International Journal of Contemporary Economics and Administrative Sciences
ISSN: 1925 – 4423
Volume: XV, Issue: 2, Year: 2025, pp. 1491-1508

Evaluation of Barriers to the Adoption of Technology in Sustainable Logistics by Dematel Method

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Received: 17.11.2025, Accepted:31.12.2025
10.5281/zenodo.18213509

Abstract

Supply chain operations are conducted to achieve the goal of operational efficiency in an environmental perspective towards sustainability. Improving both employee safety and working conditions in the process of providing logistics services has become an important need in terms of social sustainability. Distribution and delivery can contribute to sustainable economic growth through the selection of transport modes that reduce costs. Technology investment is a critical issue for logistics service providers in terms of contributing to sustainability dimensions. However, there are many barriers to creating and implementing technological infrastructure for sustainable logistics activities. This research aims to examine these barriers. The barriers to the use of technology in sustainable logistics applications were identified through a literature review and the importance levels of these barriers were evaluated using multi-criteria decision-making analysis under expert opinion. DEMATEL method was used to determine the relative importance of the barriers and the effects of the barriers on each other. According to the findings obtained from the study, strategy recommendations have been developed to minimise the impact of these barriers.

Keywords: Sustainable Logistics, Supply Chain Management, Barriers

Jel Code: L91, Q56, O33

1. Introduction

Sustainability is closely related to the optimal use of raw materials, minimization of carbon emissions, optimized transport routes, improved fuel efficiency and the use of recyclable packaging, which play an important role in the supply chain (Piecyk and McKinnon, 2010). The growth of international trade has

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led to a demand for environmentally friendly logistics practices. In addition, in the current economic growth of the world, ecological consciousness and awareness of sustainability are on the rise (Carter and Rogers, 2008). Increased awareness helps to accelerate the measures taken in this field, locally and globally. Each stage of the supply chain includes logistics and transportation activities that are subject to all these measures. So much so that these activities have their own carbon footprint. Therefore, the logistics sector has been forced to undergo an internal transformation in order to meet international green development goals (Srivastava, 2007; McKinnon, 2018; Dekker, Bloemhof, Mallidis, 2012). It is a much broader term that encompasses economic, ecological and social aspects of improvement in the process of producing logistics services (Macharis et al., 2014).

On the other hand, logistics service providers operate at a time when technological developments directly affect logistics, and these two concepts are closely intertwined. Automation processes, artificial intelligence and big data analytics are among the technologies that facilitate logistics processes. Data-driven decision-making support and AI-driven robotic systems enable the right decisions to be made for the rapid optimization of production facilities and production processes.

Through data driven decision support systems, agile decision making has become possible in the industry (Soumpenioti and Panagopoulos, 2023).

Digital solutions are becoming increasingly important in sustainable logistics. On the other hand, businesses face various obstacles in this process.

As the carbon footprint increases, natural resources are depleted. As the number of natural resources decreases, social inequalities emerge. The use of technology has become critical for logistics operations to be sustainable in breaking this undesirable cycle (Schachenhofer et al., 2023).

In recent years, the use of the concepts of digitalization and digital transformation by logistics service providers has increased considerably. While these technological advances have enabled the logistics industry to gain a competitive advantage, there are several barriers that hinder the integration of technology with sustainable logistics (Chakraborty et al., 2020).

The next section provides an overview of previous studies in literature to identify the barriers to technology applications in sustainable logistics. It also provides information and solutions on previous research topics and results.

The literature review conducted in this study provides clear insights into the research gap regarding the barriers to the effort to implement digital transformation in sustainable logistics practices.

(RQ1) What are the main barriers to the use of technology in sustainable logistics practices?

(RQ2) What is the ranking of the main barriers to the use of technology in sustainable logistics practices according to their importance?

Within the framework of the above research questions, the following research objectives were identified.

(RO1) To conduct a literature review to identify the main barriers to technology adoption in sustainable logistics practices

(RO2) To rank the barriers to technology adoption in sustainable logistics practices according to their importance.

2. Theoretical Background

The rapid depletion of natural resources, structural inequality in resource distribution and new expectations for corporate social responsibility have led to sustainability becoming one of the focus areas for businesses. Meanwhile, sustainability has become a priority for businesses due to the combination of increasing environmental crises, rising environmental awareness, regulatory pressures, reputation and risk management, and consumer demands. Businesses are realizing the impact of environmental awareness on their business models and shaping their profitability and market position with this perspective (Danış et al., 2022). Technology significantly supports logistics activities by contributing to the achievement of sustainability goals. However, various challenges encountered in technology applications prevent the benefits of technology from being fully realized. Research on the barriers to technology adoption in sustainable logistics practices is discussed in more detail in the following sections.

2.1.Sustainable logistics and technology

Logistics includes activities such as transportation, warehousing and inventory management. While in traditional logistics management, business objectives are only financial and operational, modern logistics management plays an important role at every point in the supply chain - inbound, production, outbound and reverse logistics - as it enables the entire supply chain. However, recently, due to the advancement of technology in workflows and increased environmental awareness, businesses are implementing sustainable supply chain practices that help their long-term profitability (Das, 2017). Supply chain management aims to eliminate unnecessary redundancies, minimize cycle time and inventory to deliver improved service to the customer at minimum cost. In a globally competitive environment, the interests of other stakeholders (public, governmental and non-governmental organizations) need to be considered as well as suppliers and buyers being part of the value chain. Today, the idea that supply chains should behave in a financially, ecologically and socially responsible manner (Mitra and Datta, 2013) has led to the vision of sustainable supply chain management.

