KMAN PUBLISHING INSTITUTE
Journal Website

Article history:
Received 19 August 2024
Revised 20 October 2024
Accepted 27 October 2024
Published online 25 November 2024

International Journal of Innovation Management and Organizational Behavior

IN PRESS

E-ISSN: 3041-8992

Determining Third- and Fourth-Party Logistics Services Based on Green Supply Chain Management Using Cross-Efficiency and Multi-Criteria Decision Making

Kamyar. Azizi[1], Morteza. Shafiee[2*], Ali. Hajiha[3], Hilda. Saleh[4]

[1] PhD Student, Department of Industrial Management, North Tehran Branch, Islamic Azad University, Tehran, Iran
[2] Associate Professor, Department of Management, Shiraz Branch, Islamic Azad University, Shiraz, Iran
[3] Assistant Professor, Department of Industrial Management, North Tehran Branch, Islamic Azad University, Tehran, Iran
[4] Assistant Professor, Department of Mathematics, Central Tehran Branch, Islamic Azad University, Tehran, Iran

*** Corresponding author email address**: Ma.shafiee277@gmail.com

A r t i c l e I n f o

Article type:
Original Research

How to cite this article:
Azizi, K., Shafiee, M., Hajiha, A., & Saleh, H. (IN PRESS). Determining Third- and Fourth-Party Logistics Services Based on Green Supply Chain Management Using Cross-Efficiency and Multi-Criteria Decision Making. *International Journal of Innovation Management and Organizational Behavior*.
https://doi.org/10.61838/kman.ijimob.5.x.x

A B S T R A C T

Objective: The purpose of this study was to determine third- and fourth-party logistics services based on green supply chain management, using cross-efficiency and multi-criteria decision making.

Methods and Materials: In this study, Interpretive Structural Modeling (ISM) was employed, and certain companies from the Rasht Industrial City were selected for the analysis. The opinions of 10 experts were used both qualitatively and quantitatively. Influential indices were identified using the fuzzy Delphi technique, and the indices were weighted through the fuzzy analytic hierarchy process.

Findings: The results of the evaluation of sustainable third- and fourth-party logistics service providers were obtained using the SuperDecisions method. Finally, key components influencing the establishment of 3PL and 4PL companies in the construction industry were identified as economic, environmental, and social factors. In terms of priority and importance, the economic index (with an average weight of 0.485) was ranked first, followed by the environmental index (weight of 0.350), and lastly, the social index (average weight of 0.181). Furthermore, it was found that five companies, A1 to A5, were identified as large companies, with company A3 having the highest sustainability score and company A4 the lowest performance in sustainability.

Conclusion: Ultimately, it was determined that for any organization aiming to achieve an effective and sustainable supply chain, the most suitable logistics service providers in the supply chain will be third- and fourth-party logistics providers.

Keywords: *Logistics, Cross-Efficiency, Supply Chain, Multi-Criteria.*

1 Introduction

Despite the significance of the economy and its vital importance for the country, and despite the numerous available opportunities, a cohesive plan for leveraging these opportunities has yet to be implemented. One highly value-generating area is the country's goods transit sector, which, according to economic experts, if optimally utilized, holds the potential for Iran to become a transit hub for the four major continents. In military battles, logistics issues often play a crucial role in determining the overall outcome of wars, especially since logistics is a terrestrial matter, and military logistics units, which are a type of military organization, must continue their activities in a more complex environment than before (Yu, 2024). Therefore, like other organizations, they must enhance their agility and flexibility (Garmash et al., 2024). The future ground force will be less focused on size and more reliant on dynamism and speed. The concept of logistics has evolved, and today, logistics involves adaptive recognition and response to the environment, which can quickly identify environmental needs and adapt to meet those needs. It is evident that this chain is only as strong as its weakest link, and any mistake anywhere in this chain can threaten the internal process of the chain (Naganawa et al., 2024). This issue necessitates attention to modern information and communication technologies, which have had a considerable impact on logistics and related concepts. One of the concepts transformed by advancements in science and the development of electronic technologies is e-logistics. E-logistics lays the foundation for improved organizational processes through real-time transparency, borderless communication, and shared solutions in the supply chain, ultimately aiding in the implementation of the electronic supply chain (Klumpp et al., 2013). Today, because many organizations view improving their supply chain as the path to success, logistics has become a significant concern for senior managers, especially in military organizations. In fact, it can be said that e-logistics has become a key competitive weapon (Ifekanandu et al., 2024).

