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Araştırma Makalesi * Research Article

Assessment of Third-Party Reverse Logistics Provider Through the SWARA-WASPAS Integrated Framework

Bütünleşik SWARA-WASPAS Yaklaşımı Aracılığıyla Üçüncü Taraf Tersine Lojistik Sağlayıcısının Değerlendirilmesi

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Abstract: The selection of the most suitable third-party provider for reverse logistics activities is a key factor in initiating effective reverse logistics processes. However, the process of identifying the optimal third-party provider involves navigating through various conflicting objectives and criteria. This task is intricate and time-consuming, necessitating the application of multi-criteria decision-making approaches. This study addresses the evaluation and selection of the best third-party reverse logistics provider by introducing a comprehensive multi-criteria decision-making framework. Therefore, this study aims to assist a manufacturer specializing in milk and dairy products who has opted to transfer its reverse logistics operations to a logistics service provider. The objective is to aid them in selecting the most suitable third-party reverse logistics provider. The proposed framework incorporates the SWARA (Step-wise Weight Assessment Ratio Analysis) technique for determining weights and the WASPAS (Weighted Aggregated Sum Product Assessment) method for thoroughly evaluating alternatives. In this study, a panel of four experts made a joint decision after identifying six criteria and five alternatives. The research concluded that the reverse logistics cost (Criteria 1) emerges as the most pivotal factor, with the service quality of reverse logistics (Criteria 3) being recognized as the least significant criterion. As a result, Alternative 1 stands out as the top choice among the third-party reverse logistics provider.

Keywords: Reverse logistics, third-party reverse logistics providers, MCDM, SWARA, WASPAS.

Öz: Tersine lojistik faaliyetleri için en uygun üçüncü taraf sağlayıcının seçimi, etkili tersine lojistik süreçlerinin başlatılmasında önemli bir faktördür. Bununla birlikte, en uygun üçüncü taraf sağlayıcıyı belirleme süreci birbiriyle çelişen çeşitli hedefler ve kriterler arasında karar vermeyi içerir. Bu görev karmaşık ve zaman alıcıdır ve çok kriterli karar verme yaklaşımlarının uygulanmasını gerektirir. Bu çalışma, kapsamlı bir çok kriterli karar verme çerçevesi sunarak en iyi üçüncü taraf tersine lojistik sağlayıcının değerlendirilmesini ve seçimini ele almaktadır. Bu nedenle bu çalışma, tersine lojistik operasyonlarını bir lojistik hizmet sağlayıcısına devretmeyi seçen süt ve süt ürünleri konusunda uzmanlaşmış bir üreticiye yardımcı olmayı amaçlamaktadır. Amaç, firmaya en uygun üçüncü taraf tersine lojistik sağlayıcıyı seçmede yardımcı olmaktır. Önerilen çerçeve, ağırlıkların belirlenmesi için SWARA (Adımsal Ağırlık Değerlendirme Oranı Analizi) tekniğini ve alternatiflerin kapsamlı bir şekilde değerlendirilmesi için WASPAS (Ağırlıklı Birleşik Toplu Çarpım Değerlendirmesi) yöntemini içermektedir. Bu çalışmada dört uzmandan oluşan bir ekip, altı kriter ve beş alternatif belirledikten sonra ortak karar almıştır. Araştırma, tersine lojistik maliyetinin (Kriter 1) en önemli faktör olarak ortaya çıktığı, tersine lojistiğin hizmet kalitesinin (Kriter 3) ise en az önemli kriter olarak kabul edildiği sonucuna varmıştır. Sonuç olarak, Alternatif 1 üçüncü taraf tersine lojistik sağlayıcılar arasında en üst sırada yer almaktadır.

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Anahtar Kelimeler: Tersine lojistik, üçüncü taraf tersine lojistik sağlayıcıları, ÇKKV, SWARA, WASPAS.

