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Challenges and Factors Influencing the Implementation of Green Logistics: A Case Study of Saudi Arabia

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Abstract: Logistics operations significantly depend on fossil fuels and non-renewable energy sources, posing challenges to environmental sustainability. Achieving a balance between environmental protection and economic efficiency is vital in logistics decision-making. The concept of green logistics aims to reduce environmental externalities by adopting sustainable practices. This research explores the adoption and utilization of green logistics technologies and information systems through a structural equation model, focusing on key factors such as environmental awareness, organizational culture, and financial considerations. The research methodology involved using a specially designed questionnaire to collect data, which was subsequently analyzed through various stages. The study selected Saudi Arabia as a case study due to its rapid development in the logistics sector and its significant CO_2 emissions. Initially, a general quantitative descriptive analysis was performed on the collected responses. This was followed by more detailed analyses to uncover the finer nuances in stakeholders' perspectives. Additionally, correlation analysis was conducted to identify significant associations between variables and to understand their potential interactions. The findings reveal high environmental awareness among stakeholders, a positive organizational culture conducive to sustainability practices, and a strong recognition of the benefits of green logistics technologies. However, there is room for improvement in technological readiness and a need for clearer government regulations and more robust policy support. Financial considerations are complex, with significant initial investments required and long-term financial benefits recognized.

Keywords: green logistics practices; driving factors; environmental policy; financial ability; structural equation model

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1. Introduction

The logistics sector, while essential to the economy and daily life, is a significant contributor to pollution and resource consumption [1–4]. The logistics sector, particularly transport, accounts for 16.2% of global greenhouse gas (GHG) emissions, with road transport alone responsible for 11.9% [5]. In contrast, the industrial sector, including iron and steel production, chemical manufacturing, and other heavy industries, contributes approximately 24.2% of global GHG emissions due to high energy use from coal, oil, and natural gas [5]. Buildings contribute around 17.5%, primarily from energy use for heating and cooling, while the agriculture and forestry sector adds about 18.4% through activities like livestock farming and deforestation [5,6]. While logistics is a major polluter, heavy industry and buildings have higher shares of emissions and energy consumption.

Logistics focuses primarily on efficiency, cost-effectiveness, and timely delivery of goods, often relying heavily on fossil fuels and non-renewable energy sources, leading to

substantial environmental degradation through high greenhouse gas emissions, pollution, and resource consumption. In contrast, green logistics aims to minimize these negative environmental effects by integrating sustainable practices such as reducing emissions, optimizing energy use, and utilizing renewable resources [7]. Green logistics, as defined in the literature, is an approach that aims to minimize the negative environmental impacts of logistics processes while maintaining social and economic objectives [8–11]. Various areas where green logistics practices are applied include designing eco-friendly products, implementing green transportation strategies, optimizing warehousing operations, using sustainable packaging materials, managing logistics data efficiently, and recycling waste.

The implementation of green logistics and supply chains is crucial in achieving Sustainable Development Goal 12 (SDG 12), which focuses on sustainable consumption and production patterns [12,13]. This goal emphasizes enhancing technological capabilities in developing countries to support sustainable practices, including waste reduction, minimizing the release of harmful substances, and promoting sustainable purchasing. As a result, businesses are adopting Green Logistics initiatives to meet the need for more sustainable practices. However, the role of green logistics technology in sustainable development remains an underexplored area in research [14]. Managing sustainable performance in complex global supply networks remains a challenge, with current practices often falling short of optimal sustainability standards. Despite the clear benefits of green logistics practices, several variables affect their implementation.

In this study, we focus on the complementary aspects of green logistics with a resilient research approach. We analyze the perceptions and attitudes of potential users of green logistics to understand the key determinants. For this purpose, we review the literature and construct a research model that combines seven variables: environmental awareness, organizational culture, technological readiness, government regulation, financial consideration, perceived benefits, and intention to adopt green logistics. These variables create a dynamic research context, and we further elaborate on various hermeneutic factors and their relationships. The choice of Saudi Arabia as the sample for this study is motivated by two reasons: the rapid development of logistics in the country and its significant CO_2 emissions [15]. Establishing a green logistics system guided by government policies is crucial for reducing greenhouse gas emissions and contributing to sustainable development. This research provides a realistic background for addressing these issues in Saudi Arabia and globally.

The findings of this study can enhance the understanding of current and potential users of green logistics, particularly in Saudi Arabia, which can aid in developing green logistics, improving its features, and providing better experiences for users. The main contributions of the paper include:

- Understanding how companies perceive green logistics.
- Investigating the relationships among key variables and the role of hermeneutic factors in the adoption of green logistics.
- Clustering companies into meaningful groups to support bold recommendations.

The rest of the paper is organized as follows: The related research works are discussed in Section 2, highlighting their research objectives and main findings. Section 3 provides a detailed background of the main variables and hypotheses. The research methodology, including the implemented research model and survey design, is presented in Section 4. Then, Section 5 discusses the analysis and findings of the collected data, followed by a discussion of the results in Section 6. Finally, the paper is concluded in Section 7.

2. Related Works

The implementation and advancement of green logistics have garnered significant attention as industries and governments strive to align with sustainable development goals. Table 1 summarizes the research works that focus on understanding the factors influencing the adoption of green logistics, the barriers faced, and strategies to overcome these challenges. Youngswaing et al. (2024) studied Thailand's automotive sector, highlight-

ing the importance of environmental responsibility and identifying government policies, financial capability, and public attitudes as key factors influencing green logistics efficiency [16]. Similarly, Hadi et al. (2023) examined green logistics in Indonesia, noting significant barriers such as technological factors, organizational climate, competition, and regulation, emphasizing the need for government intervention to support unified green logistics efforts [17].

Table 1. A summary of the related works that focused on understanding the factors influencing the adoption of green logistics.

Study	Focus Area	Key Findings	Implications
Youngswaing et al., 2024. [16]	Thailand's automotive sector	Importance of government policies, financial capability, and public attitudes in green logistics efficiency.	Insights for manufacturers and government sectors on environmental sustainability strategies.
Hadi et al., 2023. [17]	Green logistics in Indonesia	Identified barriers such as technological factors, organizational climate, competition, and regulation.	Emphasized need for government intervention for green logistics.
Prataviera et al., 2023. [18]	Italian logistics service providers	Importance of interconnected stakeholders and factors like economic, organizational, collaboration, and external factors.	Highlighted need for comprehensive approach to environmental sustainability.
Jefimovaitė & Vienažindienė, 2022. [19]	Lithuanian logistics center	Key drivers include positive image, cost reduction, regulation compliance; barriers include high initial investments and lack of technical expertise.	Addressing challenges to promote green logistics practices and sustainability goals.
Agrawal et al., 2023. [20]	Indian brass manufacturing industry	Identified critical success factors for SGSCM like top management commitment and reverse logistics management.	Environmental and financial benefits of recycling brass; challenges in implementing SGSCM.
Vienažindienė et al., 2021. [21]	Lithuanian transport and logistics companies	Key areas identified: green transportation, warehousing, management, and waste management; drivers include legal regulations, business partner requirements, and corporate culture.	Emphasized need to promote green logistics practices for sustainable development.
Fen et al., 2020. [22]	Green logistics in Malaysia	Drivers include environmental improvement; barriers include lack of government regulation.	Foundation for future studies and decision-making in green logistics.
Richnák & Gubová, 2021. [23]	Slovak automotive enterprises	Importance of corporate social responsibility and continuous implementation of ecological tools.	Enhancing sustainability in logistics through ecological innovations.
Zhang et al., 2020a. [24]	Green Logistics Policies (GLP) in Wuhan, China	Key factors: completeness of GLP system and government's green governance capacity.	Impact on regulating non-green behavior and promoting environmental restoration.
Zhang et al., 2020b. [25]	Factors influencing green logistics development	Importance of government policies, public support, and green technology innovations.	Contributions to understanding relationships among influential factors and developing a hierarchical structure.

Prataviera et al. (2023) analyzed Italian logistics service providers, focusing on the cascading effects among stakeholders and the importance of interconnected networks in addressing environmental sustainability. The study identified economic, organizational, and external factors, including incentives and regulations, as crucial influences [18]. Jefimovaitė

and Vienažindienė (2022) explored green logistics practices in a Lithuanian logistics center, finding that positive image, cost reduction, and regulation compliance were key drivers, while high initial investments and lack of technical expertise were significant barriers [19]. Addressing these challenges is essential for promoting the adoption of green logistics practices and achieving sustainability goals.

Agrawal et al. (2023) focused on the Indian brass manufacturing industry, highlighting critical success factors for Sustainable Green Supply Chain Management (SGSCM), such as top management commitment and reverse logistics management [20]. The research underscores the environmental and financial benefits of recycling brass, emphasizing the challenges faced by manufacturing units in implementing SGSCM. Vienažindienė et al. (2021) investigated the adoption of green logistics practices in Lithuanian transport and logistics companies, identifying key areas like green transportation, warehousing, management, and waste management [21]. The study found that legal regulations, business partner requirements, and corporate culture were significant drivers for the adoption of green logistics, emphasizing the need to actively promote these practices to mitigate environmental impacts and develop sustainable strategies. Fen et al. (2020) investigated drivers and barriers to green logistics in Malaysia, with environmental improvement being a primary driver and lack of government regulation a major barrier, providing a foundation for future studies and decision-making [22].

Finally, studies like those by Richnák and Gubová (2021) and Zhang et al. (2020a, 2020b) contribute to the understanding of green logistics practices by examining factors such as corporate social responsibility, government policies, public support, and green technology innovations [23–25]. These studies highlight the importance of continuous implementation of ecological tools, effective Green Logistics Policies (GLP), and the hierarchical structure of influencing factors. Collectively, these studies provide valuable insights for policymakers, industry leaders, and researchers, offering guidance to promote environmental sustainability within the logistics sector.

The existing body of research on green logistics has predominantly focused on identifying key factors influencing its adoption and implementation, as well as the barriers encountered in various geographical contexts. However, there is a notable gap in understanding the perceptions and attitudes of potential users of green logistics, particularly in the rapidly developing logistics sector of Saudi Arabia, which is characterized by significant CO_2 emissions. Moreover, previous studies have largely concentrated on the organizational and policy-driven aspects of green logistics, with less emphasis on the hermeneutic factors and their interplay in shaping the adoption of green logistics practices. Our study aims to address these gaps by delving into the perceptions and attitudes of potential users in Saudi Arabia, exploring the nuanced relationships among key variables, and clustering companies to provide targeted recommendations. Additionally, while existing research has provided valuable insights into the drivers and barriers of green logistics, there is a need for a more holistic understanding of how these factors interact within the context of a rapidly evolving logistics landscape. Our research seeks to fill this void by offering a comprehensive analysis of the determinants of green logistics adoption, with a particular focus on the Saudi Arabian context, therefore contributing to the global discourse on sustainable logistics practices.

3. Research Background and Hypotheses

Logistics plays a crucial role in supply chain management, encompassing planning, control, data storage, and product distribution from origin to consumption, catering to consumer needs. While logistics activities typically focus on procurement, distribution, maintenance, and inventory management, they usually exclude marketing activities, new product development, and finance [26]. Green logistics, on the other hand, encompasses production, distribution, packaging, and product management, emphasizing material and waste management, energy conservation, and fuel-efficient transportation, aligning with environmental and social responsibility [27,28]. The primary goals of green logistics

include minimizing the environmental impact of logistics activities, reducing energy and waste, enhancing product brand value, improving operational efficiency, and cutting costs through optimal energy use [29–31]. Additionally, green logistics aims to decrease carbon emissions, waste production, and environmental impacts in the production supply chain while promoting eco-friendly containers, packaging, and transportation [32].

Environmentally friendly logistics is a vital component of the green supply chain, serving as an effective strategy for sustainable development [26]. It aids businesses in the supply chain in becoming more efficient by selecting eco-friendly material suppliers, proposing sustainable solutions, and utilizing green transport for customer delivery. Implementing environmentally friendly logistics also enhances the competitiveness of logistics companies in global provision. Research on green logistics encompasses various factors, including green design [30,31], procurement [32–34], manufacturing [31,33], marketing [33], consumption [35], reverse logistics [30,36], transportation [30,32,37,38], and communication [39]. These factors are predominantly applied in the manufacturing industry and have been extensively tested, proving highly reliable in creating eco-production management efficiency that surpasses customer expectations and impacts the supply chain [40–43].