By examining the leading logistics countries globally, it is observed that some of them, despite having less than one-third of Iran's logistical advantages, have positioned themselves as leading logistics countries and, in some cases, earn more than Iran's oil revenues (for example, Singapore) (Ristovska et al., 2017). Despite all the existing facilities and opportunities for transforming the country into a logistics center, unfortunately, we have not been able to make proper use of these divine gifts and our long-standing history in logistics and commerce. It can even be said that over the past century, logistics and commerce development has never been among the country's top goals and programs; in fact, it has not even received the attention it deserves within its capabilities. While the primary concern of the country's planning system in recent decades has been industrial development, and the more industrial the development plans have become, the more praise they have received, some neighboring countries have rightly understood the environmental conditions and foresight and have skillfully capitalized on the unique position of the Middle East to develop their logistics and trade (Omoush, 2022). Today, the world recognizes an oil-rich country like the UAE not for its oil wells but for being a logistics hub (Kern, 2021).

The term logistics, in its broader and more modern sense, was first emphasized in Jomini's theory of war. This theory was published in 1838 after the author had served under Napoleon. In explaining the triangle of strategy, tactics, and logistics, or their mutual interrelationship, Jomini described logistics as the means and arrangements that make it possible to implement strategy and tactics. With the addition of issues such as manufacturing, procurement, and orders to distribution management, the concept of "logistics" emerged. Logistics science typically covers everything from estimation, supply, maintenance, and storage of raw materials to distribution of goods, as well as after-sales services, meaning from the first supplier to the final consumer, providing services along the way (Iulia et al., 2022; Naganawa et al., 2024; Ningrum et al., 2024).

Logistics activities include ordering, purchasing, inventory control, facility planning, and transportation within the supply network and flow through three stages: supply, production, and distribution. In fact, suppliers, producers, and distributors have increasingly focused on logistics systems as a way to reduce costs and improve responsiveness to customers (i.e., delivering the product at the time and place the customer desires). To this end, integrating total cost within the logistics network is key to effective organizational logistics management. Effective integrated logistics management can only be achieved through organizing logistics as a system and minimizing total costs in customer service (Sergiy et al., 2022; Yu, 2024; Zhang, 2018).

Logistics management establishes the connection and interaction between logistics levels with supply sources on the one hand and consuming units in the organization on the other, such that it provides the best goods and materials to

IJIMOB
E-ISSN: 3041-8992

those in need of logistics services at the lowest cost. In return, by receiving corrective feedback from both sides and transmitting it to the units, this interaction is maximized to increase productivity (Lynch et al., 2000). Logistics management is one of the central elements responsible for designing, planning, policy-making, developing work methods, coordinating tasks, issuing instructions, and overseeing logistics matters, and its performance quality directly impacts the organization's main operations (Zhang, 2018).

Essentially, logistics management is a comprehensive process aimed at optimizing the flow of materials and supplies through the organization and its operations for the customer. In principle, logistics management is an information-based planning and operational process. Market requirements, through this planning process, are converted into production requirements and then into material needs (Lin et al., 2023).

Supply chain management (SCM) is another concept referenced in the definition of logistics. Supply chain management encompasses all activities related to the flow of goods, from raw material supply to final product delivery to the consumer (Alhalalmeh, 2022). As such, suppliers of materials and components, manufacturers, distributors, and end consumers are considered elements of the supply chain. SCM is the process and activity of sourcing raw materials or organizational components that a company needs to create a product or service and deliver it to customers. The goal of SCM is to improve the performance of these components (Maloni et al., 2024).