INTRODUCTION

The simultaneous advancement of the worldwide economy has compelled human society to confront the twin dilemmas of resource utilization and environmental preservation. Nations across the globe are earnestly striving to strike a harmonious equilibrium between fostering industrial progress for heightened competitiveness and safeguarding resources and the environment to fortify capabilities for sustainable development (Yang et al., 2024). In recent times, reverse logistics has emerged as an innovative approach, fostering the creation of new resources and addressing environmental considerations (Eydi & Rastgar, 2022). Reverse logistics (RL) emerges as a contemporary sustainability strategy, aiming to enhance competitiveness within the corporate sector while alleviating environmental burdens. RL is commonly defined as the systematic coordination of planning, execution, and supervision to optimize the economical and efficient movement of raw materials across the entire inventory and finished goods management process, along with associated information, from product origin to consumption points (Mohammadkhani & Mousavi, 2023). The potential returns on certain products, like cell phones and computers, can be notably high, possibly surpassing 50% of sales (Jauhar et al., 2021).

The growing attention to reverse logistics activities is driven by their ability to complete the loop, ensuring efficient collection and distribution of materials for subsequent processing, thereby preserving the material's value (Palmgren et al., 2023). Including reverse logistics activities complicates the planning and decision-making process, introducing new material and information flows and new contributors to the supply chain (Guggeri et al., 2023). Therefore, firms must develop appropriate strategies for overseeing the RL network and ensuring an optimal management process (Haq et al., 2023). Firms can choose from three alternatives to implement an effective RL network: handle it internally, establish logistics subsidiaries, or delegate RL activities to third-party partners, allowing them to focus on their core operations (Mohammadkhani & Mousavi, 2022). Today, most companies delegate their logistics activities to third-party providers (3PLs). 3PLs and firms cooperate closely to efficiently manage and handle product returns (Haq et al., 2023). Cooperating with a third-party reverse logistics provider (3PRLP) can lead to substantial cost reductions and risk mitigation. However, organizations allocate resources to their primary strengths, thereby maximizing overall benefits (Yang et al., 2022).

Following the choice to work with a 3PL, companies must select an appropriate supplier from among the available options (Eydi & Rastgar, 2022). Making the option to use 3PRLPs is critical since they support sustainable development and improve a company's supply chain performance (Jauhar et al., 2021). Selecting the appropriate 3PL to conduct RL activities is another essential first step in RL. However, the choice of 3PL is based on a number of competing goals or standards (Yang et al., 2022, p. 1). The implementation of this process could be difficult and time-consuming, hence MCDM approaches would be required (Eydi & Rastgar, 2022). When there are many objectives involved in decision-making that may clash with one another, MCDM techniques are frequently applied (Guggeri et al., 2023). For example, Kannan et al. (2009) used a hybrid strategy to select a reverse logistics provider by combining fuzzy TOPSIS and ISM. Cheng & Lee (2010) assessed and chose 3PRLPs using the Analytic Network Process (ANP). Also, Büyüközkan & Çifçi (2012) aimed to improve the effectiveness of 3PRLP selection, a comprehensive framework integrating the fuzzy DEMATEL, fuzzy ANP, and fuzzy TOPSIS approaches was presented.

The breadth of criteria taken into account and the more exact MCDM procedures utilized to choose 3PRLPs are two limitations of previous studies. Thus, this research aims to support a milk and dairy products manufacturer that has decided to shift its reverse logistics operations to a logistics service provider. The goal is to help them choose the most appropriate 3PRLP. The research utilized a combined method involving the SWARA-WASPAS. The SWARA and WASPAS techniques offer simplicity and reduce processing time. Through the SWARA method, decision-makers attain more objective outcomes by eliminating the need for a predefined scale when assessing the significance of decision criteria in relation to one another. Conversely, the WASPAS method enables decision-makers to appraise alternatives based on both subjective and objective criteria. Furthermore, the method facilitates consistency in alternative rankings by performing sensitivity analysis within its operational framework (Yücenur & Ipekçi, 2021). With these attributes, the proposed methodology stands apart from other MCDM methods, thus being selected as the preferred solution method within the study's scope. The SWARA technique was used to determine criterion weights, while the WASPAS method ranked the alternatives. To the author's knowledge, the model integrated in this study was employed for the first time in the 3PRLP selection process. Priorly, Sremac et al. (2018) employed the SWARA-WASPAS method to determine the optimal 3PL. Therefore, the outcomes of the suggested model's rankings are crucial for companies and managers when choosing the optimal 3PRLP. The introduced framework provides a comprehensive and reliable tool for selecting the best 3PL. Thus, the objective of this study is to aid managers and practitioners in efficiently choosing the most suitable 3PRLP, leading to savings in both time and costs during strategic decision-making.