As can be seen in Table 1, when the research on the barriers to the adoption of technology in sustainable logistics in the literature is examined, it is determined that there is no universal classification. It can be said that the classification varies according to the sector and its scope.

Table1. Barriers to the Adoption of Technology in Sustainable Logistics: A Summary of Literature

Author and Year	Main Barrier Dimensions in the Study
Waqas et al. (2021)	Financial, Technology
Chakraborty et al. (2020)	Financial
Bhandari et al. (2019)	Financial, Strategic, Humanitarian
Derse (2024)	Financial, Strategic, Humanitarian, Environmental,
Tadic et al. (2024)	Strategic
Kervall and Palsson (2023)	Financial, Strategic, Humanitarian, Environmental,
Malek and Desai (2021)	Financial, Strategic, Humanitarian, Environmental,
Waqas et al. (2018)	Financial, Strategic, Humanitarian, Technology
Moktadir et al. (2018)	Financial, Strategic, Environmental, Technology
Menon and Ravi (2021)	Financial, Strategic, Humanitarian, Technology
Trstenjak et al. (2023)	Strategic, Humanitarian, Technology
Prakash and Barua (2016)	Humanitarian
Gruchmann et al. (2019)	Strategic, Technology
Dahooie et al. (2020)	Humanitarian
Goh (2019)	Financial, Strategic, Humanitarian, Technology
Paddeu et al. (2018)	Strategic, Humanitarian, Technology
Sirisawat and Kiatcharoenpol	Strategic, Humanitarian
Iwan et al. (2024)	Strategic, Humanitarian
Mathiyazhagan et al. (2014)	Strategic, Environmental
Orji et al. (2019)	Financial, Humanitarian, Technology
Solati et al. (2021)	Financial, Strategic
Tumpa et al. (2019)	Financial, Strategic
Ullah et al. (2021)	Strategic
Chakraborty vd. (2024)	Strategic, Humanitarian

Hart and Milstein (2013) define sustainability as 'meeting the needs of the present without compromising the ability of future generations to meet their own needs.' Sustainable logistics activities have multidimensional structure which focus on development systems that is environmentally friendly, minimize resource cost and also serves the societal benefit. This configuration combines a range of techniques and instruments.

Sustainable development aims to harmonize the relationship between environmental issues and the economy to create social, economic and environmental sustainability. When businesses focus on sustainability, they have to consider all three dimensions for long-term development (Chiesa et al., 1999). Sustainable development contributes significantly to reducing the environmental impact of business, increasing economic value, and improving people's quality of life. Sustainable logistics activities are a multidimensional approach that aims to establish systems that are environmentally friendly, optimize costs and prioritize community interests. This structure includes various methods and tools.

While the concept of green logistics aims to reduce environmental impacts, reverse logistics focuses on creating sustainable value from finished products and minimizing environmental pollution from waste management (Sun et al., 2022). In this respect, digital transformation enables logistics operations to be carried out more effectively and efficiently, as in many sectors. Digital transformation is becoming increasingly decisive to synchronize the economic, environmental and social dimensions targeted by sustainable development (Ferraro et al., 2023).

The integration of sustainable logistics and technology leads to many changes in the value chain network. This integration accelerates the development of a flexible logistics network with simultaneous information sharing that can meet individual customer needs by adopting environmentally friendly practices. (D'Amico et al., 2021).

The use of technology can positively impact all sustainable digital logistics processes, from procurement to distribution. This helps businesses to provide high quality customer service and gain a global competitive advantage. (Parhi, et al., 2022).

While the importance of comprehensive digital transformation is growing in sustainable logistics, it also reveals various barriers to technology adoption. A systematic examination of these barriers is critical to understanding the current state of the field. This paper proposes a systematic literature review to identify the most frequently recurring themes related to barriers to technology adoption in sustainable logistics. It also aims to develop a multidimensional framework that ranks these barriers according to their importance.

2.2.Barriers to the use of technology in sustainable logistics activities

Sustainable logistics has a significant impact on concepts such as environmental effectiveness, resource efficiency and adaptation to the circular economy. For this adaptation to take place, technologies from information technology to automation, digital tracking systems, data analysis and reverse logistics software need to be properly established. Some of the barriers and problems encountered in the process of implementing sustainable logistics have been mentioned in the literature. The literature review in this study provides a comprehensive framework for examining the barriers to the use of technology in sustainable logistics. It also serves as a starting point for this topic.

The analysis considered here consists of four stages: identification, screening, relevance and inclusion. In order to identify the barriers to the use of technology in sustainable logistics activities, an extensive search was conducted in the Web of Science (WoS) database. In this context, the studies identified as a result of the search were examined and the relevant barriers were mentioned as a result of the literature review.

Tadic and colleagues (2024) analysis on challenges towards the adoption of drones in last mile logistics. They emphasized that operational uncertainties are a primary obstacle to the application of drones in the broadest sense.

Iwan et al. (2024) investigated the use of knowledge-based applications in urban logistics. They found that the most important barrier to the use of technology is the lack of shared information infrastructure and integration.

Trstenjak et al. (2023) explored the integrated of Industry 5.0 technologies into logistics efforts. In their study, they identified the level of infrastructure and digital transformation as the main limiting factor.

Many studies in the same areas show that one of the main barriers to technological transformation in sustainable operations is insufficient top management support. Wagas et al. (2021) examined the effects of reverse logistics practices on sustainability. They claim that the barriers to the success of the process are technology-based, citing organizational resistance, lack of training, high upfront costs and lack of government support as some of the most important challenges. In their study in the electronics sector, Menon and Ravi (2021) pointed out that the lack of top management involvement and weak strategic planning hinder implementation.