The six main components of this process are planning, finding appropriate resources, production, distribution of goods, support, and final evaluation. Ensuring sustainable development for any country depends on the conservation and optimal use of limited and non-renewable resources. Government regulations for environmental standards and the growing demand from consumers for green products in the supply chain (which includes all activities related to the complete flow from raw materials to the delivery of goods to end consumers) have led to the emergence of the concept of green supply chain management (GSCM), which covers the product life cycle stages from design to recycling (Jangid, 2022). Adopting a green procurement investment strategy in the field of improving the environmental performance of the supply chain brings numerous benefits for companies and organizations, such as energy savings, pollution reduction, waste elimination or minimization, creating value for customers, and ultimately enhancing productivity (Iulia et al., 2022). Various definitions of GSCM exist in the literature, some of which are presented in this study.

This process is rooted in both environmental management and supply chain management literature. Adding the "green" component to supply chain management involves addressing the impact and relationships between SCM and the natural environment. Supply chain management includes product design, sourcing and material selection, production processes, delivery of the final product to consumers, and post-use product lifecycle management (Jaggernath, 2015; Ningrum et al., 2024; Sergiy et al., 2022). Green design is widely used in the literature to indicate the design of products with specific environmental considerations. This involves systematically addressing design issues related to environmental safety and health throughout the product's entire lifecycle and its process development (Alawamleh et al., 2022). Green operations pertain to all aspects related to production, product regeneration, use, handling, logistics, and waste management after the finalization of the design. The goal of green production is to reduce environmental burden by using appropriate materials and technologies, while remanufacturing refers to the industrial process in which worn products are restored to a like-new condition (Mohsin et al., 2023).

Given the importance of logistics in various industries, the construction sector, which plays a critical role in sustainable development and the preservation of the human environment, highlights the need to assess the performance of construction contractors from a GSCM perspective. This study aims to analyze the environmental concerns at various stages in this industry and examine how contractors can make successful choices by employing efficient logistics providers in different sectors. Ultimately, the study seeks to present an effective model for sustainable logistics in the construction industry as a case study to address this significant necessity.

2 Methods and Materials

This research is categorized as a causal study, as it investigates the causal relationship between variables. In this context, the statistical technique of structural equation modeling (SEM), a method for examining causal relationships, was used. However, based on the research's objective, the method is applied research because the researcher aims to provide practical solutions for the issue under investigation by collecting data from the target

IJIMOB
E-ISSN: 3041-8992

population and analyzing the data, which can be useful for the target population.

A questionnaire is one of the most common tools for measurement and is a direct method for collecting research data. The questionnaire is a set of written questions designed around the variables of a research problem and is completed by respondents either in person or remotely, directly or indirectly.

Various methods are used to determine the validity of the test. In this study, the content validity method was used. In this approach, the quantity and quality of the questions were evaluated by experts. To assess validity, the initial questionnaire was designed based on the researcher's studies and reviewed by university professors. After making necessary revisions, the questionnaire was distributed to 5 members of the target population for feedback on the designed questions, and the final questionnaire was prepared for broader distribution.

In this study, Cronbach's alpha was used to measure the reliability of the questionnaire. The formula for Cronbach's alpha is as follows (Zakariya, 2022):

$$r_a = \frac{N}{N-1}\left(1-\frac{\sum S_i^2}{S_i^2}\right)$$

- α: Cronbach's alpha coefficient
- k: Number of questions in the questionnaire
- σ²_i: Variance of responses to the i-th question
- σ²_total: Total variance of the questionnaire responses

SPSS software was used to determine reliability, and the Cronbach's alpha coefficient was found to be 0.893, indicating that the questionnaire has sufficient reliability.

In this research, Interpretive Structural Modeling (ISM) was used to identify factors affecting the performance of the green supply chain with a sustainable approach. The companies in Rasht Industrial City were selected for the study. The technique used in this research requires collecting information from relevant experts and experienced professionals. After extracting the dimensions and indicators of the study through a literature review, input was obtained from several university professors in this field. For this study, 10 experts were selected, consisting of senior managers from Rasht Industrial City and managers of companies responsible for supplying raw materials.