In the realm of Green Logistics adoption, the literature delves into both external and internal factors that play a pivotal role. External factors encompass consumer/supplier and third-party influences, including regulatory and institutional pressures, international environmental regulations, competition, reputation, and social responsibility, with government policies and legal regulations often emerging as dominant forces [44]. The literature extensively explores external and internal factors influencing Green Logistics' adoption. External factors include consumer/supplier and third-party influences, such as regulatory and institutional pressures, international environmental regulations, competition, reputation, and social responsibility, with government policies and legal regulations often identified as dominant forces. Internal factors considered in this study for adopting and utilizing green logistics technologies and information systems include: (i) Environmental Awareness: The level of environmental consciousness among logistics stakeholders, reflecting the priority given to sustainability and environmental responsibility, (ii) Organizational Culture: The influence of leadership support, employee engagement, and the emphasis on sustainability within the organization on attitudes and behaviors towards green logistics technologies, (iii) Technological Readiness: The organization's preparedness to adopt and implement green logistics technologies, including the availability of necessary infrastructure and technical expertise, (iv) Government Regulations and Policies: The impact of regulatory frameworks, environmental standards, and policy support on promoting the adoption of green logistics technologies, (v) Financial Considerations: The financial feasibility, initial investment costs, return on investment, and long-term cost savings associated with green logistics technologies, (vi) Perceived Benefits: Stakeholders' perception of the advantages of green logistics technologies, such as cost savings, improved efficiency, reduced environmental impact, and enhanced corporate image, and (vii) Intention to Adopt Green Logistics: The willingness and commitment of organizations to integrate green logistics practices into their operations. These factors provide a comprehensive framework for investigating the adoption and utilization of green logistics technologies and information systems, contributing to the broader understanding of sustainable logistics practices.

3.1. Environmental Awareness

Several studies have highlighted the significance of environmental awareness in implementing green logistics [3,16,23,25]. It represents the level of consciousness among logistics stakeholders regarding sustainability and environmental responsibility. An organization's eco-friendly reputation can drive environmental management success and support green innovation, including adopting eco-design principles and using environmentally friendly materials [45]. Customer satisfaction is a primary driver for businesses to implement green logistics practices. However, a lack of genuine commitment from some organizations has been observed. Customer pressure significantly contributes to financial performance,

suggesting that managers should provide employees with more autonomy and flexibility [46,47]. The application of green logistics practices is influenced not only by legislative, policy, or client needs but also by managerial environmental understanding, awareness, and human resources. A survey of Swedish logistics companies identified objectives such as improving the company's image, long-term cost savings, enhancing competitiveness, and responding to societal needs [48].

Social supervision plays a crucial role in the effectiveness of Green Logistics Policies (GLP) implementation. It involves public monitoring of negative environmental behaviors, violations of green laws, and government inaction. Social supervision, through public reporting and opinion, exerts external pressure on the government and logistics enterprises. This can influence policy effectiveness by prompting government action and adjusting enterprise behavior. Exposure of violations or proactive GLP implementation by logistics companies can lead to concerns about penalties and social image, potentially resulting in positive actions. Public dissatisfaction can compel the government to act cautiously to maintain social stability. While some scholars advocate for increased government supervision resources, the rapid transmission of information in the digital age suggests that external public or media supervision can form public opinions that drive government action.

The study analyzes several facets of environmental awareness that significantly influence the adoption of green logistics, as outlined in Table 2. The research sets the hypothesis: **Hypothesis 1 (H1)** Environmental awareness of stakeholders influences organizational culture and green logistics implementation. The factors considered include knowledge of environmental issues and an understanding of challenges such as climate change, pollution, and resource depletion among logistics stakeholders. The perception of environmental impact evaluates stakeholders' awareness of the potential negative consequences of logistics operations and the necessity for sustainable practices. Commitment to environmental sustainability measures the extent to which individuals and organizations integrate sustainability principles into their logistics practices, including the willingness to invest in green technologies and adhere to environmental regulations. Environmental responsibility practices focus on implementing specific measures within logistics operations, such as waste reduction and energy efficiency. Stakeholder engagement in environmental initiatives assesses participation in sustainability programs and collaborations with environmental organizations. Lastly, monitoring and reporting environmental performance examines the extent to which stakeholders track and transparently report their sustainability progress using environmental metrics and key performance indicators.

Table 2. The main factors of the environmental awareness variable that significantly impact the adoption of green logistics.

Code	Factor	Description
V1F1	Knowledge of Environmental Issues	This factor assesses the level of knowledge and understanding of environmental challenges, such as climate change, pollution, and resource depletion, among logistics stakeholders [3,23].
V1F2	Perception of Environmental Impact	This factor examines how logistics stakeholders perceive the impact of their activities on the environment. It evaluates their awareness of the potential negative consequences of logistics operations and the need for sustainable practices [3,23].
V1F3	Commitment to Environmental Sustainability	This factor measures the extent to which individuals and organizations are committed to incorporating environmental sustainability principles into their logistics practices. It includes their willingness to invest in green technologies, adopt eco-friendly processes, and adhere to environmental regulations [25].

Table 2. *Cont.*

Code	Factor	Description
V1F4	Environmental Responsibility Practices	This factor evaluates the implementation of specific environmental responsibility practices within logistics operations. It includes factors such as waste reduction, energy efficiency, recycling initiatives, and carbon footprint reduction efforts [23,25].
V1F5	Stakeholder Engagement in Environmental Initiatives	This factor assesses the level of participation and involvement of logistics stakeholders in environmental initiatives and collaborations. It considers partnerships with environmental organizations, engagement in sustainability programs, and participation in industry-wide sustainability initiatives [16].
V1F6	Monitoring and Reporting Environmental Performance	This factor focuses on the degree to which logistics stakeholders monitor and report their environmental performance. It includes the use of environmental metrics, tracking of key performance indicators, and transparency in reporting sustainability progress [16,25].

3.2. Organizational Culture

Numerous studies have highlighted the crucial role of organizational culture in the adoption of green logistics practices [3,9,16–19]. This includes the impact of leadership support, employee involvement, and the organization's focus on sustainability, all of which shape attitudes and behaviors toward implementing green logistics technologies. In the logistics industry, environmental sustainability is becoming increasingly important alongside commercial sustainability [49]. Industry leaders must adopt the right mindset to ensure environmental sustainability, which may involve providing training and courses on green concepts to shift away from traditional thinking [50].

Organizational factors, including company culture and internal management, play a significant role in developing green initiatives. The willingness and capability to develop such initiatives depend on competences, knowledge, sustainability awareness, and the ability to overcome internal resistance [51–55]. Developing performance measurement systems can support monitoring activities and define plans, while effective communication can enhance the company's image and reputation, therefore strengthening sustainability-oriented initiatives [56–58]. Senior management's encouragement and support are crucial for applying green logistics practices as they decide on resource allocation and investment in the latest technologies [59,60]. Organizations are more inclined to apply green logistics if it improves sustainability and environmental indicators while reducing or maintaining costs. Economic benefits, competitive advantage, compliance with legislation, and rising transport costs are both drivers and barriers to the further application of green logistics [22].

The study analyzes various factors of organizational culture that significantly influence the adoption of green logistics, as detailed in Table 3. **Hypothesis 2 (H2)** suggests that organizational culture influences green logistics implementation. Leadership support is evaluated based on the extent to which leaders advocate for sustainability, allocate resources, and actively promote green initiatives. Employee engagement measures the involvement and participation of employees in green logistics initiatives. Emphasis on sustainability examines whether sustainability goals are integrated into the organization's mission, vision, and strategic objectives, along with the presence of policies and training programs. Communication and awareness assess the effectiveness of communication channels in disseminating information about green logistics technologies and raising awareness among employees. Collaboration and teamwork measure the degree of collaboration within the organization, including cross-functional teams and knowledge-sharing platforms. Performance measurement and recognition assess the organization's approach to recognizing achievements related to green logistics technologies, including performance indicators and reward systems. Training and development examine the availability of programs that enhance employees' knowledge and skills in green logistics technologies. Organizational structure and processes evaluate how the organization's structure supports

the integration and implementation of green logistics technologies. Change management and adaptability assess the organization's ability to manage change and adapt to new technologies and practices. Lastly, supplier and stakeholder relationships examine the organization's engagement with eco-friendly suppliers and stakeholders in promoting green logistics technologies and sustainable practices.

Table 3. The main factors of the organizational culture variable that significantly impact the adoption of green logistics.

Code	Factor	Description
V2F1	Leadership Support	This factor assesses the extent to which organizational leaders demonstrate support and commitment to green logistics technologies. It includes their advocacy for sustainability, resource allocation, and active involvement in promoting and implementing green initiatives [3,9].
V2F2	Employee Engagement	This factor measures the level of employee involvement and participation in green logistics initiatives. It considers the extent to which employees are encouraged to contribute ideas, provide feedback, and actively engage in sustainable practices within their roles [3].
V2F3	Emphasis on Sustainability	This factor examines the organization's emphasis on sustainability as a core value. It evaluates whether sustainability goals are integrated into the organization's mission, vision, and strategic objectives. It also considers the presence of policies, guidelines, and training programs that promote sustainable practices [3,17].
V2F4	Communication and Awareness	This factor evaluates the effectiveness of communication channels and strategies in disseminating information about green logistics technologies. It assesses the organization's efforts to raise awareness among employees about the importance of sustainability and the benefits of adopting green technologies [16,17].
V2F5	Collaboration and Teamwork	This factor measures the degree of collaboration and teamwork within the organization to promote green logistics technologies. It considers the presence of cross-functional teams, knowledge-sharing platforms, and collaborative initiatives aimed at driving the adoption and utilization of these technologies [18,19].
V2F6	Performance Measurement and Recognition	This factor assesses the organization's approach to measuring and recognizing the performance and achievements related to green logistics technologies. It includes the presence of performance indicators, targets, and reward systems that incentivize the adoption and effective utilization of these technologies [18,19].
V2F7	Training and Development	This factor examines the availability of training and development programs that enhance employees' knowledge and skills in green logistics technologies. It considers the organization's investment in providing relevant training opportunities and promoting continuous learning in this area [17,19].
V2F8	Organizational Structure and Processes	This factor evaluates how the organization's structure and processes support the integration and implementation of green logistics technologies. It considers the alignment of roles, responsibilities, and decision-making processes with sustainability objectives [59,60].
V2F9	Change Management and Adaptability	This factor assesses the organization's ability to manage change and adapt to new technologies and practices. It includes the presence of change management strategies, flexibility in adapting to evolving sustainability requirements, and openness to innovation [59,60].
V2F10	Supplier and Stakeholder Relationships	This factor examines the organization's engagement with suppliers and stakeholders in promoting green logistics technologies. It considers collaboration with eco-friendly suppliers, engagement in sustainable supply chain initiatives, and partnerships with stakeholders to drive sustainable practices [19].

3.3. Technological Readiness

The concept of technological readiness and its influence on the implementation of green logistics has been extensively explored in the literature [3,17,19,25]. Technological readiness encompasses an organization's ability to adopt and implement green logistics technologies, which includes the availability of essential infrastructure and technical expertise [9]. Green logistics practices, driven by green investment decisions, play a significant role in enhancing logistics performance and promoting the use of renewable energy. These practices positively influence purchasing decisions, encouraging the consumption of goods manufactured through eco-friendly processes [61].

In Indonesia, regional disparities in technological readiness, particularly in the eastern region, pose challenges to the implementation of green logistics. Enhancing information technology services is crucial for logistics companies to efficiently manage product transportation and reduce disruptions caused by poor performance. Addressing these disparities can make green logistics operations more efficient [62].

Technological factors impacting the adoption of green logistics include the complexity and maturity of technological innovations, which can extend implementation time [51,54]. Compatibility issues may arise, requiring changes in existing equipment [51]. Infrastructure development, such as the distribution of charging stations for electric vehicles, is also critical for enabling widespread use. Studies have shown that while technological and environmental awareness factors have a minor impact, organizational factors significantly influence the intention to adopt green practices [63,64]. Innovations in green materials and clean energy are pivotal for reducing waste pollution and greenhouse gas emissions in logistics activities [65]. For example, the Underground Logistics System (ULS) has gained attention for its potential to enhance green logistics capacity by alleviating traffic disturbances and congestion [66].