Gruchmann et al. (2018) mentioned institutional barriers in their study. They identified dependence on top-level companies, competitiveness and lack of coordination as barriers to the development of sustainable logistics service providers. The results of this study highlight the fact that the allocation of technological resources is related to both financing and the structure and decision-making processes of the organization.

Many studies in literature also draw attention to economic barriers. The results of the study by Malek et al. (2021) show that green practices are delayed due to lack of financing, short-term cost-benefit concerns, and limited customer demand. In addition, Waqas and Dong (2018) stated that the initial costs and uncertain return processes of reverse logistics negatively affect the investment decisions of businesses.

Orji and colleagues (2019) emphasize that inadequate financing is the primary barrier to ecological innovation. For this reason, they state that there is a focus on financial support systems for technological change in developing countries. Another challenge identified in the findings is the lack of legal and regulatory infrastructure.

According to Ullah et al. (2021), the absence of enforceable regulations and poor interaction between the government and the private sector remains one of the main barriers to the success of green innovations and reverse logistics.

In their analysis of urban logistics, Paddeu et al. (2018) found that the lack of targets to follow and procedures for implementation slowed down green policies and mechanisms. These studies show that the adoption of regulatory government incentives and strategy adjustments for sustainable logistics is vital for sustainable practices. In addition to the previous studies, literature has also focused on lack of knowledge, low level of education and poor public awareness.

Studies by Moktadir et al. (2018) and Solati et al. (2023) mentioned that customers' and businesses' awareness of sustainable practices is weak. This inadequacy reduces the willingness to implement technology and motivation for integration. They have stated. Prakash and Barua (2016) found that inadequate customer awareness and poor coordination between third-party service providers are significant barriers to technology adoption in reverse logistics. They have stated.

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It also shows that the barriers mentioned are sector and country specific. For example, in the textile sector, the production age of plants and machinery is cited as an obstacle, while in the fresh fruit and vegetable sector, cold chain and fast supply processes override production constraints as an infrastructure-related issue (Raut, Gardas, 2018; Moktadir et al., 2018).

Another example is that while regulatory gaps and financial constraints have a more dominant impact in emerging economies, the lack of multi-stakeholder planning in developed urban logistics conditions limits the widespread adoption of technological applications (Paddeu et al., 2018; Kervall and Palsson, 2022). Derse, in his study (2024), tries to identify the barriers to reverse and green logistics activities and proposes solutions to overcome the barriers. Similarly, Kervall and Pålsson (2022) tried to examine the barriers to the development of a sustainable urban freight transportation system from a systemic perspective.

On the other hand, Dahooie et al. (2021) and Goh (2019) focused on sustainability practices in supply chain management processes and highlighted the barriers in these processes.

A review of the literature reveals that the sources examined offer various solutions to reduce barriers to technology applications in sustainable logistics activities. Strengthening public-private partnerships, supporting R&D and technology investment capacity, ensuring regulatory compliance, creating integration that will increase strategic cooperation among supply chain stakeholders, and implementing training programs at the enterprise level to raise awareness are among the main solution proposals emphasized in the literature (Waqas et al., 2018; Chakraborty et al., 2020; İlbaş and Kaya, 2025; Ullah et al., 2021; Shee Weng, 2025).

A review of current studies reveals that various methods have been used to examine the obstacles encountered in sustainable logistics and technology utilisation processes. Previous studies have frequently employed surveys and multi-criteria decision-making methods. However, studies examining the barriers to the use of technology in sustainable logistics activities are scarce in literature. Considering the limited number of studies examining the barriers to the use of technology in sustainable logistics activities in developing countries such as Turkey, this study makes a unique contribution to the literature with its systematic and exploratory nature.

Certainly, it is inevitable that sustainability will be affected by digital transformation, as logistics is an integral part of both service providers and service purchasers, and the backbone of all supply chain operations. Therefore, conducting research in the field of logistics, which is one of the sectors where the convergence of sustainability and technology will provide a significant competitive advantage, increases the importance of this study.

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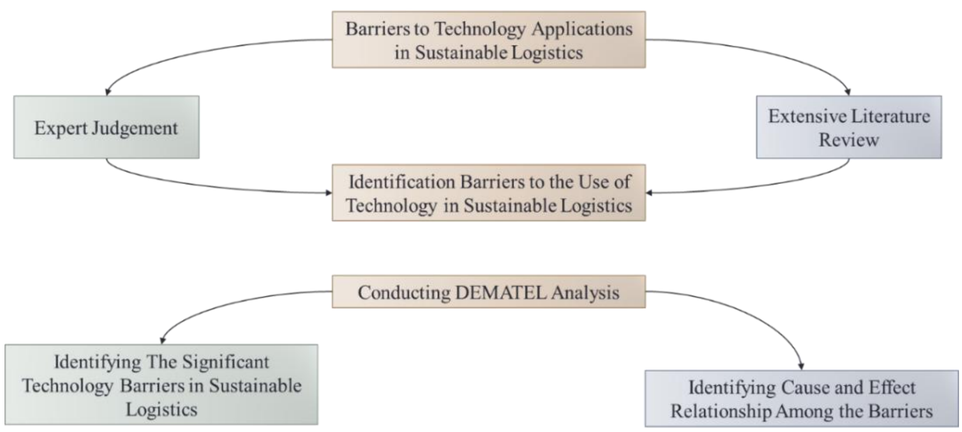
3. Methodology

This study aims to identify the barriers to technology in sustainable logistics and to assess the significance of each barrier. Additionally, it investigates the cause–effect relationships among these barriers.