Khaddad Hosseini and colleagues (2011) stated that the number of experts in their research ranged between 4 and 14 individuals. Therefore, the opinions of 10 experts from Rasht Industrial City companies, who were involved in the subject of the study and possessed the necessary knowledge and experience to make logical judgments in this area, were used.

To collect the required data and assess the research indicators, a questionnaire specifically designed for Interpretive Structural Modeling (ISM), which has a matrix structure, was used. Before being evaluated through the questionnaire, the research indicators were reviewed by several experts in the relevant field at universities, and finally, the agreed-upon questionnaire was used as the data collection tool for model design.

Based on the literature review, the evaluation indicators for sustainable third- and fourth-party logistics providers were identified. These variables, which include economic, environmental, and social factors, are presented in Table 1.

Table 1

Identified Components and Their Variables

Variable	Components
Economic	Cost, quality, timely delivery, technology, financial performance, risk management, geographical location
Environmental	Environmental management systems, resource consumption, green technology, environmental pollutant emissions, eco-design, green transportation, dry and hazardous waste management
Social	Employee health and safety, customer satisfaction, impact on local communities, flexible employment contracts, workforce stability and job security, shareholders' rights

After identifying the variables, the influencing indicators were determined using the fuzzy Delphi technique, based on feedback from 10 industry experts. To rank and prioritize the indicators, the fuzzy analytic hierarchy process (FAHP) was employed. A pairwise comparison matrix questionnaire was sent to 8 experts from the companies. Finally, each of the third- and fourth-party logistics service providers was evaluated and ranked using SuperDecisions software based on the responses from 8 experts.

3 Findings and Results

IJIMOB
E-ISSN: 3041-8992

Data analysis is a multi-step process through which the data collected using the sampling tools are summarized, coded, categorized, and ultimately processed to facilitate various types of analyses and establish relationships between these data for hypothesis testing. The raw data were analyzed using statistical techniques and then processed into information for the benefit of users. Since this research focuses on examining cross-efficiency and multi-criteria decision-making for selecting third- and fourth-party logistics services with a green supply chain management approach, this section reviews the results obtained from the conducted analyses. All pairwise comparison matrices were calculated, and the weights of criteria, sub-criteria, and indicators derived from the supermatrix were examined.

3.1 Identifying Evaluation Criteria for Sustainable Third- and Fourth-Party Logistics Providers Using the Fuzzy Delphi Method

In the first step, after a comprehensive review of the theoretical foundations of the research, 20 sustainability evaluation indicators for third- and fourth-party logistics providers were identified. In the second step, a questionnaire was sent to a group of specialists related to the research topic, consisting of 10 experts and industrial professionals, to determine the influence and relevance of the identified indicators.

3.2 Weighting Results for the Indicators Using the Fuzzy Analytic Hierarchy Process (FAHP)

In this phase, to calculate the weights of the indicators using the FAHP method, a questionnaire was used as the proposed approach for collecting the necessary data. Based on the research indicators, a questionnaire with 4 pairwise comparisons (one for the main indicators and 3 for the sub-indicators) was designed and completed by 8 industry experts from the construction sector. The weights of the main and sub-indicators were obtained using the FAHP method. The main and sub-indicators were compared pairwise using verbal variables in the form of a matrix. Table 2 shows the fuzzy spectrum and corresponding verbal variables used.