The paper is organized as follows: Section 2 provides an overview of pertinent literature resources, highlighting research gaps in outsourcing RL activities through MCDM techniques. Section 3 delves into the outline of the proposed model. Section 4 presents a case sample, illustrating the selection of 3PRLPs for a real-world problem. The study concludes in the final section, summarizing key findings and outlining avenues for future research.

LITERATURE REVIEW

Stock (1992) acknowledged the significance of the Reverse logistics (RL) field for both business and society at large (Ravi et al., 2005). RL has garnered significant focus in the last two decades, encompassing the strategic handling of product recovery to optimize both financial and ecological benefits while concurrently minimizing waste (Haq et al., 2023). RL involves transporting goods from consumers to producers within a distribution channel (Ravi et al., 2005). RL involves the organized process of rerouting goods from their initial destination to extract value or ensure appropriate disposal (Ahmadi et al., 2024). Implementing successful RL strategies can yield environmental and financial advantages while also enhancing organizations' corporate reputations. Numerous nations have mandated environmental guidelines for producers or entities, necessitating the proper management of product returns after their functional lifespan (Prakash & Barua, 2016a).

Efficiently handling product returns enhances resource utilization rates and contributes to the establishment of sustainable business operations (Mohammadkhani & Mousavi, 2022). However, products that have been returned may vary in terms of their conditions and quantities (Thibbotuwawa et al., 2023). Thus, an effective deployment of RL necessitates a well-suited logistics network (Mohammadkhani & Mousavi, 2022). The RL network of companies must have diverse options to handle these varying scenarios (Thibbotuwawa et al., 2023). Developing effective strategies to handle the reverse logistics network poses an increasingly significant challenge for the retail sector, given its potential to substantially influence the company's performance (Haq et al., 2023). The careful design of an RL network is essential to guarantee the smooth and effective functioning of the process, given its involvement with various stakeholders such as retailers, third-party logistics providers, manufacturers, and customers (Tasoglu & Ilgin, 2024).

RL is gaining significance for businesses aiming to minimize waste, diminish their environmental footprint, and enhance efficiency within their supply chains (Tasoglu & Ilgin, 2024). Given the contemporary business landscape, adopting RL strategies is an unavoidable necessity. Nevertheless, uncertainties stemming from diverse factors within the supply chain frequently influence the choice of implementing RL. A genuine RL functions within a dynamic environment of uncertainty (Mohammadkhani & Mousavi, 2022). Due to the unpredictable nature of demand, the irregular timing, and the varying quality of returned products, the need for flexible capacity and transportation services becomes imperative. As a result, numerous organizations, constrained by limited resources and capabilities, opt to delegate their RL activities to third-party entities (Prakash & Barua, 2016b).

Opting for outsourcing RL functions can enhance cost-effectiveness, elevate delivery performance, and boost customer satisfaction (Kannan et al., 2009). Furthermore, third-party providers can efficiently manage warehousing, infrastructure, and support services for RL operations (Prakash & Barua, 2016b).

When a company chooses to implement reverse logistics outsourcing as a strategic approach, carefully selecting a 3PRLP becomes crucial (Kannan et al., 2009). However, choosing the criteria for 3PRLP selection is crucial as it involves subjective and quantitative factors. The proper set of criteria that align with the organization's objectives is fundamental for making appropriate selection decisions (Mohammadkhani & Mousavi, 2023). The choice of a 3PL provider hinges on the total contract cost and the quality of service performance (de Almeida, 2007).