The study analyzes various factors of technological readiness that significantly influence the adoption of green logistics, as detailed in Table 4. The study considers **Hypothesis 3 (H3):** Technological readiness influences green logistics implementation. The study examines several aspects of technological readiness that significantly impact the adoption of green logistics technologies. Infrastructure availability evaluates the presence of necessary hardware, software, and network connectivity to support green logistics technologies. Technical expertise assesses the organization's level of technical knowledge and skills related to these technologies, considering employees' proficiency in utilization and maintenance. Resource allocation examines the distribution of financial and human resources, including budget allocation, staffing, and training programs, to support the adoption and utilization of green logistics technologies. Compatibility with existing systems measures the ease of integration and potential challenges in aligning green logistics technologies with the organization's current systems and processes. Data Management and Security focus on the organization's capability to effectively manage and secure data generated by green logistics technologies, including considerations of data storage, privacy, and cybersecurity measures. Scalability and flexibility assess the organization's technological infrastructure's ability to accommodate future growth and changes in green logistics technologies.

Table 4. The main factors of the technological readiness that significantly impact the adoption of green logistics.

Code	Factor	Description
V3F1	Infrastructure Availability	This factor evaluates the presence of adequate infrastructure, such as hardware, software, and network connectivity, necessary to support the implementation of green logistics technologies [3,17].
V3F2	Technical Expertise	This factor assesses the level of technical knowledge and skills within the organization related to green logistics technologies. It considers the expertise of employees in utilizing and maintaining these technologies effectively [3,17].

Table 4. *Cont.*

Code	Factor	Description
V3F3	Resource Allocation	This factor examines the allocation of financial and human resources to support the adoption and utilization of green logistics technologies. It includes factors such as budget allocation, staffing, and training programs [19].
V3F4	Compatibility with Existing Systems	This factor measures the compatibility of green logistics technologies with the organization's existing systems and processes. It evaluates the ease of integration and potential challenges in aligning these technologies with the current infrastructure [19].
V3F5	Data Management and Security	This factor focuses on the organization's capability to effectively manage and secure the data generated by green logistics technologies. It includes considerations of data storage, privacy, and cybersecurity measures [17,25].
V3F6	Scalability and Flexibility	This factor assesses the scalability and flexibility of the organization's technological infrastructure to accommodate future growth and changes in green logistics technologies [25].

3.4. Government Regulation and Policies

Several studies have explored the influence of government regulation on the adoption of green logistics practices [16–19,23,25]. This variable examines the role of regulatory frameworks, environmental standards, and policy support in encouraging the implementation of green logistics technologies. The government plays a crucial role in shaping organizational behavior and raising public sector awareness about eco-industry development [67]. It enforces strict environmental regulations to ensure effective environmental protection controls by the domestic industry sector.

Government intervention is often preferred over private sector control, which primarily focuses on profit maximization. Consequently, the government regulates private sector business operations through environmental regulations and incentives, such as promotional policies for cost reduction, low-interest loans for clean technology procurement, and support for research grants for green industry promotion [68]. The government's responsibility extends to enforcing environmental laws and rules, impacting environmental monitoring efficiency and public security and well-being. By enacting strict regulations regarding environmental standards for products, the government emphasizes environmental conservation and recovery for sustainable development. This regulatory framework supports the government's environmental policy, environmental quality management, and the promotion of sustainable efficiency [69].

Changes in the natural environment significantly influence business relationships, leading companies to adopt environmental management practices [70]. Organizational social responsibility and sustainable development policies have been examined in various studies, focusing on employee perceptions of internal environmental policies, innovation, and sustainable development, as well as top executives' intentions to encourage compliance with environmental practice standards. The literature also highlights the stimulation of voluntary compliance with green policies, the adoption of international certifiable environmental management standards like ISO 14001 and ISO 9000, and the promotion of service and process performance measurement and improvement policies [71–75]. The logistics business is influenced by both consumer pressure for green processes and government policies mandating green logistics implementation. Regulation guides companies to adopt eco-friendly production processes, and the development of green logistics policies with more environmentally friendly standardization is considered necessary [76].

The study investigates the impact of government regulation and policies on the adoption of green logistics practices, as detailed in Table 5. It presents **Hypothesis 4 (H4)**, proposing that government regulation and policies significantly shape green logistics

implementation. The study evaluates various aspects of government regulation and its impact on adopting green logistics technologies. It examines the extent to which regulatory frameworks influence compliance with environmental laws, adherence to sustainability standards, and the effects of regulatory incentives or penalties on organizational behavior. The role of industry and international environmental standards, such as ISO 14001, is assessed to determine their impact on guiding the adoption and implementation of green logistics technologies. The study also evaluates the support provided by governmental and non-governmental policies, including subsidies, tax incentives, grants, and other instruments designed to encourage sustainable technology adoption. Furthermore, it explores the extent and effectiveness of collaborations and partnerships aimed at advancing green logistics initiatives, considering joint ventures with technology providers, participation in sustainability consortia, and partnerships with environmental organizations. Additionally, the study assesses efforts to raise awareness and communicate about green logistics practices, including internal and external communication strategies, educational programs, and marketing initiatives related to sustainability.

Table 5. The main factors of the government regulation that significantly impact the adoption of green logistics.

Code	Factor	Description
V4F1	Regulatory Frameworks	This considers the influence of government regulations and legal requirements on the adoption of green logistics technologies. It includes compliance with environmental laws, adherence to sustainability standards, and the impact of regulatory incentives or penalties [16–18].
V4F2	Environmental Standards	This factor assesses the role of industry and international environmental standards in guiding the adoption and implementation of green logistics technologies. It considers certifications such as ISO 14001 and the organization's commitment to meeting or exceeding these standards [16–18].
V4F3	Policy Support	This evaluates the support provided by governmental and non-governmental policies in promoting green logistics practices. It includes subsidies, tax incentives, grants, and other policy instruments designed to encourage the adoption of sustainable technologies [19].
V4F4	Collaboration and Partnerships	This factor examines the extent and effectiveness of collaborations and partnerships aimed at advancing green logistics initiatives. It considers joint ventures with technology providers, participation in sustainability consortia, and partnerships with environmental organizations [19].
V4F5	Awareness and Communication	This assesses the efforts made by the organization to raise awareness and communicate about its green logistics practices. It includes internal and external communication strategies, educational programs, and marketing initiatives related to sustainability [23,25].

3.5. Financial Considerations

Numerous studies have emphasized the significance of financial considerations in implementing green logistics [16–19,23]. Financial feasibility, initial investment costs, return on investment, and long-term cost savings are critical factors associated with green logistics technologies. Governments and local agencies support investments in pollution control and environmental problem-solving, highlighting the importance of organizational financial capability in enhancing value and marketability [77,78]. Research shows that financial ability, technological innovation, and government policy positively impact green transformation efficiency, as seen in China's manufacturing industry [79,80]. Customer willingness to pay for eco-friendly products drives green supply chain practices, influencing retail pricing and motivating green technology investment [81,82]. Cooperation between suppliers and

customers in green logistics operations positively affects sustainable consumption behavior, though high transaction costs can hinder this relationship [83,84].

Competitiveness in the logistics industry is influenced by costs, services, human resources, and networks. The capacity for innovation is crucial for maintaining competitiveness, with successful market players generating improvements in services, facilities, and infrastructure [85,86]. Collaboration with other logistics businesses can reduce costs and enhance resilience. Economic and financial factors related to company profitability, with economic aspects often seen as barriers due to the long-term nature of financial benefits from Green Logistics Practices (GLPs) [51,87,88]. While GLPs require significant investments, they can reduce operational costs. However, a lack of financial incentives and uncertainty about payback times increases hesitation about adopting GLPs [89,90].

Barriers to green logistics include a lack of communication and coordination, technical difficulties, and costs. Acquiring advanced technologies and employee training are investment intensive. The lack of human and financial resources hinders companies from adopting GL practices, which are crucial for improving performance and competitiveness [22,91]. Business firms, as the main body of economic value creation, play a key role in adopting green logistics strategies and implementing activities. Pursuing economic interests is significant for developing green logistics, which can enhance customer and public relationships and reduce resource consumption. Developing green logistics is beneficial for breaking emissions caps and trade barriers improving global green competitiveness [92,93].

The research investigates the financial aspects influencing the adoption of green logistics, detailed in Table 6. **Hypothesis 5 (H5)** suggests that financial feasibility, initial investment costs, return on investment, and long-term cost savings play significant roles in implementing green logistics technologies. The study explores various financial factors impacting green logistics adoption, scrutinizing initial investment costs, operational cost savings, long-term cost benefits, and financial risk assessments. A cost-benefit analysis assesses the economic viability of green logistics technologies, aiding in informed decision-making regarding sustainable logistics investments. Regulatory and supply chain pressures are examined as external drivers for adopting green logistics practices, including compliance with environmental regulations and the influence of sustainability-prioritizing supply chain partners.

Table 6. The main factors of the financial considerations that significantly impact the adoption of green logistics.

Code	Factor	Description
V5F1	Initial Investment Costs	This factor analyzes the upfront costs associated with adopting green logistics technologies. It considers the purchase of new equipment, installation of systems, and any modifications required to existing infrastructure [16–19].
V5F2	Operational Cost Savings	This evaluates the reduction in ongoing operational costs resulting from the implementation of green logistics technologies. Savings may arise from lower energy costs, reduced material usage, and decreased waste disposal fees [16–19].
V5F3	Long-term Cost Benefits	This factor looks at the broader financial benefits of adopting green logistics technologies over time. It includes considerations of return on investment, total cost of ownership, and the potential for cost savings through improved sustainability practices [19,23].
V5F4	Financial Risk Assessment	This assesses the financial risks associated with investing in green logistics technologies. It includes analyzing market risks, technology obsolescence risks, and the potential impact on the organization's financial stability [16,17].
V5F5	Cost-Benefit Analysis	This examines the economic viability of green logistics technologies by comparing costs (acquisition, operation) with benefits (efficiency savings, enhanced reputation, environmental impact), guiding informed decisions on sustainable logistics investments [18,19].

3.6. Perceived Benefits

Several studies have discussed the perceived benefits of green logistics and their influence on implementation [24,25]. Stakeholders perceive advantages such as cost savings, improved efficiency, reduced environmental impact, and enhanced corporate image. The Technology Acceptance Model posits that perceived usefulness and ease of use significantly influence an individual's willingness to use a system [94]. Perceived usefulness is the belief that using the system will enhance job performance, while perceived ease of use pertains to the belief that the system will be effortless to use [95]. In the context of public policy, the perceived usefulness and ease of use of a policy can affect its acceptance and implementation [96]. For example, logistics enterprises' perception of green logistics policies influences their willingness to accept and implement these policies. A high perception of the usefulness of green logistics policies can enhance compliance, therefore improving policy effectiveness. Conversely, if logistics enterprises perceive these policies as burdensome or unhelpful, they may not seriously implement them.

Social supervision plays a crucial role in the effectiveness of green logistics policy implementation. It involves public monitoring of negative environmental behaviors, violations of green laws, and government inaction. Social supervision can take the form of public reporting and opinion, exerting external pressure on the government and logistics enterprises. This can influence policy effectiveness by prompting government action and adjusting enterprise behavior. The rapid development of the Internet and information technology has made information transmission swift, making external public or media supervision more likely to form public opinions that compel government action.

The study examines the potential benefits that can be realized as green logistics practices mature, as outlined in Table 7. **Hypothesis 6 (H6)** suggests that these perceived benefits become more apparent as the core elements of green logistics reach maturity. The study explores several factors influencing the adoption of green logistics technologies and their impact on organizations. Cost savings are assessed by evaluating financial benefits through reduced operational costs, improved energy efficiency, and optimized resource utilization. Improved efficiency is analyzed by examining enhancements in logistical operations, such as faster processing times, reduced fuel consumption, and effective route planning. The reduced environmental impact is considered by evaluating the extent to which these technologies minimize the environmental footprint of logistics activities, including reductions in carbon emissions, waste production, and energy consumption. Enhanced corporate image assesses the impact of green logistics practices on the organization's public perception and brand value, considering the contribution of sustainability efforts to a positive corporate reputation. Finally, stakeholder engagement and satisfaction evaluate the involvement and contentment of stakeholders, such as customers, employees, and suppliers, with the organization's green logistics initiatives, including feedback mechanisms and participation in sustainability programs.

Table 7. The main factors of the perceived benefits that significantly impact the adoption of green logistics.

Code	Factor	Description
V6F1	Cost Savings	This factor evaluates the financial savings that can be achieved through the adoption of green logistics technologies. It encompasses a reduction in operational costs due to improved energy efficiency, less waste production, and optimized resource utilization [24,25].
V6F2	Improved Efficiency	This examines the enhancements in logistical operations' efficiency resulting from the implementation of green technologies. Efficiency improvements may include faster processing times, reduced fuel consumption, and more effective route planning [24,25].