Table 2

Fuzzy Spectrum and Corresponding Verbal Variables

Code	Verbal Statement	Fuzzy Numbers	Inverse Fuzzy Equivalent
1	Equal Importance	(1,1,1)	(1,1,1)
2	Low to Medium Importance	(1,2,3)	(1, 1/2, 1/3)
3	Medium Importance	(2,3,4)	(1/2, 1/3, 1/4)
4	Medium to High Importance	(3,4,5)	(1/3, 1/4, 1/5)
5	High Importance	(4,5,6)	(1/4, 1/5, 1/6)
6	High to Very High Importance	(5,6,7)	(1/5, 1/6, 1/7)
7	Very High Importance	(6,7,8)	(1/6, 1/7, 1/8)
8	Very High to Extremely High Importance	(7,8,9)	(1/7, 1/8, 1/9)
9	Extremely High Importance	(9,9,9)	(1/9, 1/9, 1/9)

Table 3 shows the final weights of the main and sub-indicators of sustainability. Furthermore, the inconsistency ratio of all calculated indicators was less than 0.1. The final weights of the main and sub-indicators for sustainable third-party logistics providers are shown in Table 3.

Table 3

Final Weights of the Main and Sub-Indicators for Sustainable Third-Party Logistics Providers

Main Indicator	Main Indicator Weight	Sub-Indicator	Sub-Indicator Weight	Final Weight
Economic	0.479	C11	0.165	0.079
		C12	0.140	0.067
		C13	0.167	0.080
		C14	0.097	0.046
		C15	0.159	0.076
		C16	0.156	0.074
		C17	0.116	0.056
Environmental	0.344	C21	0.220	0.075

IJIMOB
E-ISSN: 3041-8992

		C22	0.160	0.055
		C23	0.207	0.071
		C24	0.210	0.072
		C25	0.203	0.070
Social	0.176	C31	0.330	0.058
		C32	0.200	0.035
		C33	0.220	0.039
		C34	0.250	0.044

The final weights of the main and sub-indicators for sustainable fourth-party logistics providers are shown in Table 4.

Table 4

Final Weights of the Main and Sub-Indicators for Sustainable Fourth-Party Logistics Providers

Main Indicator	Main Indicator Weight	Sub-Indicator	Sub-Indicator Weight	Final Weight
Economic	0.491	C11	0.176	0.081
		C12	0.151	0.078
		C13	0.178	0.091
		C14	0.099	0.057
		C15	0.170	0.087
		C16	0.161	0.085
		C17	0.127	0.067
Environmental	0.356	C21	0.231	0.086
		C22	0.171	0.061
		C23	0.218	0.082
		C24	0.221	0.083
		C25	0.214	0.081
Social	0.187	C31	0.341	0.069
		C32	0.212	0.046
		C33	0.231	0.040
		C34	0.261	0.049

Based on the results above, for both third- and fourth-party logistics, the indicators of timely delivery and cost held greater importance compared to other indicators. Financial performance, environmental management systems, risk management, green transportation, environmental pollutant emissions, dry and hazardous waste management, quality, employee health and safety, geographical location, resource consumption, technology, shareholders' rights, workforce stability, and flexible employment contracts ranked next in importance after timely delivery and cost.

3.3 Evaluation Results for Sustainable Third- and Fourth-Party Logistics Providers Using the SuperDecisions Method

In this section, five third- and fourth-party logistics service providers were evaluated using the SuperDecisions technique. For this purpose, these providers were evaluated by 8 experts based on 16 criteria agreed upon by the experts in the fuzzy Delphi method. A questionnaire using a 5-point Likert scale was designed, and the experts' opinions were analyzed using the multi-criteria decision-making technique of SuperDecisions. Using the weights obtained in the previous phase, the initial supermatrix was formed. In the supermatrix, the final weights of the research factors were provided, and the normalized weights for each dimension were calculated through normalization. Table 5 presents the evaluation scores of the companies based on the three strategies Ka, Kb, and Kc.

IJIMOB
E-ISSN: 3041-8992

Table 5

Scores Derived from the SuperDecisions Method

Company	S	P	Ka	Kb	Kc
A1	0.5337	12.6370	0.2067	2.5049	0.8146
A2	0.5557	11.7113	0.1925	2.4705	0.7587
A3	0.6819	15.4867	0.2537	3.1379	1.0000
A4	0.4095	10.5176	0.1715	2.0000	0.6758
A5	0.5087	10.6810	0.1756	2.2578	0.6921

The final ranking of the companies is presented in Table 6.