Figure 1 presents the comprehensive research framework adopted in this study. The research process consists of four main phases. First, an extensive literature review was conducted to identify the barriers to technology applications in sustainable logistics. Secondly, these barriers were validated and evaluated using pairwise comparison matrices with the judgments of 15 experts who have worked in the logistics sector for many years; one of them is a social responsibility leader in the logistics sector, the others are logistics and supply chain managers, air transport maintenance experts and academicians. These experts are included in the study because they have both strategic and operational knowledge and experience. Logistics and supply chain leaders provide perspectives on decision-making and implementation processes, while airline maintenance experts provide technical perspectives on technology-intensive operational processes. The social responsibility leader enabled the assessment of sustainability and stakeholder expectations. Academics contribute to the theoretical framework of the topic.

Third, the DEMATEL method was applied to analyze the direct and indirect relationships among the identified barriers. Finally, the analysis results were interpreted to determine the significant levels of technology barriers and reveal the cause-and-effect relationships among them. This systematic approach enables both the prioritization of barriers and the development of strategic recommendations for sustainable logistics practices.

Figure 1. Framework of Research



In the first phase of this study, a comprehensive literature review was conducted to identify the key barriers limiting the use of technology in sustainable logistics. In this study, we categorized all technological barriers to sustainable logistics into five groups. Subsequently, primary data was obtained from the evaluations of 15 competent experts in the field. Thus, a comprehensive research framework was followed to identify the obstacles to the application of technology in sustainable logistics. The findings revealed the most significant barriers to the adoption of technology in sustainable logistics activities. From another perspective, the detailed cause-and-effect relationships among the identified barriers were outlined. The compilation and evaluation of the data obtained have created a decision-making framework for both prioritizing barriers and developing strategies. Thus, the results of this study serve as a guide for managers in the logistics sector and also make an important contribution to literature. After the literature review, the second step of the research, which is to determine the importance of multiple barriers, the main barriers to the use of technology in sustainable logistics were identified in five different dimensions. Table 2 shows these barrier dimensions and what each barrier dimension means.

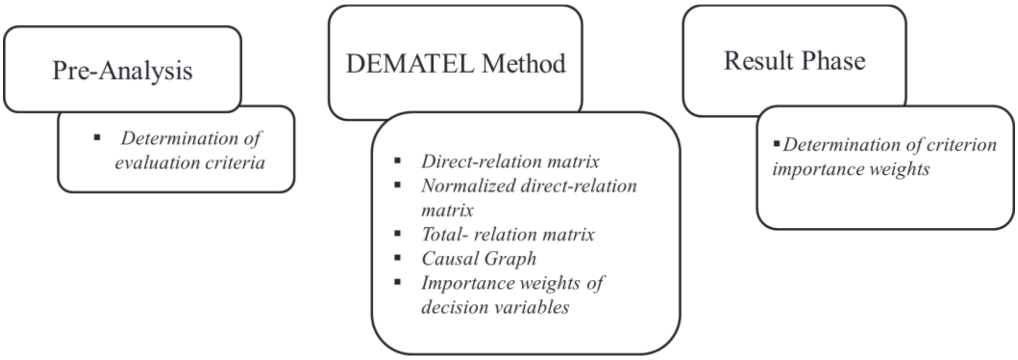
Table 2. Barriers to Technology in Sustainable Logistics

Barriers to Technology in Sustainable Logistics	
Strategic Barriers (B1)	Lack of coordination and communication between stakeholders Resistant behaviour against information sharing Absence of legislation and projects involving sustainable innovative logistics practices Lack of collaborative supply chain understanding among stakeholders
Financial Barriers (B2)	Lack of financial support from stakeholders Competition between stakeholders Lack of funds for investment in technology Monetary return-oriented approach instead of utilisation and efficiency in technology investments
Humanitarian Barriers (B3)	Labour resistance to change Weakness of motivation to use technology Absence of knowledge and expertise
Technology Barriers (B4)	Poor information technology infrastructure Non-adaptation of information technologies between organisations Limited application of sustainable technology Updating the technology frequently
Environmental Barriers (B5)	Weather conditions Changes in demand Performance of service providers The uncertainty about the environmental impacts of technology use.

The research model has been developed in accordance with the purpose of the research and the application steps of the DEMATEL method used. This research model is presented in Figure 2.

DEMATEL (Decision-Making Trial and Evaluation Laboratory) method is designed to analyze complex and intertwined problem structures by examining both direct and indirect interactions among factors, enabling the determination of their relative importance within the system (Taherdoost and Madanchian, 2023). Decision making trial and evaluation laboratory (DEMATEL) is considered as an effective method for the identification of cause-effect chain components of a complex system. It deals with evaluating interdependent relationships among factors and finding the critical ones through a visual structural model (Si, et al.,2018).

Figure 2. Steps of DEMATEL Method



Source*:* Adapted from (Chang, Chang, Wu, 2011)

This study was carried out in three stages: first, determining the evaluation criteria; second, analyzing the causal relationships by creating direct and total relationship matrices with DEMATEL method; and finally, calculating the importance weights of the criteria and evaluating the results (Fontela, and Gabus, 1976). The opinions of the experts in a decision group were obtained by using an integer scale of “no influence (0),” “low influence (1),” “medium influence (2),” “high influence (3),” and “very high influence (4)” (Liou and Chuang, 2010).