Table 7. *Cont.*

Code	Factor	Description
V6F3	Reduced Environmental Impact	This factor considers the extent to which green logistics technologies help in minimizing the environmental footprint of logistics activities. It includes reductions in carbon emissions, waste production, and energy consumption [24,25].
V6F4	Enhanced Corporate Image	This assesses the impact of adopting green logistics practices on the organization's public perception and brand value. It considers how sustainability efforts contribute to a positive corporate image and reputation among consumers, investors, and other stakeholders [24,25].
V6F5	Stakeholder Engagement and Satisfaction	This factor evaluates the involvement and satisfaction levels of stakeholders (e.g., customers, employees, suppliers) with the organization's green logistics initiatives. It includes assessing feedback mechanisms, participation in sustainability programs, and overall satisfaction with the organization's environmental stewardship [24,25].

3.7. Intention to Adopt Green Logistics

The willingness of organizations to integrate green logistics practices into their operations has been explored in a limited number of studies [47,97–99]. This intention is influenced by the maturity level of green logistics within the organization, indicating the extent to which environmentally friendly logistics practices are developed and implemented. According to [97], various determinants for adopting green innovations include technological knowledge, corporate culture, management commitment, and green corporate practices. Additionally, competitor pressure, customer requirements, and employee behavior have been found to positively impact green innovation activities [98]. Challenges such as inadequate government support and limited environmental regulations have also been identified [99].

Three main aspects could affect the intention to adopt green innovations: technology, organization, and the external environment. In terms of technology, the ease of knowledge transfer within an organization and the explicitness and accumulation of technology are considered crucial for innovative capability [47]. Organizational factors such as leadership behavior, support for innovation, availability of resources, and the quality of human capital are also deemed important. Training and education are highlighted as key to fostering a workforce capable of implementing green practices. Regarding the external environment, government support and regulations are seen as significant influencers. Government incentives and pressures from environmental uncertainty can encourage companies to adopt green practices.

The study explores the correlation between the maturity of green logistics practices and the intention to adopt them, as detailed in Table 8. It presents **Hypothesis 7 (H7)**, proposing that the readiness to implement green logistics is more pronounced when its fundamental components achieve a mature state. The study explores various factors influencing the intention to adopt green logistics, including economic incentives, customer demand, corporate social responsibility (CSR), and competitive advantage. Economic incentives such as tax breaks, grants, or subsidies for sustainable practices can motivate businesses to adopt green logistics. The growing consumer preference for environmentally friendly products and services can push businesses to adopt green logistics to meet market demand. A commitment to CSR and the desire to enhance corporate image and stakeholder relationships can also influence the intention to implement green logistics. Additionally, the desire to gain a competitive edge over rivals through differentiation based on sustainability practices can drive the adoption of green logistics.

Table 8. The main factors of the intention to adopt green logistics that significantly impact the adoption of green logistics.

Code	Factor	Description
V7F1	Cost Saving	It involves reducing costs through fuel efficiency, resource optimization, waste reduction, regulatory compliance, and enhanced brand reputation [97,98].
V7F2	Economic Incentives	Financial incentives, such as tax breaks, grants, or subsidies for sustainable practices, can motivate businesses to adopt green logistics [98,99].
V7F3	Customer Demand	Increasing consumer preference for environmentally friendly products and services can push businesses to adopt green logistics to meet market demand [97,98].
V7F4	Corporate Social Responsibility (CSR)	Commitment to CSR and the desire to enhance corporate image and stakeholder relationships can influence the intention to implement green logistics [47].
V7F5	Competitive Advantage	The desire to gain a competitive edge over rivals through differentiation based on sustainability practices can drive green logistics adoption [47].

4. Research Methodology

The research model has been based on an amalgamation and synthesis of the literature, as well as the attachment of our collaborative team research strategy. The detailed enumeration of each variable has been discussed in the previous section. Figure 1 summarizes the abstraction of our research model with reference to the research variables of our study.

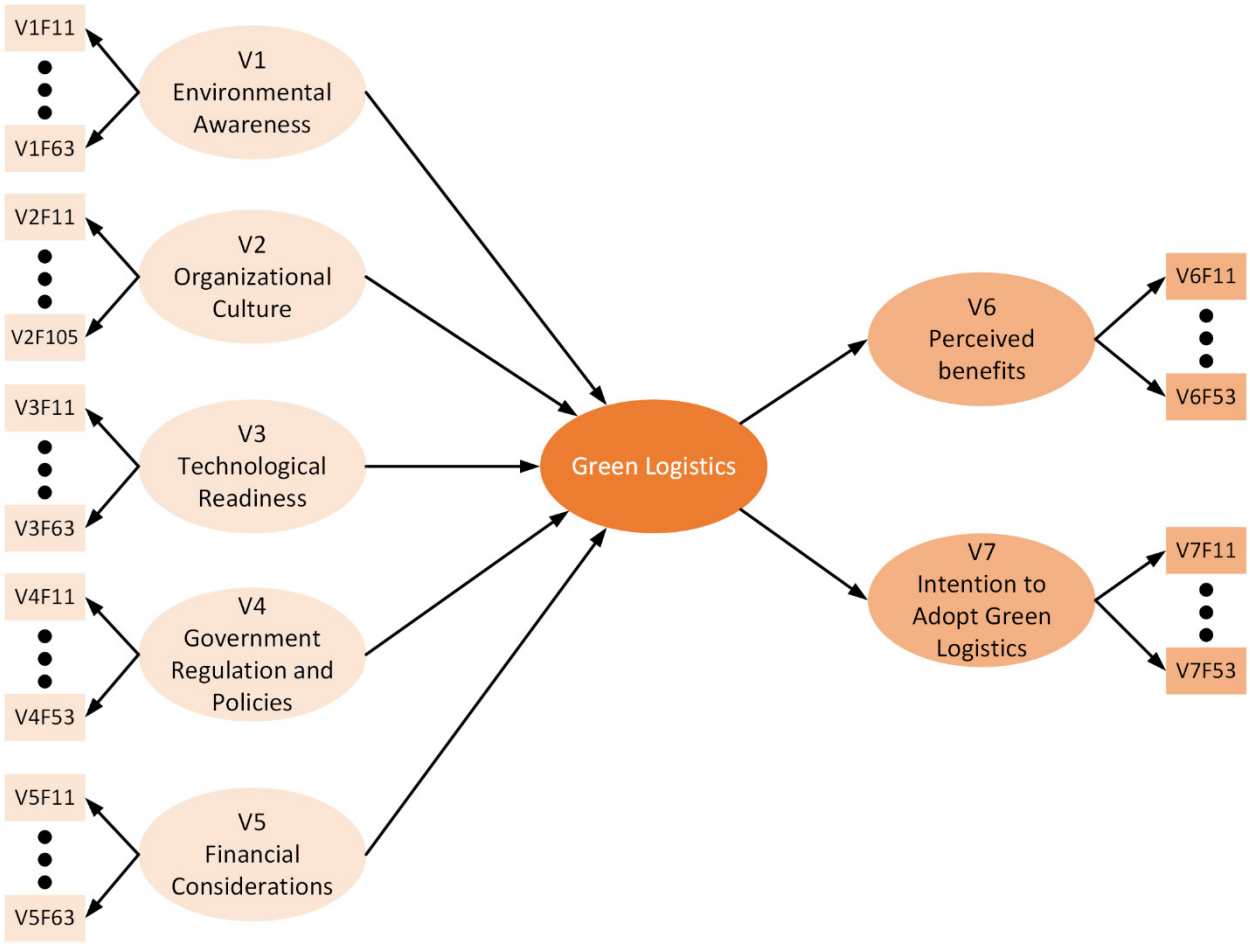


Figure 1. Abstraction of the Research Model.

Our research methodology employs a structured approach, encompassing several stages to ensure a comprehensive analysis of the implementation of green logistics:

1. Questionnaire Development: Initially, we created a survey to assess stakeholders' perceptions and attitudes toward integrating green logistics practices within their operations. This step is crucial for gathering relevant data that reflects the current sentiment and awareness regarding environmental sustainability in logistics.

2. Data Analysis: Upon collecting responses, we conducted a thorough analysis of the data. We started with a general quantitative descriptive analysis to provide an overview of the adoption of green logistics practices. This step helps identify broad trends and patterns in the data.

3. Detailed Analysis: We then delved deeper into the data, performing more specific descriptive analyses. This phase allows us to uncover finer details and subtleties in the stakeholders' responses, providing a richer understanding of their perspectives.

4. Correlation Analysis: We examined the relationships between the opinions of respondents from Saudi Arabia on various metrics related to green logistics. This analysis helps identify any significant associations between different variables and understand how they might influence each other.

By systematically progressing through these steps, our methodology aims to provide a thorough understanding of stakeholder perspectives on green logistics and identify patterns within the data that can inform strategic decisions.

The research instrument for this study was meticulously crafted, drawing on a comprehensive review of the literature and relevant empirical findings. The selection of questions was informed by prior studies that had undergone rigorous validation for accuracy and reliability using the Index of Congruence (IOC) method. The survey is structured into four distinct sections. The initial section gathers demographic information about the participants, such as gender, age, educational attainment, current city of residence, organizational tenure, job title, and years of experience in the logistics sector. The subsequent section focuses on organizational details, including the range of logistics services offered, company size, annual turnover, and the geographic scope of operations. The third section is dedicated to collecting data on green logistics practices. The final section evaluates the factors influencing green logistics practices. Responses were captured on a 5-point Likert scale, ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). Prior to the main survey, the questionnaire underwent a pilot test with 35 samples distributed to various companies, akin to the methodology employed by Mettathamrong et al. [100]. Based on the feedback received, minor adjustments were made to the questionnaire.

Eligible respondents were required to be at least 20 years old, possess a minimum of one year of professional experience in their current company, and hold positions such as engineer, manager, supervisor, logistics officer/executive, or operations staff. For model analysis, a sample-to-observable variable ratio of 1:15, as recommended by Golob [101], was adopted. With 42 observable factors identified in this study, the sample size needed to exceed 630 to meet the requirements for Structural Equation Modeling (SEM). A total of 645 samples were collected, surpassing the threshold for SEM [102]. The study employed simple random sampling in Saudi Arabia, motivated by the country's rapid growth in the logistics sector and significant carbon dioxide emissions. Contact with companies was initiated via email, yielding responses from 123 companies, representing a 52.6% response rate. Subsequently, the research team conducted face-to-face surveys from May to December 2023. Upon collection and verification of the questionnaires, data from 645 samples were analyzed. During data processing, responses lacking answers to questions related to six key factors were excluded, accounting for 1.2% of the dataset. All records with missing values were identified, and the 99 instances of null values were imputed with the mode of the corresponding questions. The dataset was then prepared for analysis by converting textual values to numerical values to facilitate analytical processing. Microsoft Excel Analytic tools (Version 2405 Build 16.0.17628.20006) and the R-4.4.1 programming language were utilized for the necessary analyses.

5. Analysis and Findings

Different statistical analyses were performed on the collected data. Our goal is to provide an overview of the questionnaire responses in general and then go deep with some interesting statistical analyses about challenges and factors that influence the implementation of green logistics.

5.1. General Quantitative Investigation

After the data preparation phase, we had 645 responses. As shown in Table 9, the distribution of gender among the participants was as follows: Female (52.25%), Male (47.75%). The respondents' age ranges were distributed as follows: 25–34 (29.77%), 35–44 (22.64%), 20–24 (21.71%), 45–54 (16.43%), and 55 and above (9.46%). Most respondents held a Bachelor's degree (61.09%), followed by a Diploma (20.62%) and a Master's or higher (18.29%). The participants were from various cities, with the highest representation from Riyadh (31.16%), followed by Jeddah (18.45%), Madinah (11.63%), Makkah (10.85%), Yonbu (10.39%), Dammam (8.84%), and Alahsa (8.68%). In terms of the years the organizations were established, the responses were: More than 8 years (39.84%), 6–8 years (30.23%), 3–5 years (19.38%), and Less than 3 years (10.54%). The distribution of job roles among the participants was as follows: Manager (27.75%), Supervisor (25.12%), Operations Staff (25.12%), and Logistics Officer/Executive (22.02%). The years of experience in logistics were distributed as follows: 1–5 years (42.02%), 6–10 years (29.77%), 11–15 years (20.0%), and More than 15 years (8.22%). This quantitative investigation provides a comprehensive overview of the demographics and characteristics of the survey respondents.

Table 9. The profiles of survey respondents (n = 645).