Table 6

Final Ranking of Companies Using the SuperDecisions Method

Company	K	Rank
A1	1.9253	2
A2	1.8525	3
A3	2.3907	1
A4	1.5634	5
A5	1.6916	4

Thus, Company A3 ranked first, Company A1 second, Company A2 third, Company A5 fourth, and Company A4 fifth.

To further clarify the topic, Table 7 can be presented to prioritize the key factors influencing the establishment of 3PL and 4PL in contractor companies.

Table 7

Prioritization and Importance of Key Factors Influencing the Establishment of 3PL and 4PL in Contractor Companies

Main Indicator	Weight of the Main Indicator (Average of Both Parties)
Economic	0.485
Environmental	0.350
Social	0.1815

4 Discussion and Conclusion

4.1 First Question: What are the key factors influencing the establishment of 3PL and 4PL companies in the construction industry as a case study?

The results indicate that three main variables—social, economic, and environmental—are the key factors influencing the establishment of 3PL and 4PL companies in the construction industry. This indicates the importance of social, economic, and environmental utility and the sensitivity of this issue from the customer's perspective. It demonstrates that timely delivery and environmental considerations, as well as the cost-effectiveness of production or services, are the primary concerns and expectations from third- and fourth-party logistics companies. These companies must address challenges such as short product lifespans, neglect of customer demands, and time constraints imposed by customers. The solution to these issues is a commitment to timely delivery and flexibility.

4.2 Second Question: What is the prioritization and importance of the key factors influencing the establishment of 3PL and 4PL in contractor companies?

Based on the evaluations in previous sections, it was determined that for both third- and fourth-party logistics, timely delivery and cost hold greater importance than other indicators. Financial performance, environmental management systems, risk management, green transportation, environmental pollutant emissions, dry and hazardous waste management, quality, employee health and safety, geographical location, resource consumption, technology, shareholders' rights, workforce stability, and

IJIMOB
E-ISSN: 3041-8992

flexible employment contracts ranked in importance after timely delivery and cost.

Accordingly, the economic indicator has the highest priority and importance (with an average weight of 0.485), followed by the environmental indicator (weight 0.350), and lastly the social indicator (average weight 0.181). In many studies, it has been shown that the primary and immediate concern for consumers or customers is the financial profit and economic value of the product or service, which sets it apart from other aspects (Lin et al., 2023). Customers seek financial returns from any project investment and accept no other condition in this regard. Therefore, the economic indicator holds the highest importance. Additionally, environmental aspects are the next concern for customers, ensuring that the product does not negatively impact the surrounding environment, such as damaging water supplies or animal habitats. Lastly, the social indicator is the least important to customers when receiving goods and services.

4.3 *Third Question: What are the determining factors for applying green management in the logistics industry in the construction sector?*

Based on the previous evaluations and the final result of the second round of the fuzzy Delphi technique for selecting indicators for third- and fourth-party logistics service providers, the determining factors for applying green management in the logistics industry in the construction sector include: financial performance, risk management, geographical location, environmental management systems, resource consumption, environmental pollutant emissions, green transportation, dry and hazardous waste management, employee health and safety, flexible employment contracts, workforce stability and security, and shareholders' rights. This result is consistent with the prior research findings (Klumpp et al., 2013; Lin et al., 2023; Lynch et al., 2000; Naganawa et al., 2024), although the prioritization may differ.

Logistics is a crucial component in every economy and company. The experience of leading countries and industries shows that increasing logistics and supply chain efficiency is one of the most important strategies for improving the business environment, reducing costs, and increasing productivity. Since logistics costs sometimes constitute up to 30% of the final product price, proper logistics management can positively affect the supply chain by reducing inventory, improving productivity, increasing agility, shortening lead times, and enhancing customer service. For this reason, companies outsource some of their logistics tasks to third- and fourth-party logistics providers. The growing awareness of logistics' importance has driven innovations in leading countries and companies worldwide, such as the creation of 3PL and 4PL logistics companies. Additionally, globalization trends have forced many organizations to transfer their logistics functions to 3PL and 4PL providers, drawing significant attention to the core capabilities of these companies.