4. Findings

The DEMATEL analysis was conducted based on the evaluations of 15 experts in the field of sustainable logistics and supply chain management. This section presents the analytical results in a systematic manner, following the methodological steps outlined in the previous section. First, the integrated direct relationship matrix is presented, showing the initial influence assessments among the five barrier dimensions. Subsequently, the normalized and total relationship matrices are calculated to reveal both direct and indirect effects. Finally, cause-and-effect relationships are identified through the computation of prominence (Dj+Ri) and relation (Dj-Ri) values, which enable the determination of importance weights and the classification of barriers as either causes or effects within the system.

First, a direct relationship matrix based on pairwise comparisons is created to determine the relationships between the criteria. The comparison scale was used within the scope of the study. Based on the data obtained from the group of participants consisting of competent experts in their field, the direct relationship matrix table shown in Table 3 was created by integrating the assessments of each expert.

Table 3. Direct relationship matrix (Integrated)

	Strategic	Financial	Humanitarian	Technology	Environmental
Strategic	0,000	2,533	2,667	2,533	1,333
Financial	2,800	0,000	3,067	3,667	1,600
Humanitarian	2,000	1,667	0,000	2,400	1,067
Technology	2,800	1,933	2,200	0,000	1,867
Environmental	1,800	1,867	1,600	2,067	0,000

After the assessments of competent experts in the field were consolidated into a single table, the data was standardized and normalized, and a direct relationship matrix was created, as shown in Table 4.

Table 4. Normalized direct relationship matrix

	Strategic	Financial	Humanitarian	Technology	Environmental
Strategic	0,000	0,228	0,240	0,228	0,120
Financial	0,251	0,000	0,275	0,329	0,144
Humanitarian	0,180	0,150	0,000	0,216	0,096
Technology	0,251	0,174	0,198	0,000	0,168
Environmental	0,162	0,168	0,144	0,186	0,000

The threshold value was calculated as 0.7206628, and which was obtained by calculating the arithmetic mean. To reach the threshold value, the arithmetic mean of all values in Table 3 is calculated. The aim is to determine the overall level of all relationships in the matrix and to accept relationships above this value as meaningful relationships. In Table 5, values above the threshold value are indicated in bold (Ebrahimi, 2023).

Table 5. Total relationship matrix

	Strategic	Financial	Humanitarian	Technology	Environmental
Strategic	0,66627	**0,76008**	**0,86832**	**0,918**	0,5459
Financial	**0,98799**	0,67767	**1,01149**	**1,11479**	0,64325
Humanitarian	0,69544	0,59919	0,54853	**0,77242**	0,44727
Technology	**0,84402**	0,70504	**0,81467**	0,70499	0,56632
Environmental	0,69167	0,62116	0,68375	**0,76283**	0,36551

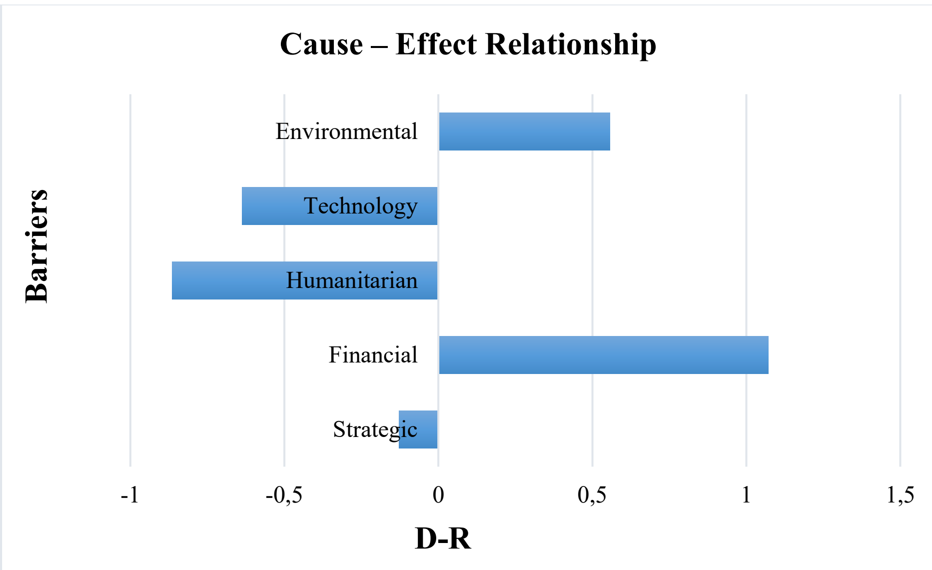
As shown in Table 6, in the total relationship matrix, $D_j–R_i$ indicates the direction and strength of a factor's effect on the system, while D_j+R_i indicates the overall importance of that factor. D represents the total effect of one variable on the other variables (sum of rows), R represents the total effect of one variable on the others (sum of columns), i is the row index and j is the column index. The value of '$D_j – R_i$' indicates whether a variable is a cause or an effect within the system. When the value is positive, the variable is the influencer, i.e., the 'cause'; when negative, it is the influence, i.e., the 'effect'. '$D_j + R_i$' represents the variable's overall importance level in the system. An increase in this value indicates that the variable plays a more decisive role in interactions within the system (Šmidovnik and Grošelj, 2023).