Characteristic		Number of Respondents	Percentage
Gender	Female	337	52.25%
	Male	308	47.75%
Age Range	25–34	192	29.77%
	35–44	146	22.64%
	20–24	140	21.71%
	45–54	106	16.43%
	55 and above	61	9.46%
Education Level	Bachelor's	394	61.09%
	Diploma	133	20.62%
	Master's or higher	118	18.29%
Current City	Riyadh	201	31.16%
	Jeddah	119	18.45%
	Madinah	75	11.63%
	Makkah	70	10.85%
	Yonbu	67	10.39%
	Dammam	57	8.84%
	Alahsa	56	8.68%
Years Organization Established	More than 8 years	257	39.84%
	6–8 years	195	30.23%
	3–5 years	125	19.38%
	Less than 3 years	68	10.54%

Table 9. *Cont.*

Characteristic		Number of Respondents	Percentage
Job Role	Manager	179	27.75%
	Supervisor	162	25.12%
	Operations Staff	162	25.12%
	Logistics Officer/Executive	142	22.02%
Years of Experience in Logistics	1–5 years	271	42.02%
	6–10 years	192	29.77%
	11–15 years	129	20.00%
	More than 15 years	53	8.22%

The distribution of type of logistics services among the participants was as follows: Third-party logistics (3PL) (35.81%), Supply chain management (33.64%), Freight transportation (17.44%), Warehousing and distribution (13.11%). The company size (number of employees) was distributed as follows: Less than 50 (38.6%), 501–1000 (36.12%), and 50–100 (25.27%). The annual revenue of the participants' companies was as follows: Less than USD 1 million (42.48%), USD 1 million–USD 5 million (31.63%), More than USD 5 million (25.89%). The geographical coverage of operations was distributed as follows: Regional (43.88%), National (35.97%), and International (20.15%). Regarding the implementation of green logistics practices, 62.48% of the participants indicated that their companies do implement such practices, while 37.52% indicated otherwise. The green logistics practices adopted were diverse, with the most common being waste reduction and recycling (21.55%), use of alternative fuels (20.47%), carbon footprint measurement and reduction (19.38%), efficient route planning (18.29%), vehicle electrification (10.85%), and collaboration with eco-friendly suppliers (9.46%). The challenges in adopting green logistics among the participants were as follows: not applicable (28.53%), supply chain complexity (15.35%), lack of stakeholder support (15.19%), regulatory compliance issues (14.73%), lack of information (13.8%), budget constraints (12.4%).

5.2. Quantitative Analysis

The quantitative analysis offers valuable insights into the current state of the industry and its commitment to sustainability, highlighting areas of strength and opportunities for improvement.

Environmental Awareness: The quantitative analysis of responses concerning environmental awareness within the logistics sector offers a detailed view of the industry's stance on sustainability. A significant portion of the respondents demonstrate a robust understanding and awareness of environmental issues, with 41.4% strongly agreeing that they comprehend the environmental challenges in logistics. Awareness of the environmental impact of logistics activities is similarly high, with 42.64% strongly agreeing on their awareness of such impacts. Furthermore, 41.71% strongly agree that they keep themselves updated on the latest environmental issues relevant to logistics, underlining a proactive approach towards staying informed on sustainability matters.

When it comes to the perception of the environmental impact of logistics operations, over 40% of respondents strongly agree that these operations have a significant environmental footprint. Additionally, 41.55% strongly believe in the importance of considering the environmental consequences of logistics activities, highlighting a prevalent recognition of the sector's impact on the environment and the critical need for mindful operations. The commitment to environmental sustainability is evident, with 39.53% strongly believing that sustainable logistics practices can make a positive environmental difference. About 42.17% strongly affirm their organization's commitment to environmentally sustainable practices, and 38.29% are willing to invest in green logistics technologies and solutions,

signaling a tangible commitment to incorporating sustainability into business strategies and investments.

In terms of environmental responsibility practices, 42.17% of participants indicated that environmental responsibility is a priority for their organization. Moreover, 41.24% actively implement waste reduction and recycling initiatives, while 41.09% integrate energy efficiency measures into their logistics processes. Additionally, 39.69% are striving to minimize their carbon footprint and greenhouse gas emissions, demonstrating a widespread commitment to tangible environmental responsibility in daily operations and strategic planning. Stakeholder engagement in environmental initiatives receives strong support, with 42.02% collaborating with environmental organizations and 44.96% engaging in partnerships and programs that support environmental conservation. This indicates a recognition of the value of collective action and collaboration across the industry for achieving significant sustainability outcomes.

Finally, monitoring and reporting of environmental performance are recognized as essential, with 42.79% regularly monitoring and measuring their environmental performance. The commitment to transparency is evident, as 38.6% report their sustainability progress openly to stakeholders, and 43.41% strive continuously to improve their environmental performance, highlighting an ongoing commitment to accountability and enhancement in sustainability practices. These findings portray a logistics sector increasingly committed to environmental sustainability, actively engaging in responsible practices, stakeholder collaboration, and transparency. The data reflects a sector poised for proactive and forward-thinking approaches to overcome environmental challenges, signaling a transformative journey toward sustainability.

Organizational Culture: The analysis of organizational culture in relation to green logistics technologies provides insightful findings across several key factors. The analysis reveals strong endorsement from organizational leaders in adopting and utilizing green logistics technologies. A significant majority of respondents, nearly 50%, strongly agree that their leaders actively promote sustainable practices and provide resources and guidance for green logistics technologies. Effective communication by leadership about the importance of sustainability was also acknowledged by 49.92% of respondents. The second factor, Employee Engagement, shows positive engagement and empowerment of employees in sustainable practices. About 49.92% of respondents strongly agree that employees are actively involved in implementing green logistics technologies, encouraged to contribute ideas, provided with training and development opportunities, and empowered in sustainable behaviors. This indicates a participatory approach to sustainability efforts within organizations.

The analysis highlights a strong emphasis on sustainability, with nearly 50% of respondents strongly agreeing that their organization considers sustainability a core value and aligns sustainability goals with strategic objectives. Policies and guidelines promoting sustainable practices are established, and sustainability is prioritized in decision-making. Communication and awareness are also key, with effective communication about green technologies and informed employees being strongly agreed upon by approximately 50% of respondents. The importance of collaboration and teamwork in driving the adoption of green logistics technologies is underscored. Around 50% of respondents strongly agree that there is a strong culture of collaboration, with cross-functional teams working on sustainable practices and knowledge-sharing being encouraged. Effective collaboration for sustainability goals is strongly agreed upon by 49.92% of respondents.

Across all factors, the mean score for responses is around 3.98, indicating strong agreement on average. This consistency reflects a cohesive and supportive organizational culture towards environmental sustainability, emphasizing leadership support, employee engagement, sustainability, effective communication, and collaborative teamwork. Additional factors such as Performance Measurement and Recognition, Training and Development, Organizational Structure and Processes, Change Management and Adaptability, and Supplier and Stakeholder Relationships further illustrate the comprehensive approach to sustain-

ability within organizations. Each factor highlights different aspects of the organizational commitment to green logistics, from evaluating contributions and enhancing employee skills to managing changes and fostering collaborative relationships with suppliers and stakeholders. The analysis paints a comprehensive picture of the organizational culture towards green logistics, showcasing a proactive and integrated approach towards environmental responsibility within the logistics sector.

Technological Readiness: The analysis of Technological Readiness in relation to green logistics technologies reveals nuanced perspectives on various factors, including Infrastructure Availability and Technical Expertise. The responses indicate a diverse perspective on the organization's readiness to support green logistics technologies. Approximately 20.16% of respondents strongly agree that their organization possesses the necessary hardware and software infrastructure. However, the distribution of responses across the Likert scale suggests a variance in perceptions of infrastructure readiness among participants. This highlights the critical importance of infrastructure in supporting green logistics technologies and suggests that while there is acknowledgment of infrastructure support, there is also room for improvement in ensuring that hardware and software fully meet the needs for effective implementation.

The responses reflect a balanced perspective on the technical expertise available within organizations to utilize, maintain, and troubleshoot green logistics technologies. While there is a notable distribution of agreement that signifies confidence in the workforce's technical capabilities, the presence of disagreement and neutrality points towards variability in this confidence across different organizations or departments. This suggests an area for potential development, emphasizing the need for ongoing training and skill enhancement to fully leverage green logistics technologies. The combined mean agreement for Resource Allocation is approximately 40.47%, indicating a measured view on the adequacy and effectiveness of resource allocation towards supporting the technological aspects of green logistics. Organizations recognize the importance of dedicating sufficient resources but may face challenges in optimizing allocation for maximal impact.

The Compatibility with Existing Systems sees a combined mean agreement of about 39.02%, suggesting cautious optimism regarding the integration of green logistics technologies with existing infrastructures. While there is recognition of the importance of compatibility for seamless operation and transition, there remains room for improvement in ensuring technologies can be effectively integrated without disruptive overhauls. Data Management and Security has a combined mean agreement of 38.14%, reflecting concerns and the critical need for robust data management practices and security measures. As green logistics technologies often rely on data-driven insights for optimization and efficiency, ensuring the integrity, security, and effective management of data is paramount, yet viewed as an area needing further enhancement. Lastly, Scalability and Flexibility garners a combined mean agreement of 42.12%, indicating a more positive view of organizations' ability to adapt and scale green logistics technologies according to changing needs and growth. This factor is crucial for sustainability initiatives, as it ensures that technological solutions remain viable and effective as organizations evolve.

These insights into Technological Readiness emphasize the multifaceted nature of preparing for and implementing green logistics technologies. While there is a foundational level of agreement on certain capabilities, such as scalability and flexibility, areas like data management, security, and system compatibility present challenges that require focused attention and improvement. Ensuring technological readiness involves not just the initial adoption of green technologies but also their sustainable integration, management, and evolution within the organizational ecosystem.

Government Regulation: The analysis of the Government Regulation factor in green logistics technologies reveals insights into Regulatory Frameworks, Environmental Standards, and other related areas. The responses indicate varied perspectives on the clarity, supportiveness, and enforcement of regulatory frameworks related to green logistics technologies. While there is acknowledgment of clear and well-defined regulations, the levels of

agreement suggest room for improvement in creating a more supportive environment and ensuring consistent and effective enforcement. This highlights the importance of strong, clear, and supportive government regulations in fostering the adoption and effective implementation of green logistics technologies. Stakeholders recognize the presence of specific environmental standards and targets related to logistics operations, suggesting awareness of benchmarks set for sustainable practices. There is a perception that these standards provide necessary guidance and benchmarks for the adoption of green logistics technologies. Adhering to environmental standards is viewed as essential for the organization's reputation and compliance with legal requirements. The spread of responses suggests variability in perceptions of their effectiveness and implementation, pointing to the need for clearer communication and more robust support mechanisms.

The combined mean agreement for Policy Support stands at approximately 40.47%, indicating that while there is some degree of policy support for green logistics, stakeholders feel there could be more robust backing from government policies to further facilitate sustainable practices. Collaboration and Partnerships see a combined mean agreement of about 39.02%, suggesting stakeholders recognize the importance of collaborative efforts between the government and other entities in promoting green logistics. However, there is room for growth in fostering partnerships that can drive more significant advancements. The combined mean agreement for Awareness and Communication is approximately 38.14%, reflecting stakeholders' views on the effectiveness of government-led initiatives to raise awareness and communicate about green logistics technologies and practices. This indicates a need for more targeted and effective communication strategies to ensure stakeholders are well-informed and engaged in sustainability efforts.

The analysis of these factors points to a landscape where government regulation plays a pivotal role in shaping the future of green logistics. Stakeholders perceive the need for clearer regulations, more supportive policies, enhanced collaboration, and improved awareness and communication efforts. Strengthening these areas could significantly impact the logistics sector's ability to embrace and benefit from sustainable practices, underlining the necessity for continued dialogue and action on regulatory support for green logistics initiatives.

Financial Considerations: The analysis of Initial Investment Costs related to adopting green logistics technologies reveals stakeholders' varied perceptions. Regarding the Perception of Initial Financial Investment, responses are distributed as follows: Strongly Disagree 21.09%, Disagree 18.14%, Neutral 17.67%, Agree 22.95%, and Strongly Agree 20.16%. This suggests a balanced view among stakeholders regarding the initial financial investments required, indicating awareness of the costs and recognition of their necessity. Regarding the Affordability and Feasibility of Initial Investment, stakeholders show concern, with responses as follows: Strongly Disagree 21.71%, Disagree 20.78%, Neutral 21.09%, Agree 16.12%, and Strongly Agree 20.31%. This highlights the need for careful financial planning and consideration.