4.4 *Fourth Question: Which large contractors and sustainability criteria affect the establishment of logistics service providers?*

Five companies—A1 to A5—were identified as large contractors. The ranking results showed that Company A3 had the highest sustainability score, while Company A4 had the lowest performance in sustainability. Research (Garmash et al., 2024; Yu, 2024; Zhang, 2018) identified companies and their sustainability criteria. Given the importance of logistics activities due to the economic concerns of customers, a proper decision-making model for evaluating third- and fourth-party logistics providers before signing contracts is beneficial for managers. The criteria used must provide producers and industry participants with a comprehensive set of indicators and metrics to assess the status of selected third- and fourth-party logistics service providers. Based on the economic indicator, the cost of purchasing services and goods (construction) is higher than in other industries. In the current market, construction must be such that the builder does not suffer losses. Construction must also meet standards and deliver the final product on time to avoid losses for the client in today's volatile market. This requires market analysis, speeding up activities, and timely delivery of the project to the end customer. Therefore, it can be concluded that timely delivery to reduce potential losses and increase profits is the primary motivation that drives construction companies to cooperate with third- and fourth-party logistics providers. Additionally, financial performance ranked as the third most important factor influencing the selection of suppliers after timely delivery and cost.

4.5 *Fifth Question: What are the main reasons for implementing green supply chain management practices?*

Based on the results, it was determined that selecting the most suitable third- and fourth-party logistics service provider in the supply chain is strategically important for any organization aiming to achieve an effective and sustainable

IJIMOB
E-ISSN: 3041-8992

supply chain. This is the primary reason for implementing green supply chain management practices. According to the findings, timely delivery and cost were the most important factors, followed by financial performance, environmental management systems, risk management, green transportation, environmental pollutant emissions, dry and hazardous waste management, quality, employee health and safety, geographical location, resource consumption, technology, shareholders' rights, workforce stability and security, and flexible employment contracts. These factors are crucial for implementing green supply chain management practices. This result is consistent with prior research (Lin et al., 2023; Lynch et al., 2000; Naganawa et al., 2024; Omoush, 2022). Considering sustainability and its various dimensions, multi-criteria decision-making approaches provide effective and practical strategies for analyzing different criteria and helping specialists and managers balance and assess various elements to simplify and clarify management decisions.

Authors' Contributions

All authors have contributed significantly to the research process and the development of the manuscript.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Acknowledgments

We would like to express our gratitude to all individuals helped us to do the project.

Declaration of Interest

The authors report no conflict of interest.

Funding

According to the authors, this article has no financial support.

Ethical Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were observed.

References

Alawamleh, H., Hasan, K., Al, A., Alhalalmeh, D. M., Alatyat, Z., Saraireh, S., Akour, I., Alneimat, S., Alathamneh, F., Abu-Farha, Y., Ibraheem, S., & Alhawary, S. (2022). Uncertain Supply Chain Management The effect of green supply chain on sustainability: Evidence from the pharmaceutical industry. *Uncertain Supply Chain Management*, *10*. https://doi.org/10.5267/j.uscm.2022.8.002

Alhalalmeh, M. (2022). Uncertain Supply Chain Management 10 (2022) ****-**** Uncertain Supply Chain Management The impact of supply chain 4.0 technologies on its strategic outcomes. *Uncertain Supply Chain Management*, *10*. https://doi.org/10.5267/j.uscm.2022.8.008

Garmash, O., Олександрович, Б., Marchenko, V., Maksymov, O., Taghiyev, T., Damirov, M., Karpun, O., Yakovenko, V., Pozniak, O., Kateryna, Y., Chikalkin, S., Dolynskyi, S., Slyvka, Y., & Shcherban, M. (2024). Intellectualization of logistics and Supply Chain Management #23 - 2024. *Electronic Scientific Journal Intellectualization of Logistics and Supply Chain Management #1 2020*, *1*, 81. https://doi.org/10.46783/smart-scm/2024-23