Table 6. Received and given table (Cause-effect)

	D_j-R_i	D_j+R_i	w	W	Importance Weights
Strategic (B1)	-0,12684	7,64399	7,64505	0,21111	3
Financial (B2)	*1,07206*	7,79833	7,87168	0,21737	2
Humanitarian (B3)	-0,8639	6,98962	7,04281	0,19448	4
Technology (B4)	-0,63799	*7,90809*	7,93378	0,21908	**1**
Environmental (B5)	*0,55668*	5,69317	5,72032	0,15796	5

In the third column of Table 6, the priority, i.e. raw weight value (w) of each criterion is calculated. In the next column, the raw weight values calculated for each criterion are normalized to obtain the final importance weights (W).

Figure 3. Influence Graph Cause – Effect Relationship Between the Barriers



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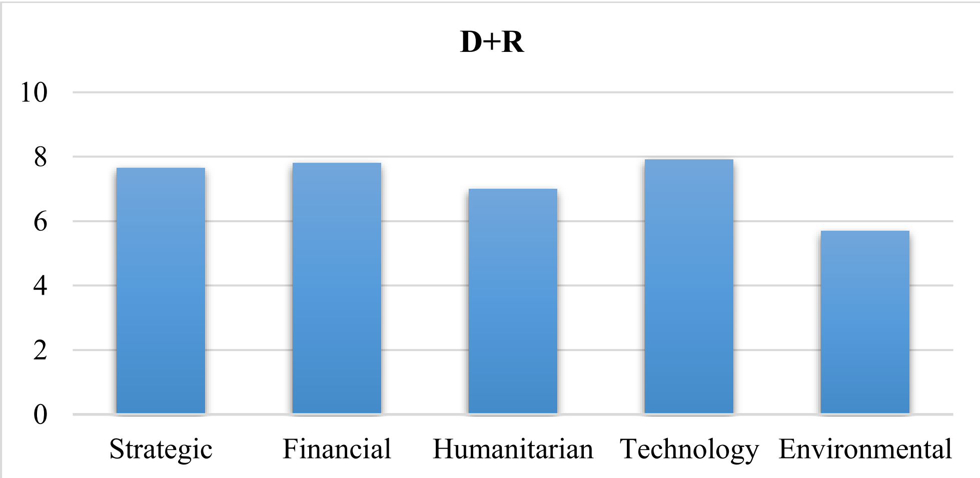
ISSN: 1925 – 4423
Volume: XV, Issue: 2, Year: 2025, pp. 1491-1508

The graphs in Figure 3 and Figure 4 show the main drivers with the most significant and strong linkages and the autonomous drivers with less significant but strong linkages. The influence graph showing the cause-and-effect relationships between the barriers to technology implementation in sustainable logistics is presented in Figure 3 that shows the barriers with positive and negative values. Environmental and financial barriers are identified as positive values. Positive values have an impact on all barriers. In other words, positive criteria affect other criteria. Negative values are influenced by other criteria. In other words, technology, human and strategic barriers are affected by environmental and financial barriers. The results show that technological barriers constitute the most important driving forces, followed by financial barriers, while strategic barriers are the third most influential group.

Figure 4. Relation Graph (Relationship Between the Barriers)



As seen in Figure 4, technology barrier is identified as the most important driving force after financial barriers in the research. Strategic barriers are in third place.

5. Conclusion

This study shows that the barriers to technology in sustainable logistics activities are multidimensional. As a result of this study, the importance of financial and environmental barriers was identified. In addition, these two dimensions have a significant impact on human and strategic barriers. These barriers may manifest themselves in different ways depending on the sector and geographical region. Therefore, solutions and support for both policy makers and practitioners may be needed. The research conducted within the scope of this study has shown that environmental and financial factors, which are barriers to technology adoption, rank high in terms of importance. In terms of environmental barriers, it can be said that weather conditions complicate sustainability goals, while factors related to climate change and weather forecasts require the adoption of technologies in logistics activities. In terms of the importance of environmental barriers, sudden changes in demand can cause imbalances in the logistics network. This can require additional transportation capacity and resource utilization, which can increase environmental impacts. Technologies used for demand forecasting and inventory management can help to better manage demand. However, continuous data and updates are required for these technologies to work correctly. The use of technology can be an important tool to improve the performance of logistics service providers. However, all logistics service providers may differ in their ability to access and use technology effectively. Long-term environmental uncertainties in terms of technology further highlight the financial barriers due to high investment costs, maintenance and upgrading expenses. On the other hand, economic factors can be said to be a barrier to investments in staff training and long-term strategic planning. Therefore, it is necessary to pursue various solution strategies to overcome such obstacles in sustainable logistics practices. Measures such as strengthening technological infrastructure and harmonizing systems among supply chain stakeholders will both facilitate the use of technology and strengthen cooperation. Most importantly, these improvements will also improve the sustainability performance of logistics. As a result of this study, some gaps in literature have been identified. Within the framework of technology applications in sustainable logistics activities, it can be suggested that future studies should be designed to be independent of each other; internationally comparative, examining the social dimension, industry 5.0 and human-centered, prioritizing the social dimension and addressing long-term effects.

The Use of Generative Artificial Intelligence and AI-Enabled Technologies in the Writing Process

During the preparation of this manuscript, the authors used DeepL (Deep Learning) Translator to correct language, improve academic expressions and enhance methodological clarity. Following the use of these tools, the au-thors carefully reviewed and revised the manuscript and took full responsibility for the content of the published article.

REFERENCES

Bhandari, D., Singh, R. K., & Garg, S. K. (2019). Prioritisation and evaluation of barriers intensity for implementation of cleaner technologies: Framework for sustainable production. Resources, Conservation and Recycling, 146, 156-167.

Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: moving toward new theory. International journal of physical distribution & logistics management, 38(5), 360-387.