In the literature on 3PRLP, multiple techniques and standards exist to choose the ideal partner for outsourcing logistics services. Numerous research endeavors have concentrated on improving the evaluation and prioritization techniques to support decision-makers in selecting the best course of action when presented with both certain and ambiguous data (Mohammadkhani & Mousavi, 2023). For example, Krumwiede & Sheu (2002) assessed the viability of 3PRLPs using a decision model. Ravi et al. (2005) proposed a decision model based on the Analytic Network Process (ANP) and used a balanced scorecard approach to manage end-of-life computers through reverse logistics techniques., Efendigil et al. (2008) presented a two-stage model to choose the best 3PRLP. Min & Ko (2008) presented a multi-integer programming model that focused on the location and distribution of repair equipment in third-party logistics firms. Kannan et al. (2009) selected a reverse logistics provider utilizing a hybrid approach that used fuzzy TOPSIS and Interpretive Structural Modeling (ISM).

Cheng & Lee (2010) evaluated and selected 3PRLPs using the ANP. Büyüközkan & Çifçi (2012) presented an integrated framework to help an automotive company choose ecologically friendly suppliers. It included the Fuzzy DEMATEL, Fuzzy ANP, and Fuzzy TOPSIS methodologies. A decision support system was created by Jayant et al. (2014) to help a company's senior management select and evaluate various 3PRL service providers. They used a hybrid strategy that combined the TOPSIS and AHP methods. A fuzzy AHP-PROMETHEE-based approach was presented by Kafa et al. (2015) for partner selection and closed-loop supply chain network configuration, especially when reverse logistics is outsourced to a third-party logistics provider. Guarnieri et al. (2015) presented an MCDM model and indicated difficulties in assessing and selecting 3PRLP.

Li et al. (2018) selected the best 3PRLP using HI-MCDM approach based on CPT. Govindan et al. (2019) suggested the integrated ELECTRE I-SMAA approach to locate a 3PRLP. Zarbakhshnia et al. (2020) suggested a combined model to evaluate the best 3PRLP. Rostamzadeh et al. (2020) used the FARAS method to suggest the MCDM model for determining optimum 3PRLP. Jauhar et al. (2021) used two-steps approach to determine the best 3PRLP. Mishra & Rani (2021) employed the integrated CRITIC-CoCoSo model to determined the best 3PRLP. Mohammadkhani & Mousavi (2022) suggested the combined CRITIC-VIKOR model to determine the RL providers. Mohammadkhani & Mousavi (2023) integrated the fuzzy compromise approach-fuzzy BWM methods to evaluate the 3PRLPs.

METHODOLOGY

This study aims to identify the best 3PRLPs using an integrated SWARA-WASPAS approach. In this context, firstly, the criteria weights were determined using the SWARA technique developed by Keršulienė et al. (2010) These weights are also the input of the WASPAS method developed by Zavadskas et al. (2012) and used to evaluate alternatives. This section presents the methodological steps of both methods.

The Step-wise Weight Assessment Ratio Analysis (SWARA)

SWARA is a technique for determining the relative importance of each criterion, taking into account expert opinions (Agarwal et al., 2020). In this technique, experts assign weight values to criteria according to their decreasing importance (Yücenur & Ipekçi, 2021). In order to determine the importance of the criteria, a pairwise comparison matrix is created and priority weights are determined (Agarwal et al., 2020). The implementation steps of this technique are as follows (Keršulienė et al., 2010):

Step 1: The expert determines the criteria in descending order of importance.

Step 2: Starting with the second criterion the expert decides how important criterion j is relative to the preceding criterion $j-1$. This relative importance is calculated proportionally and denoted by s_j.