In terms of Cost-effectiveness and ROI Evaluation, responses are as follows: Strongly Disagree 19.53%, Disagree 20.31%, Neutral 18.76%, Agree 20.16%, and Strongly Agree 21.24%. There is a slightly more positive outlook on the long-term cost-effectiveness and potential return on investment, suggesting optimism about the financial benefits of adopting green technologies in the long run. These insights reflect the complexity of financial considerations in the decision-making process for adopting green logistics technologies. Stakeholders acknowledge the substantial initial investment required but also understand its long-term benefits, underscoring the importance of thorough financial analysis and planning. The analysis of Financial Consideration factors related to the adoption of green logistics technologies provides valuable insights into stakeholders' perceptions and evaluations. Stakeholders recognize the potential for significant cost savings through reduced energy consumption, lower fuel costs, and optimized resource utilization. The long-term financial benefits, including reduced maintenance costs and potential access to financial incentives, are also acknowledged. Stakeholders evaluate the financial risks associated with adopting green logistics technologies cautiously, considering market uncertainty,

technological obsolescence, and regulatory changes. They also conduct a comprehensive cost-benefit analysis to evaluate the financial feasibility, reflecting a thorough and informed decision-making process.

These findings underscore the importance of financial considerations in the decision-making process for adopting green logistics technologies. Stakeholders are keenly aware of both the potential cost savings and long-term benefits while also carefully assessing financial risks and conducting detailed cost-benefit analyses. This comprehensive financial evaluation is crucial for organizations navigating the transition towards sustainable logistics practices, highlighting the need for effective financial planning and risk management strategies.

Perceived benefits: The analysis demonstrates a strong recognition among stakeholders of the multifaceted benefits of adopting green logistics technologies, including environmental, operational, strategic, and relational advantages. The positive attitudes reflected in the mean scores and agreement percentages underscore the perceived value of green logistics practices in contributing to sustainable, efficient, and socially responsible business operations. Stakeholders perceive significant cost reductions and operational efficiencies from green logistics technologies. Approximately 43.1% of respondents agree or strongly agree that these technologies can lead to fuel, energy, and waste management cost reductions, with a strong agreement rate of 20.16%. The mean score for this perception is 3.03, indicating a positive attitude towards the financial and operational benefits of green logistics.

There is a notable perception that green logistics technologies contribute to a positive work environment, customer loyalty, and stronger stakeholder relationships. Around 41.08% to 43.56% of respondents agree or strongly agree with these benefits, with strong agreement percentages ranging from 19.84% to 22.02%. These aspects received mean scores between 2.98 and 3.07, reflecting a positive consensus on the non-financial benefits of adopting green practices. Stakeholders recognize the potential of green logistics technologies to mitigate environmental impacts and gain a competitive advantage. The agreement on these points ranges from 37.05% to 41.24%, with strong agreement between 18.29% and 20.62%. The mean scores in these areas are around 2.93 to 3.06, indicating that stakeholders see environmental and competitive benefits as significant factors.

The data suggests a belief that green logistics can drive innovation and improve market position, with agreement levels of 37.67% to 42.33% and strong agreement rates of 19.69% to 22.02%. The mean scores for these perceptions hover around 2.91 to 3.07, showcasing a positive attitude towards the strategic benefits of sustainability. The combined mean agreement scores across all benefits range from approximately 2.89 to 3.07, indicating a general positive attitude towards green logistics. The stronger responses towards environmental impact reduction, operational efficiency, and stakeholder relations highlight a multifaceted appreciation for green logistics beyond just the immediate financial gains.

Intention to Adopt Green Logistics: The comprehensive analysis across various categories reveals a strong consensus in favor of adopting green logistics, with mean scores ranging from 4.17 to 4.26. This indicates a widespread agreement on the critical role of regulatory pressures, economic incentives, customer demand, Corporate Social Responsibility (CSR), and competitive advantage in the decision-making process for green logistics adoption. A notable 81% of respondents agree or strongly agree that regulations significantly influence their decision to adopt green logistics, demonstrated by a mean score of 4.18. Supply chain dynamics are also acknowledged as important by over 80% of participants, with a mean score of 4.14. Industry standards stand out as a major driver, with a high mean score of 4.21 and 83% agreement.

Financial incentives are recognized by approximately 82% of respondents, with a mean score of 4.19, highlighting their role in promoting green logistics. Long-term cost savings, with the highest mean response of 4.26, are identified as a significant motivator. The overall economic benefits are considered crucial, as indicated by a mean score of 4.20 and about 83% agreement. The demand for eco-friendly practices is a key driving factor, with a mean score of 4.22 and about 83% agreement. Market preference significantly influences logistics strategies, as reflected by a mean score of 4.23 and about 84% agreement. Customer

satisfaction plays an important role, with a mean score of 4.24 and 83% agreement. The commitment to CSR is underlined by approximately 82% agreement and a mean score of 4.22. Ethical considerations are emphasized by a mean score of 4.17 and about 81% agreement. The reputational benefits associated with green logistics are recognized, with a mean score of 4.17 and similar agreement levels. The strategic importance of sustainability is highlighted by about 82% agreement and a mean score of 4.18. Market differentiation is valued, with a mean score of 4.23 and 83% agreement. The strategic advantage of green logistics is underscored by a mean score of 4.19 and 82% agreement.

The combined insights from the percentage of agreement and mean scores illustrate a strong recognition of the multifaceted benefits of adopting green logistics. This encompasses compliance with regulations, achieving economic and operational efficiencies, meeting customer demands, fulfilling CSR obligations, and gaining competitive advantages. The findings emphasize the perceived value of green logistics practices in fostering sustainable, efficient, and responsible business operations, highlighting the necessity for organizations to integrate these practices into their strategic planning and operations.

5.3. Exploratory Data Analysis

In this section, we delve into the process of scrutinizing and interpreting the data set through exploratory techniques, aiming to extract insights and understand the dynamics between the studied elements. This segment outlines the methodologies utilized in examining the data collected from respondents in Saudi Arabia concerning the seven variables under investigation. Commencing with descriptive analytics, we assess the correlation coefficients to discern the nature and intensity of associations between paired variables, which can range from -1 to 1. Concerning the nature of these connections, a positive coefficient signifies a direct relationship wherein both variables move conjointly. Conversely, a negative coefficient indicates an inverse relationship, with the variables moving in opposition. As for the intensity, a coefficient nearing the extremities of -1 or 1 denotes a more potent link between the variables. By contrast, a coefficient proximate to zero suggests a lack of interdependence, meaning that changes in one variable do not systematically relate to shifts in the other. To quantify these correlations, we employ the Pearson Correlation Coefficient (PCC), which visually depicts the correlations among the studied factors that may affect the adoption of green logistics. The outcomes of this computation for all seven variables are represented in Figure 2.

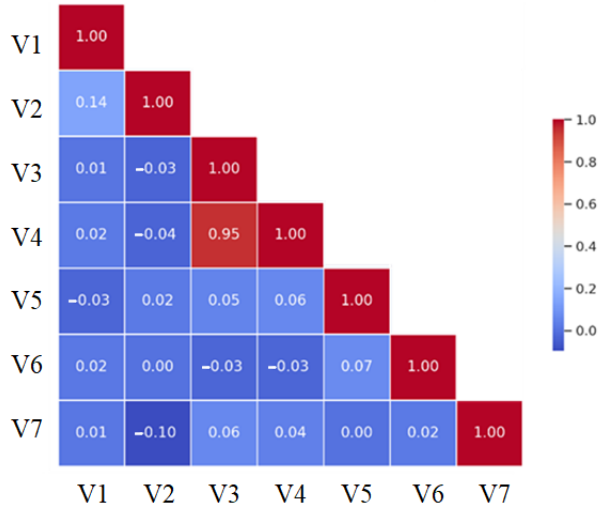


Figure 2. The correlation coefficient matrix.

The matrix analysis provides insights into the relationships between factors influencing the adoption of green logistics. Environmental Awareness is weakly correlated with other factors, suggesting that respondents' awareness of environmental issues does

not strongly relate to their views or practices concerning the other factors measured. In contrast, Organizational Culture exhibits a moderate positive correlation with Environmental Awareness, indicating that organizations with a culture attuned to environmental issues tend to have slightly higher awareness of environmental concerns. However, Organizational Culture has a small negative correlation with the Intention to Adopt Green Logistics, suggesting that organizational culture may not be a strong driver of the intention to adopt green logistics in this dataset. Technological Readiness and Government Regulation demonstrate a high positive correlation, indicating that they likely move in tandem. This suggests a synergistic relationship between regulatory frameworks and technological preparedness, where government regulations support technological readiness. On the other hand, Financial Considerations display very low correlation values with all factors, indicating that financial aspects may not be the primary determinant of the adoption of green logistics practices or the development of related factors.

The correlations between Perceived Benefits and various factors are generally weak, suggesting that Perceived Benefits may not be a strong driver of these factors in the context of green logistics adoption. Specifically, the correlation between Environmental Awareness and Perceived Benefits is very weak, indicating a slight increase in perceived benefits as environmental awareness increases. The relationships between Organizational Culture, Technological Readiness, Government Regulation, and Perceived Benefits could not be determined due to the absence of displayed correlation values in the provided data. The correlation between Financial Considerations and Perceived Benefits is negligible, suggesting no practical linear relationship. Regarding the intention to adopt green logistics, Government Regulation, Financial Considerations, and Perceived Benefits show very low positive correlations, indicating negligible linear relationships. This suggests that these factors may not be strong drivers of the intention to adopt green logistics within this dataset. However, certain elements of Organizational Culture are slightly at odds with the intention to adopt green logistics, and Technological Readiness, while slightly associated with a higher intention to adopt green logistics, is not a strong enough factor to make a significant impact on its own. This highlights the complexity of factors influencing the adoption of green logistics and the need for a multifaceted approach to understanding and promoting it.

To visualize the distribution of the variables, we used boxplots (a.k.a. box-and-whiskers plots), which are a common type of visual measure that displays the distribution of a continuous variable broken down by a categorical variable. Figures 3 and 4 show the boxplots for perceived benefits and Intention to adopt green logistics grouped by job role, respectively.



Figure 3. Boxplot of the perceived benefits according to job role.

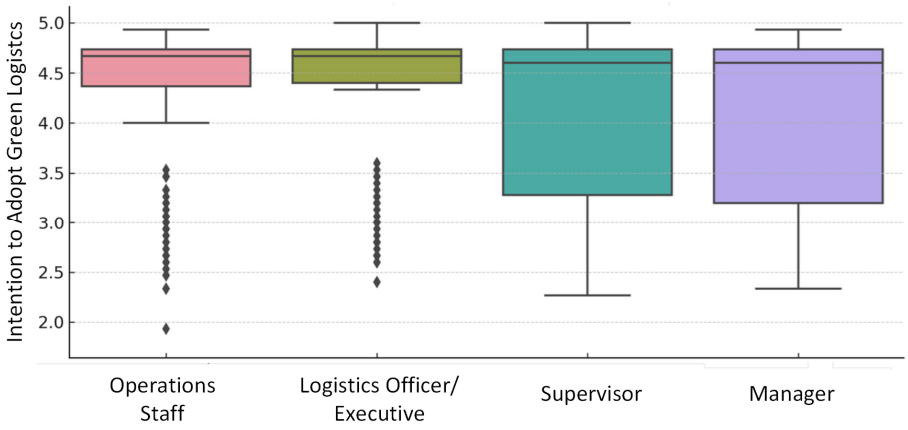


Figure 4. Boxplot of the Intention to adopt green logistics according to job role.

The boxplots provided offer a comparison of the perceived benefits and intentions towards adopting green logistics among four distinct job roles: Operations Staff, Logistics Officer/Executive, Supervisor, and Manager. When considering the perceived benefits of job roles, the data reveals interesting insights across different dimensions. First, the range of responses varies significantly among the job roles. Operations Staff members display a wide range of perceptions about the benefits of green logistics, indicating either diverse opinions within the group or a lack of consensus on the topic. On the other hand, Logistics Officers/Executives have a somewhat narrower interquartile range (IQR), pointing towards a greater level of agreement on the benefits of green logistics within this group. Supervisors exhibit a range of perceived benefits similar to that of Logistics Officers/Executives, with a relatively tight IQR, while Managers show the broadest IQR, suggesting that perceptions of the benefits of green logistics vary widely among individuals in these roles.

In terms of median values, all groups recorded medians above the midpoint of the scale. This suggests a general inclination towards acknowledging the benefits of green logistics across all job roles. Notably, Managers had a slightly higher median perceived benefit compared to other roles, which may indicate that, on average, individuals in managerial positions see greater benefits in green logistics. The analysis also highlighted the presence of outliers in each category, with Managers showing a particularly high number of individuals whose perceptions significantly deviate from the majority. This observation points to the existence of significantly different views on the benefits of green logistics, especially among those in managerial positions.