Chakraborty, S., Sharma, A., & Vaidya, O. S. (2020). Achieving sustainable operational excellence through IT implementation in Indian logistics sector: An analysis of barriers. Resources, Conservation and Recycling, 152, 104506.

Chang, B., Chang, C. W., & Wu, C. H. (2011). Fuzzy DEMATEL method for developing supplier selection criteria. Expert systems with Applications, 38(3), 1850-1858.

International Journal of Contemporary Economics and Administrative Sciences
ISSN: 1925 – 4423
Volume: XV, Issue: 2, Year: 2025, pp. 1491-1508

Chiesa, V., Manzini, R., & Noci, G. (1999). Towards a sustainable view of the competitive system. Long Range Planning, 32(5), 519-530.

D'Amico, G., Szopik-Depczyńska, K., Dembińska, I., & Ioppolo, G. (2021). Smart and sustainable logistics of Port cities: A framework for comprehending enabling factors, domains and goals. Sustainable Cities and Society, 69, 102801.

Danis, M., Acar, A. Z., & Arslan, A. (2022). Is the use of Green Certification Strategic or not? TransNav, The International Journal on Marine Navigation and Safety of Sea Transportation, 16(2), 203–209. doi:10.12716/1001.16.02.01

Das, D. (2017). Development and validation of a scale for measuring sustainable supply chain management practices and performance. Journal of Cleaner Production, 164, 1344-1362.

Dekker, R., Bloemhof, J., & Mallidis, I. (2012). Operations Research for green logistics–An overview of aspects, issues, contributions and challenges. European Journal of operational research, 219(3), 671-679.

Derse, O. (2024). Prioritizing solutions of green Reverse logistics barriers with Fuzzy DEMATEL–FUCOM–SWARA methods. Ecological Indicators, 165, 112198.

Ebrahimi, S. H. (2023). Some equations to identify the threshold value in the DEMATEL method. Operations Research and Decisions, 33(2), 1-22.

Ferraro, S., Cantini, A., Leoni, L., & De Carlo, F. (2023). Sustainable logistics 4.0: a study on selecting the best technology for internal material handling. Sustainability, 15(9), 7067.

Fontela, E., and Gabus, A. (1976). The DEMATEL observer, DEMATEL 1976 Report. Switzerland Geneva: Battelle Geneva Research Center.

Goh, S. H. (2019). Barriers to low-carbon warehousing and the link to carbon abatement: A case from emerging Asia. International Journal of Physical Distribution & Logistics Management, 49(6), 679-704.

Gruchmann, T., Melkonyan, A., & Krumme, K. (2018). Logistics business transformation for sustainability: Assessing the role of the lead sustainability service provider (6PL). Logistics, 2(4), 25.

Gupta, A., & Singh, R. K. (2020). Developing a framework for evaluating sustainability index for logistics service providers: graph theory matrix approach. International Journal of Productivity and Performance Management, 69(8), 1627-1646.

Hart, S. L., & Milstein, M. B. (2013). Creating sustainable value. Academy of Management Executive, 17(2), 56-69.

Heidary Dahooie, J., Zamani Babgohari, A., Meidutė-Kavaliauskienė, I., & Govindan, K. (2021). Prioritising sustainable supply chain management practices by their impact on multiple interacting barriers. International Journal of Sustainable Development & World Ecology, 28(3), 267-290.

Iwan, S., Wagner, N., Kijewska, K., & Jensen, S. A. (2024). Concept of the knowledge-based city logistics: Problems and solutions. PLoS One, 19(6), e0305563.

İlbaş, A., & Kaya, H. (2025). Evaluation of Operational Performance of Major European International Airports with Data Envelopment, Journal of Aviation, 9(2), 436–444.

Kervall, M., & Palsson, H. (2022). A multi-stakeholder perspective on barriers to a fossil-free urban freight system. Sustainability, 15(1), 186.

Liou, J. J., & Chuang, Y. T. (2010). Developing a hybrid multi-criteria model for selection of outsourcing providers. Expert Systems with Applications, 37(5), 3755-3761.

Macharis, C., Melo, S., Woxenius, J., & Van Lier, T. (Eds.). (2014). Sustainable logistics. Emerald Group Publishing.

Malek, J., & Desai, T. N. (2021). A framework for prioritizing the solutions to overcome sustainable manufacturing barriers. Cleaner Logistics and Supply Chain, 1, 100004.

Mathiyazhagan, K., Sengupta, S., & Poovazhagan, L. (2018). A decision making trial and evaluation laboratory approach to analyse the challenges to environmentally sustainable manufacturing in Indian automobile industry. Sustainable Production and Consumption, 16, 58-67.

McKinnon, A. (2018). Decarbonizing logistics: Distributing goods in a low carbon world. Kogan Page Publishers.

Menon, R. R., & Ravi, V. (2021). Analysis of barriers of sustainable supply chain management in electronics industry: An interpretive structural modelling approach. Cleaner and Responsible Consumption, 3, 100026.

Mitra, S., & Chatterjee, A. K. (2000). Managing relationships in supply chains of the 21st century. In J. N. Sheth, A. Parvatiyar, & G. Shainesh (Eds.), Customer relationship management: Emerging concepts, tools and applications (pp. 336-345). Tata McGraw Hill.

Mitra, S., & Datta, P. P. (2013). A survey of sustainable supply chain management practices in Indian manufacturing firms. Indian Institute of Management Calcutta, Working Paper Series, WPS No. 723.