Step 3: Calculate the coefficient k_j using the following equation:

$$k_j = \begin{cases} 1 & j = 1 \\ s_j + 1 & j > 1 \end{cases}. \tag{1}$$

Step 4: Calculate the reevaluated weight q_j using the following equation:

$$q_j = \begin{cases} 1 & j = 1 \\ \frac{k_{j-1}}{k_j} & j > 1 \end{cases}. \tag{2}$$

Step 5: The relative importance of each evaluation criterion is determined by the following formula:

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k}, \tag{3}$$

n is the total number of criteria and the weight of the j criterion is denoted by w_j.

Weighted aggregated sum product assessment (WASPAS)

The WASPAS technique, whose results are reliable (Agarwal et al., 2020), takes into account the results of two approaches: the Weighted Sum Model (WSM) and the Weighted Product Model (WPM) (Yücenur & Ipekçi, 2021). In this technique, alternatives are ranked according to three optimality criteria. First, various decision criteria evaluate a large number of alternatives using the WSM technique. Subsequently, it appraises alternatives using WPM in the context of multiplicative exponential criteria. Finally, it evaluates the weighted aggregation of both additive and multiplicative methods, capturing a more realistic scenario (Agarwal et al., 2020). Nevertheless, the approach maintains the ability to manage consistency in alternative rankings through internal sensitivity analysis during its execution (Yücenur & Ipekçi, 2021). WASPAS demonstrates superior performance compared to other MCDM techniques, allowing for a reliable assessment and ranking of alternatives with a high level of accuracy (Agarwal et al., 2020). The procedural stages of the WASPAS method can be outlined as follows (Yücenur & Ipekçi, 2021):

Step 1: Establishing criteria (C_j) and identifying alternatives (A_i) ($j = 1, \dots, n; i = 1, \dots, m$).

Step 2: The criteria weights are established by applying an MCDM method.

Step 3: To standardize the initial decision matrix, utilize Eq. (4) and Eq. (5) for benefit-based criteria (to maximize) and cost-based criteria (to minimize), respectively.

$$\overline{x_{ij}} = \frac{x_{ij}}{max_i x_{ij}} \tag{4}$$

$$\overline{x_{ij}} = \frac{min_i x_{ij}}{x_{ij}} \tag{5}$$

Step 4: The initial total relative importance value, denoted as $Q_i^{(1)}$, is determined using Eq. (6) by the Weighted Sum Model.

$$Q_i^{(1)} = \sum_{j=1}^{n} \overline{x_{ij}} w_j \tag{6}$$

Step 5: The second total relative importance value, denoted as $Q_i^{(2)}$, is determined by applying Eq. (7) per the Weighted Product Model.

$$Q_i^{(2)} = \prod_{j=1}^{n} (\overline{x_{ij}})^{w_j} \tag{7}$$

Step 6: Q_i represents the aggregated optimality value determined using Equation (8). The coefficient λ falls within the range of [0,1] and signifies the degree of combined optimality. When the WSM and WPM approaches contribute equally to the combined optimality criteria, the value of λ is set to 0.5.

$$Q_i = \lambda Q_i^{(1)} + (1-\lambda)Q_i^{(2)} \quad (8)$$

Step 7: Every option is arranged considering the aggregated optimality value (Q_i). The alternative with the highest Q_i value is the optimal choice and holds the top position in the ranking.

IMPLEMENTATION AND FINDINGS

This study identifies a food business in Antalya to demonstrate how the proposed model can be applied. The company's primary focus is on producing milk and dairy products. The company aims to cultivate a sustainability-focused image and mitigate its activities' environmental and social impact by entrusting its reverse logistics tasks to a third-party logistics provider. In pursuit of this goal, the company is actively exploring a holistic strategy to discern the criteria for evaluating and selecting a reverse logistics supplier, thereby facilitating the integration of sustainability into its operational practices.

Initially, a decision-making panel comprised four experts: an academic, a senior manager, a production manager, and an operations manager. Each expert boasts at least ten years' experience, with a balanced gender representation of two males and two females aged between 39 and 58. Among them, one holds a bachelor's degree, another a master's degree, and two possess doctoral degrees. The author conducted an extensive literature review to identify 17 potential criteria impacting the selection of 3PRLP. Below are these 17 potential criteria along with their explanations.

