1 Strategic Roadmap for Saudi Policymakers and NIDLP Architects

Regulatory measures will have to change from soft regulation to hard coercive and data-driven measures, with the Ministry of Industry and Mineral Resources leading, in coordination with the government's environmental policy, the setting of a mandatory Lifecycle Assessment (LCA) policy that is sector-wide. Mandatory policies must set a clear methodology that calculates Scope 1, 2, and 3 emissions, replacing the vague estimates that companies currently use.

Additionally, a national central data platform will have to be established, and companies must be required to link their enterprise resource planning (ERP) systems to the government platform, so that real-time, real data on emissions per freight, energy use, and rates of waste diversion can be accessed.

In the interest of overcoming the financial barrier that is the source of the Execution Lag in the case of the SMEs, NIDLP must also establish and make public its own policies to motivate and subsidize investments in these areas. This will include incentives, like tax rebates, for companies who acquire low emission vehicles or for those that receive green technology in customs, or even subsidised rates on capital for the creation of reverse logistics systems and sorting facilities.

6.2 Strategic Roadmap for Industrial CEOs and Supply Chain Managers

Industrial leaders must completely change their organization's focus to long-term ecological sustainability from a short-term cost saving mindset. Change must be facilitated from the CEO level. Environmental key performance indicators such as actual amount of emissions reduction, and percent of secondary materials in products should be included in the CEO and other executives' and managers' compensation plans.

Supply chain managers can manage their cash flow by making incremental investments. They can start with quick-win investments such as route optimization, and environmentally focused supplier audits of

key strategic suppliers. They should wait until they have enough working capital to invest in more complex capital-intensive investments such as remanufacturing investments.

Supply chain managers should invest in employee skills. To implement these investments, firms need to invest in skills to train supply chain management and purchasing employees in green supply chain logistics, supplier audits on sustainability, and the implementation of the Circular Carbon Economy.

6.3 Strategic Roadmap for Future Academic and Empirical Research

Scholars in this area should improve the methodological quality of the body of work regarding sustainable regional supply chains. Future experimental inquiries should no longer use qualitative surveys identifying managerial attitudes. In the body of work it would be appropriate to shift towards rigorous quantitative methods relying on specific volumetric figures obtained straight from companies' databases or national statistics.

Therefore, researchers should give priority to longitudinal cross-industrial studies identifying any changes in environmental performance indicators following the implementation of green logistics practices. This will enable researchers to calculate the ROI horizons for the technologies based on science. Lastly, future research should focus on the creation of localized rigorous models that will help isolate the influence of certain green logistics variables on specific GHG emissions and thus develop a verifiable scientific foundation for future policies.

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