Ifekanandu, C., Ihuoma, I., Rennner, A., & Lawrence, O. (2024). Logistics Management and Operational Efficiency of Food and Beverage Firms in Port Harcourt. *African Journal of Economics and Sustainable Development*, *7*, 111-122. https://doi.org/10.52589/AJESD-9XM6NX0Q

Iulia, T., Belu, M., Paraschiv, D., & Joldes, C. (2022). *Supply Chain Digital Transformation*. https://doi.org/10.24818/BASIQ/2022/08/079

Jaggernath, R. (2015). Green supply chain management. *World Journal of Entrepreneurship, Management and Sustainable Development*, *11*, 37-47. https://doi.org/10.1108/WJEMSD-06-2014-0018

Jangid, M. (2022). *Supply chains will need to become more efficient in 2022*.

Kern, J. (2021). The Digital Transformation of Logistics: A Review About Technologies and Their Implementation Status. In (pp. 361-403). https://doi.org/10.1002/9781119646495.ch25

Klumpp, M., Clausen, U., & Hompel, M. (2013). Logistics Research and the Logistics World of 2050. In (pp. 1-6). https://doi.org/10.1007/978-3-642-32838-1_1

Lin, X., Mamun, A., Yang, Q., & Masukujjaman, M. (2023). Examining the effect of logistics service quality on customer satisfaction and re-use intention. *PLoS One*, *18*, 1-24. https://doi.org/10.1371/journal.pone.0286382

Lynch, D., Keller, S., & Ozment, J. (2000). The effects of logistics capabilities and strategy on firm performance. *Journal of Business Logistics*, *21*, 47-67.

Maloni, M., Franza, R., Lowman, G., Naphsin, S., & Golara, S. (2024). Supply chain management research productivity and topics: 2020–2022. *Transportation Journal*, *63*. https://doi.org/10.1002/tjo3.12010

Mohsin, A., Awain, S., Al-Ansi, A., & Jaboob, M. (2023). Green Supply Chain Management: A Comprehensive Review of Research, Applications and Future Directions. *Management and Production Engineering Review*, *14*, 118-133. https://doi.org/10.24425/mper.2023.147194

Naganawa, H., Hirata, E., Firdausiyah, N., & Thompson, R. (2024). Logistics Hub and Route Optimization in the Physical Internet Paradigm. *Logistics*, *8*, 37. https://doi.org/10.3390/logistics8020037

Ningrum, E., Nugroho, A., Darmansyah, D., & Ahmar, N. (2024). A Scoping Review of Green Supply Chain and Company Performance. *International Journal of Quantitative Research and Modeling*, *5*, 26-30. https://doi.org/10.46336/ijqrm.v5i1.608

Omoush, M. (2022). The impact of the practices of logistic management on operational performance: A field study of road transport companies. *Journal of Governance and Regulation*, *11*, 237-245. https://doi.org/10.22495/jgrv11i4siart4

Ristovska, N., Kozuharov, S., & Petkovski, V. (2017). The Impact of Logistics Management Practices on Company's Performance. *International Journal of Academic Research in Accounting, Finance and Management Sciences*, *7*. https://doi.org/10.6007/IJARAFMS/v7-i1/2649

Sergiy, G., Олександрович, Б., Ierkovska, Y., D.D, B., M.Yu, H., Yu, Z., Trushkina, N., S.I, G., T.I, D., V.Z, N., V.A, K., V.Ye, M., O.M, H., Karpun, O., & N.M, P. (2022). Intellectualization of logistics and Supply Chain Management #12 - 2022. *12*.

Yu, L. (2024). Automobile Transportation Logistics Supply Chain Management Strategy. *Proceedings of Business and Economic Studies*, *7*, 56-61. https://doi.org/10.26689/pbes.v7i1.6078

Zhang, L. (2018). Research on Logistics Industry Transformation and Upgrading based on Resource Integration and Sharing. *IOP Conference Series: Earth and Environmental Science*, *186*, 012046. https://doi.org/10.1088/1755-1315/186/6/012046