Moktadir, M. A., Ali, S. M., Rajesh, R., & Paul, S. K. (2018). Modeling the interrelationships among barriers to sustainable supply chain management in leather industry. Journal of cleaner production, 181, 631-651.

Mukherjee, S., Nagariya, R., Baral, M. M., Patel, B. S., Chittipaka, V., Rao, K. S., & Rao, U. A. (2023). Blockchain-based circular economy for achieving environmental sustainability in the Indian electronic MSMEs. Management of Environmental Quality: An International Journal, 34(4), 997-1017.

Orji, I. J., Kusi-Sarpong, S., Gupta, H., & Okwu, M. (2019). Evaluating challenges to implementing eco-innovation for freight logistics sustainability in Nigeria. Transportation Research Part A: Policy and Practice, 129, 288-305.

Paddeu, D., Parkhurst, G., Fancello, G., Fadda, P., & Ricci, M. (2018). Multi-stakeholder collaboration in urban freight consolidation schemes: Drivers and barriers to implementation. Transport, 33(4), 913-929.

Parhi, S., Joshi, K., Gunasekaran, A., & Sethuraman, K. (2022). Reflecting on an empirical study of the digitalization initiatives for sustainability on logistics: The concept of sustainable logistics 4.0. Cleaner Logistics and Supply Chain, 4, 100058.

Piecyk, M. I., & McKinnon, A. C. (2010). Forecasting the carbon footprint of road freight transport in 2020. International journal of production economics, 128(1), 31-42.

Prakash, C., & Barua, M. K. (2016). A multi-criteria decision-making approach for prioritizing reverse logistics adoption barriers under fuzzy environment: Case of Indian electronics industry. Global Business Review, 17(5), 1107-1124.

Raut, R., & Gardas, B. B. (2018). Sustainable logistics barriers of fruits and vegetables: An interpretive structural modeling approach. Benchmarking: An International Journal, 25(8), 2589-2610.

Schachenhofer, L., Kummer, Y., & Hirsch, P. (2023). An analysis of underused urban infrastructures: usage opportunities and implementation barriers for sustainable logistics. Applied Sciences, 13(13), 7557.

Shee Weng, L. (2025). Green Logistics in 2025: Integrating Sustainability, Technology, and Business Strategy. Green Logistics in.

Si, S. L., You, X. Y., Liu, H. C., & Zhang, P. (2018). DEMATEL technique: a systematic review of the state-of-the-art literature on methodologies and applications. Mathematical problems in Engineering, 2018(1), 3696457.

Sirisawat, P., & Kiatcharoenpol, T. (2019). Correlation of reverse logistics performance to solutions using structural equation modeling. Journal of Advanced Manufacturing Systems, 18(04), 511-525.

Šmidovnik, T., & Grošelj, P. (2023). Solution for convergence problem in DEMATEL method: DEMATEL of finite sum of influences. Symmetry, 15(7), 1357.

Solati, S., Shojaei, P., Alimohammadlou, M., & Heidari Hesamabadi, Z. (2023). Reverse Logistics Implementations Solutions: Interval Type 2 FAHP-FTOPSIS Approach. Discrete Dynamics in Nature and Society, 2023(1), 6805773.

Soumpenioti, V., & Panagopoulos, A. (2023, September). AI Technology in the Field of Logistics. In 2023 18th International Workshop on Semantic and Social Media Adaptation & Personalization (SMAP) 18th International Workshop on Semantic and Social Media Adaptation & Personalization (SMAP 2023) (pp. 1-6). IEEE.

Srivastava, S. K. (2007). Green supply-chain management: a state-of-the-art literature review. International journal of management reviews, 9(1), 53-80.

Sun, X., Yu, H., Solvang, W. D., Wang, Y., & Wang, K. (2022). The application of Industry 4.0 technologies in sustainable logistics: a systematic literature review (2012–2020) to explore future research opportunities. Environmental Science and Pollution Research, 29(7), 9560-9591.

Tadić, S., Krstić, M., & Radovanović, L. (2024). Assessing strategies to overcome barriers for drone usage in last-mile logistics: A novel hybrid fuzzy MCDM model. Mathematics, 12(3), 367.

Taherdoost, H., & Madanchian, M. (2023). Understanding Applications and Best Practices of DEMATEL: A Method for Prioritizing Key Factors in Multi-Criteria Decision-Making. Taherdoost, H., Madanchian, M, 17-23.

Trstenjak, M., Mustapić, M., Gregurić, P., & Opetuk, T. (2023). Use of green industry 5.0 technologies in logistics activities. Tehnički glasnik, 17(3), 471-477.

Tumpa, T. J., Ali, S. M., Rahman, M. H., Paul, S. K., Chowdhury, P., & Khan, S. A. R. (2019). Barriers to green supply chain management: An emerging economy context. Journal of cleaner production, 236, 117617.

Ullah, S., Ahmad, N., Khan, F. U., Badulescu, A., & Badulescu, D. (2021). Mapping interactions among green innovations barriers in manufacturing industry using hybrid methodology: insights from a developing country. International Journal of Environmental Research and Public Health, 18(15), 7885.

Waqas, M., Dong, Q. L., Ahmad, N., Zhu, Y., & Nadeem, M. (2018). Critical barriers to implementation of reverse logistics in the manufacturing industry: a case study of a developing country. Sustainability, 10(11), 4202.

Waqas, M., Honggang, X., Khan, S. A. R., Ahmad, N., Ullah, Z., & Iqbal, M. (2021). Impact of reverse logistics barriers on sustainable firm performance via reverse logistics practices. LogForum, 17(2), 213-230.