The analysis of the intention to adopt green logistics by job role provides insights into the commitment levels across different positions within an organization. When considering the range of responses, Operations Staff members display a notably narrow range, indicating a more uniform belief or plan regarding the adoption of green logistics practices within this group. Logistics Officers/Executives exhibit a similar narrow range but with a higher median, suggesting a strong collective intention to adopt green logistics. Supervisors have an interquartile range comparable to that of Logistics Officers/Executives but with fewer outliers, indicating a more consistent intention among this group. Managers, on the other hand, show the broadest range, pointing to diverse intentions about adopting green logistics practices among individuals in this role. In terms of median values, the intention to adopt green logistics is consistent across job roles, being around the upper third of the scale. This suggests that, on average, respondents from each job role have a strong intention to engage in green logistics practices. However, the presence of outliers, particularly in the Operations Staff and Manager categories, indicates that there are individuals who may either be not as convinced of the benefits or are particularly motivated towards adopting green logistics practices.

The boxplots reveal some general observations regarding the consensus and diversity in perceptions and intentions toward green logistics across different job roles. There is a

noticeable trend that suggests a greater consensus on the intention to adopt green logistics across all job roles compared to the perceived benefits. This may indicate that while individuals vary in how much benefit they perceive from green logistics, their intention to adopt these practices is more uniformly strong. The variability in perceptions and intentions by job role could be influenced by factors such as the level of influence in decision-making, exposure to strategic information, and responsibility for the implementation of green practices. Managers and Supervisors, who tend to have broader responsibilities, may need to consider the wider impacts of green logistics, which might explain the wider range of perceptions and intentions observed in these groups. For organizations looking to implement green logistics, understanding these differences can inform targeted interventions. For example, narrowing the range of perceptions, especially among Managers who show the greatest diversity in views, could be achieved by providing more information and education on the benefits of green logistics.

The boxplots suggest a generally positive attitude towards green logistics across all job roles but with significant variability within each group. Managers, in particular, exhibit the greatest diversity in both perceived benefits and intentions to adopt green logistics, highlighting the need for targeted communication and engagement strategies. Organizations have opportunities to further educate and align their staff on the importance and benefits of green logistics practices, especially among those with decision-making power or those who are skeptical. Understanding the specific concerns and motivators of each job role can help organizations tailor their approach to implementing green logistics practices. This could include targeted training sessions for operations staff to ensure they understand the practical benefits and applications of green logistics or strategic sessions with managers to align green logistics initiatives with business objectives. Additionally, the presence of outliers in all categories indicates that individual factors can significantly influence one's perception and intentions, underscoring the need for personalized engagement strategies. Finally, it is important to consider that these insights are based on a visual interpretation of the boxplots; a more rigorous statistical analysis could provide a deeper understanding of the significance of the observed differences.

Figures 5 and 6 show boxplots of the perceived benefits and Intention to adopt green logistics according to education level. It is observed that individuals with a Diploma perceive the benefits of green logistics slightly lower than those with a Bachelor's degree, and both groups perceive lower benefits compared to those with a Master's degree or higher. This trend suggests that as educational level increases, so does the awareness or value placed on the benefits of green logistics. The spread of perceptions, as indicated by the IQR, is relatively similar for Diploma and Bachelor's degree holders, suggesting a consistent range of views within these groups. In contrast, the IQR for those with a Master's degree or higher is tighter, indicating a more uniform perception of benefits among individuals with higher education levels. Outliers are present in the Diploma and Bachelor's degree groups, indicating that there is some variation in perceptions among individuals with these education levels. However, there are no outliers in the Master's or higher group, suggesting that individuals with higher education levels have more similar perceptions of the benefits of green logistics. The whiskers of the boxplots, which indicate variability outside the upper and lower quartiles, extend further for Diploma holders. This indicates more variance in perceptions of the benefits of green logistics among this group compared to those with higher education levels.

When examining the intention to adopt green logistics across different education levels, it is apparent that this intention does not vary as significantly as perceived benefits do. This suggests that regardless of educational attainment, the intention to adopt green logistics may be influenced by factors other than education. For Diploma holders, the IQR is broader, showing more diversity in their intentions to adopt green logistics. In contrast, the IQR for Bachelor's degree holders and those with a Master's degree or higher is narrower, indicating more agreement within these groups. Similar to the perceived benefits, the whiskers for Diploma holders indicate greater variance in the intention to

adopt green logistics, suggesting that individuals with this level of education have a wider range of intentions regarding the adoption of green logistics practices.

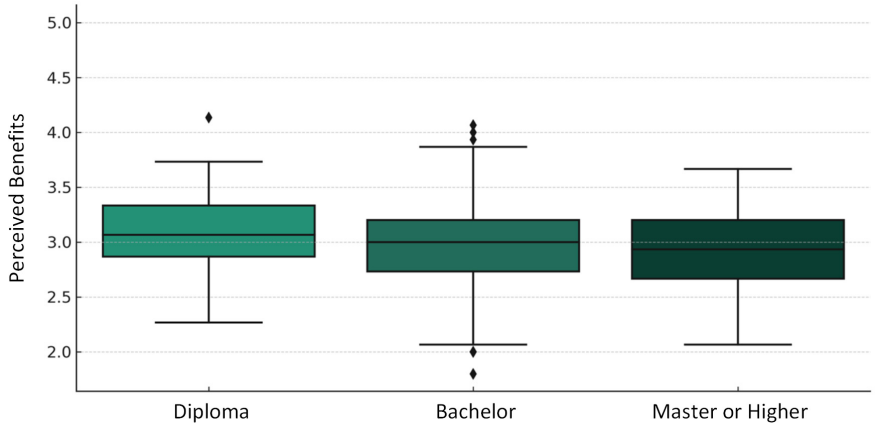


Figure 5. Boxplot of the perceived benefits according to education level.

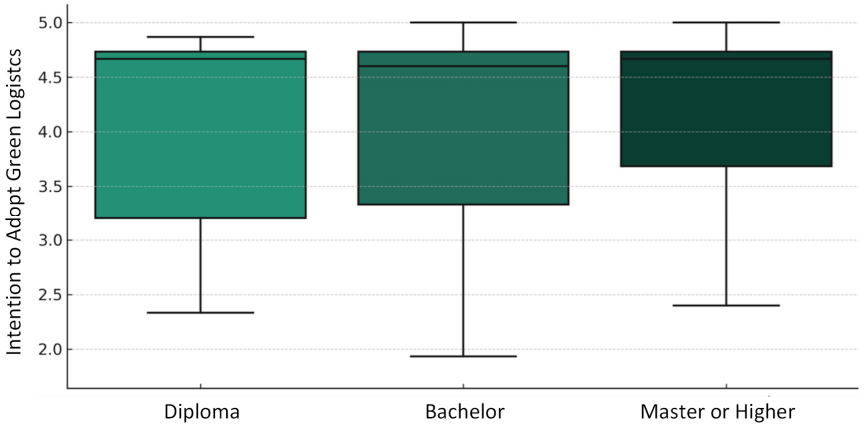


Figure 6. Boxplot of Intention to adopt green logistics according to education level.

The analysis of the impact of education level on the perceived benefits and intention to adopt green logistics reveals some combined observations. Education appears to have a more pronounced effect on the perceived benefits of green logistics than on the intention to adopt such practices. This discrepancy may arise because education can enhance awareness and the perceived importance of green practices, while the actual intention to adopt may be more influenced by factors like organizational policies, individual values, or professional responsibilities, which are not directly tied to formal education levels. Across both variables, as the education level increases, variability seems to decrease, suggesting a convergence of attitudes with higher education. However, the median values indicate that higher education does not necessarily equate to stronger intentions to adopt green logistics. This observation suggests that other practical considerations, such as company resources and individual capacity to influence change, might play a more crucial role in determining whether an individual intends to adopt green logistics practices, regardless of their education level.

The data suggests that while education may enhance awareness and perceived benefits of green logistics, it does not necessarily translate directly into the intention to adopt these practices. For organizations aiming to promote green logistics, this could imply that educational initiatives should be complemented by other supports, such as providing resources or incentivizing adoption, to effectively translate awareness into action.

Figure 7 analyzes the perceived benefits of green logistics based on annual revenue and reveals that companies with "Less than USD 1 million" and "More than USD 1 billion" annual revenue have lower median perceived benefits compared to those in the middle revenue categories, such as "1 million–10 million" and "10 million–100 million".

The "1 million–10 million" revenue category exhibits the smallest IQR, indicating a more consistent perception of benefits within this group, while larger companies with "More than USD 1 billion" in revenue have a wider IQR, suggesting more variability in their perceptions. There are significant outliers in both the smallest and the largest revenue categories, indicating that companies at both ends of the revenue spectrum have perceptions that greatly differ from the median. The longer whiskers in the "Less than USD 1 million" category suggest that perceptions of benefits vary widely among these smaller companies, with variance diminishing as revenue increases, up until the "More than USD 1 billion" category, where the variance in perception increases again. These observations suggest that the size of a company, as indicated by its annual revenue, can influence the perceived benefits of green logistics, with companies in the middle revenue categories tending to have more consistent and higher perceptions of benefits.

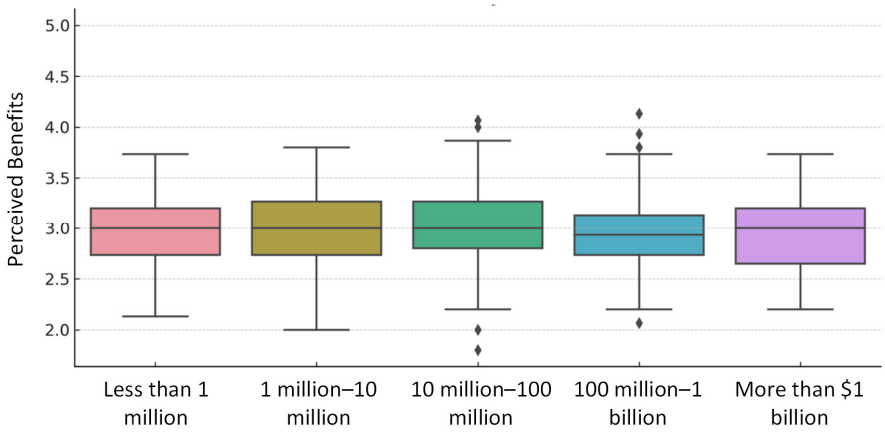


Figure 7. Boxplot of the perceived benefits according to annual revenue.

As shown in Figure 8, when examining the intention to adopt green logistics across different annual revenue categories, it is observed that all categories have a high median intention to adopt green logistics, with the "1 million–10 million" and "10 million–100 million" revenue categories being slightly higher than the others. There is a broad spread of IQR across all categories, but it is most pronounced in the "More than USD 1 billion" category, suggesting differing intentions among the largest companies. Notable outliers in the "Less than USD 1 million" and "More than USD 1 billion" categories indicate that within these revenue brackets, some companies are significantly less inclined to adopt green logistics compared to others. Additionally, the length of the whiskers suggests that the widest variance in intentions is among the smallest and largest companies, indicating a diverse range of intentions to adopt green logistics within these groups.

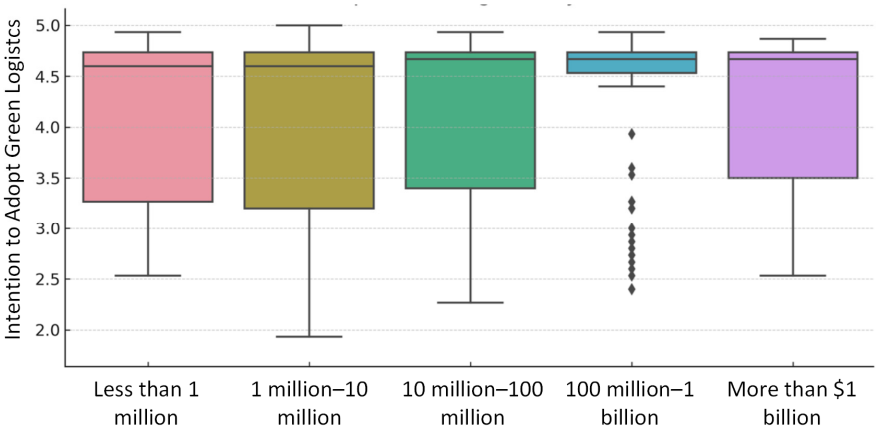


Figure 8. Boxplot of Intention to adopt green logistics according to annual revenue.

There appears to be a relationship between company revenue and perceived benefits of green logistics, with mid-sized companies generally perceiving more benefits than smaller or larger companies. This could be due to mid-sized companies being at a stage where they can more readily see the advantages of green logistics practices, such as cost savings and efficiency improvements, without the complexity that larger companies may face. Intentions to adopt green logistics are generally high across all revenue categories, which may reflect a growing recognition of the importance of sustainability across the business spectrum. The variance in intentions within the largest companies could reflect diverse corporate strategies towards green logistics, ranging from aggressive implementation to cautious evaluation. In summary, while revenue size does not seem to strongly influence the overall intention to adopt green logistics practices, it does seem to have a more noticeable effect on the perceived benefits. For smaller companies, the challenges of resource allocation towards green logistics might explain the lower perceived benefits and greater variance in intention. Conversely, larger companies may encounter complexities in integrating green logistics into well-established supply chains, resulting in a wider spread of both perceptions and intentions.

Figures 9 and 10 present boxplots depicting the perceived benefits and intention to adopt green logistics, categorized by whether companies implement green logistics practices. The analysis of the perceived benefits of green logistics practices reveals some interesting patterns. Companies that implement green logistics practices have a slightly higher median perceived benefit compared to those that do not. Additionally, the IQR for companies that implement green logistics is narrower, indicating a more consistent perception of benefits among these companies. In contrast, the IQR is broader for companies that do not implement these practices, suggesting more varied perceptions. Outliers are present in both categories, but they are more pronounced in the group that does not implement green logistics, indicating that while most companies in this group perceive lower benefits, a few perceive high benefits. The "whiskers" are longer for the "No" category, indicating greater variation in perceptions of benefit among companies that do not implement green logistics practices.

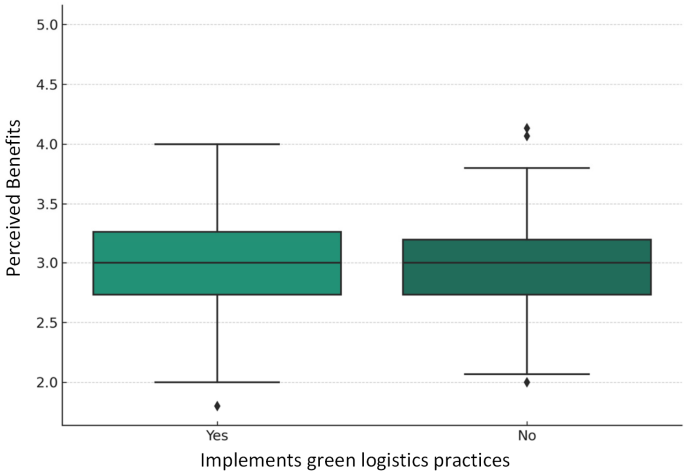


Figure 9. Boxplot of the perceived benefits of implementing green logistics practices.

In examining the intention to adopt green logistics practices, both groups demonstrate a high median intention, with the group that currently implements green logistics practices exhibiting a slightly higher median. The IQR is relatively narrow for both groups, indicating consistency within each group regarding their intentions. However, there are a few outliers in the group that do not implement green logistics practices, suggesting that some companies in this group have a particularly low intention to adopt such practices. The whiskers extend further in the "No" category, especially towards the lower end, indicating a wider spread of intention levels among companies that do not currently implement green logistics practices.

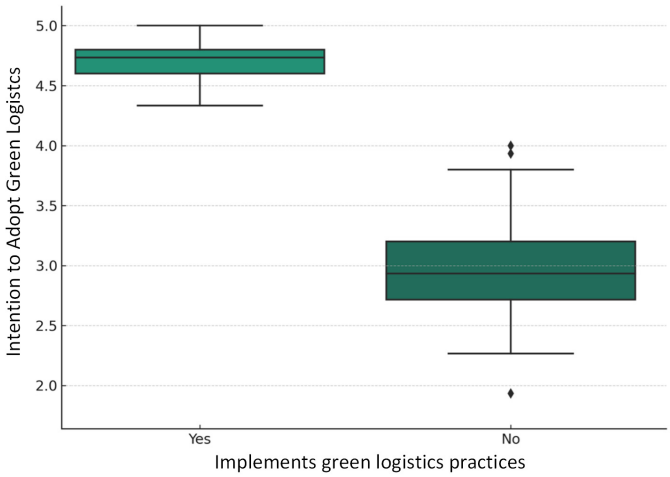


Figure 10. Boxplot of Intention to adopt green logistics according to implementing green logistics practices.

There is a general trend of higher perceived benefits and intentions to adopt green logistics among companies that already implement these practices, which could reflect a positive feedback loop where implementation leads to recognition of benefits, further fueling the intention to engage in green practices. The presence of outliers in the "No" category suggests that while some companies may not see immediate benefits or intend to implement green logistics, there are exceptions that might recognize long-term benefits or face barriers to implementation despite their intentions. The variability in the "No" category for both perceived benefits and intentions to adopt points to potential untapped opportunities for growth in the adoption of green logistics practices. Companies that do not yet implement green logistics practices but perceive high benefits or have a high intention to adopt may be in a transitional phase or influenced by external factors such as industry trends, customer demand, or regulatory pressures.

The generally high intention to adopt green logistics across both groups indicates a recognition of the importance of these practices, although actual adoption may be influenced by other factors like financial capacity, operational feasibility, and organizational culture. For companies already implementing green logistics practices, maintaining and enhancing these practices could be a key strategy, as the perceived benefits reinforce their intentions to continue. Conversely, companies that have not yet adopted these practices may need additional support and incentives, along with success stories showcasing the benefits, to overcome barriers to adoption. While there is an overall positive attitude towards green logistics, companies that have already embraced these practices appear to have a more uniform and strong recognition of their benefits. For those that have not yet implemented green logistics, the greater variance suggests a need for targeted strategies to address the specific barriers and motivations influencing these companies.

6. Findings and Discussion

The analysis reveals several key findings and insights: Stakeholders demonstrate high environmental awareness, recognizing the impact of logistics activities on the environment and showing a proactive approach to sustainability. Organizational culture is identified as crucial for adopting green logistics, with strong leadership support and employee engagement contributing to a conducive environment for sustainability practices. However, there is room for improvement in technological readiness, as organizations need to invest in infrastructure and technical capabilities to fully leverage green logistics technologies. Stakeholders have varied perspectives on government regulation, highlighting the need for clearer regulations and more robust policy support. Financial considerations are complex, with stakeholders acknowledging the importance of thorough financial analysis and planning due to the substantial initial investment required and the recognition of long-term financial benefits. There is strong recognition of the multifaceted benefits of adopting

green logistics technologies, including cost reductions, operational efficiencies, positive environmental impact, and enhanced corporate image. Moreover, there is a high intention among stakeholders to adopt green logistics, driven by regulatory pressures, economic incentives, customer demand, CSR, and competitive advantage, indicating a widespread recognition of the importance of sustainability in the logistics sector.

In general, the analysis supports the hypotheses that environmental awareness, organizational culture, technological readiness, government regulation, financial considerations, perceived benefits, and the intention to adopt green logistics significantly impact the adoption of green logistics practices. The findings support the hypothesis that multiple factors drive the adoption of green logistics. Table 10 summarizes the main findings in relation to each hypothesis.

Table 10. The key findings in relation to the hypotheses.

Variable	Hypothesis	Findings
V1: Environmental awareness	H1: Environmental awareness of stakeholders influences the organizational culture and green logistics implementation.	• Environmental awareness significantly impacts the adoption of green logistics practices. • Stakeholders in the logistics sector exhibit high levels of environmental awareness. • Many respondents strongly agree with their understanding of environmental challenges. • There is significant awareness of the environmental impact of logistics activities. • Stakeholders actively stay updated on the latest environmental issues. • Environmental awareness positively influences organizational culture. • A supportive organizational culture promotes the implementation of green logistics practices.
V2: Organizational culture	H2: Organizational culture influences green logistics implementation.	• Organizational culture significantly impacts the adoption of green logistics practices. • Strong leadership support is essential. • Employee engagement is a key factor. • Emphasis on sustainability shapes attitudes and behaviors towards green logistics technologies. • A supportive organizational culture significantly influences the successful implementation of green logistics.
V3: Technological Readiness	H3: Technological readiness influences green logistics implementation.	• Technological Readiness significantly impacts the adoption of green logistics practices. • Varied perspectives on technological readiness for green logistics technologies. • There is recognition of the existing infrastructure and technical expertise needed. • There is an acknowledgment of areas needing improvement. • Enhancing technological readiness is crucial for the effective implementation of green logistics.
V4: Government regulation and policies	H4: Government regulation and policies play a significant role in shaping the implementation of green logistics.	• Regulatory frameworks and policy support significantly encourage the adoption of green logistics technologies. • Clear and supportive government regulations are essential. • Environmental standards are crucial for fostering the implementation of green logistics practices.

Table 10. *Cont.*

Variable	Hypothesis	Findings
V5: Financial Considerations	H5: Factors such as financial feasibility, initial investment costs, return on investment, and long-term cost savings play a significant role in the implementation of green logistics technologies.	• Financial considerations are complex and crucial in the decision-making process for adopting green logistics technologies. • Stakeholders recognize the importance of financial feasibility. • Initial investment costs are a significant factor. • Long-term cost savings are also essential. • There is a need for thorough financial planning and risk management when implementing green logistics.
V6: Perceived Benefits	H6: Perceived benefits become more apparent as the core elements of green logistics reach a state of maturity.	• Stakeholders strongly recognize the benefits of adopting green logistics technologies. • Key benefits include cost savings, improved efficiency, reduced environmental impact, and enhanced corporate image. • Perceived benefits play a significant role in motivating the adoption of green logistics practices.
V7: Intention to Adopt Green Logistics	H7: Readiness to implement green logistics is more pronounced when its fundamental components achieve a mature state.	• There is a strong consensus in favor of adopting green logistics. • Critical factors influencing the decision include regulatory pressures, economic incentives, customer demand, CSR, and competitive advantage. • The intention to adopt green logistics is influenced by a combination of internal and external factors.

These findings provide valuable insights for organizations aiming to promote and implement green logistics practices effectively. Organizations in the logistics sector are recommended to enhance their sustainability practices and promote the adoption of green logistics by strengthening environmental awareness through educational programs, training, and regular updates on environmental issues. They should foster a supportive organizational culture by actively promoting sustainable practices, providing resources for green logistics technologies, and encouraging employee engagement and empowerment. Improving technological readiness is crucial, with investments needed in upgrading infrastructure and providing ongoing training to fully leverage green logistics technologies. Organizations should engage with regulatory frameworks to influence the development of supportive government regulations and policies for green logistics, collaborating with government agencies and industry associations. Addressing financial considerations is also important, with the development of financial planning and risk management strategies to tackle initial investment costs and long-term cost savings, exploring financial incentives, and seeking partnerships or grants to support the adoption of sustainable practices.

7. Conclusions

The logistics industry, integral to economic and everyday activities, significantly contributes to environmental degradation and resource consumption. The sector faces increasingly stringent environmental regulations due to its impacts on traffic congestion, safety, and pollution, alongside a growing demand for sustainable logistics solutions. Consequently, companies are adopting Green Logistics strategies to meet these demands. The primary research problem addressed in this study is the identification and analysis of key determinants influencing the adoption of green logistics within the context of Saudi Arabia's rapidly developing logistics sector. Despite the critical need to reduce greenhouse

gas emissions and align with sustainable development goals, there is limited understanding of the perceptions and attitudes of potential users of green logistics in this region. This study fills this gap by constructing a comprehensive research model that includes seven variables: environmental awareness, organizational culture, technological readiness, government regulation, financial considerations, perceived benefits, and the intention to adopt green logistics. Data were collected using a specially designed questionnaire and analyzed through various techniques. Initially, a general quantitative descriptive analysis was performed, followed by more detailed analyses to uncover nuances in stakeholders' perspectives. Correlation analysis was also conducted to identify significant relationships between variables and understand their potential interactions. The findings revealed high environmental awareness among stakeholders, a supportive organizational culture for sustainability practices, and strong recognition of the benefits of green logistics technologies. However, areas for improvement were noted in technological readiness, along with a need for clearer government regulations and stronger policy support. Financial considerations were complex, requiring significant initial investments but also offering long-term financial benefits. However, the study focuses on Saudi Arabia's logistics sector, which may limit its generalizability to other regions. Self-reported data and the specific time frame of data collection introduce potential biases and temporal constraints. Future research should consider comparative studies across different regions, in-depth case studies, and longitudinal research to better understand the long-term impacts and broader applicability of green logistics practices.

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