- **Environmental friendliness**: Rate of environmental expenditure, waste minimization, certification for environmental protection, production with eco-design principles, and capability in green technology (Li et al., 2018).

- **Cost of reverse logistics**: The expenses encompass shipping costs, fixed expenses for warehouse and processing facilities, unit operating costs for recycling and disposal, environmental expenditures, and costs associated with redistribution (Li et al., 2018).

- **Company capacity**: Financial capability, workforce capacity, networking capabilities, capacity utilization ratio, integration technology, market presence, storage capabilities, future readiness, and expertise (Guarnieri et al., 2015).

- **Service quality of reverse logistics**: The requested level of service quality by the customer (Efendigil et al., 2008).

- **Reverse logistics revenue**: Savings in costs, income generated from recyclable sales, value recapture, and returns from green policies (Li et al., 2018).

- **Value added services to customers**: Convenience, client support, eco-friendly offerings, client contentment, assembly/disassembly, packaging/labeling adjustment, product remanufacturing, renewal, disposal, call center management, post-purchase assistance, and managerial/performance analysis (Guarnieri et al., 2015).

- **Alliances with suppliers**: Enhancing competitiveness, providing mentorship to suppliers, establishing strategic alliances, and managing knowledge effectively (Guarnieri et al., 2015).

- **Total order cycle time**: The duration spanning from the commencement to the conclusion of the inverse procedure (Efendigil et al., 2008).

- **Confirmed fill rate**: The proportion of deliveries that meet the criteria of being the "right amount and right size" compared to the total number of deliveries (Efendigil et al., 2008).

- **Reverse logistic practices**: This pertains to the supplier's ability regarding RLs, encompassing processes such as reclamation, recycling, collection, sorting, treatment, redistribution, implementation of take-back policies, provision of after-sales services, and recall solutions (Mohammadkhani & Mousavi, 2023).

• **Delivery and service of product**: It pertains to the aspects of timely shipment and supply, encompassing the ability of each supplier to adhere to delivery schedules, provide accurate forecasts for transit times, and possess effective tracking capabilities (Mohammadkhani & Mousavi, 2023).

• **Environmental Competencies**: It pertains to the supplier's ability to diminish the impact of pollution, employ eco-friendly materials, and utilize technology in their processes, thereby minimizing harm to the environment (Mohammadkhani & Mousavi, 2023).

• **Waste management and pollution prevention**: The nature of the raw material necessitates minimizing both wastage and pollution during the product manufacturing process (Luthra et al., 2017).

• **Green design and purchasing**: Integrating environmentally conscious approaches during the phases of design and procurement (Luthra et al., 2017).

• **Social responsibility of enterprise**: It encompasses, among other aspects, the obligation felt by enterprises towards the environment and resources, governmental bodies and the public, consumers, as well as stakeholders and employees (Yang et al., 2024).

• **Environmental management system**: Developing environmental policies, strategizing for environmental objectives, and overseeing environmental activities through review and control (Goodarzi et al., 2022).

• **Pollution control**: The regulations established by the supplier to manage the quantity of pollution discharged into the environment (Goodarzi et al., 2022).

The experts evaluated these criteria, identifying six as the focal points for research, reflecting shared perspectives. Table 1 illustrates the evaluation criteria. Furthermore, the research pinpointed five 3PRLPs functioning as alternatives to facilitate the company's reverse logistics operations.

Table 1. *Evaluation criteria for 3PRLP selection*

Code	Criteria	Max/Min	References
C_1	Cost of reverse logistics	Min	Efendigil et al. (2008); Guarnieri et al. (2015); Li et al. (2018); Min & Ko (2008); Yang et al. (2024)
C_2	Reverse logistics practices	Max	Mohammadkhani & Mousavi (2023)
C_3	Service quality of reverse logistics	Max	Efendigil et al. (2008); Guarnieri et al. (2015); Jharkharia & Shankar (2007); Li et al. (2018); Ravi et al. (2005); Yang et al. (2024)
C_4	Delivery and service of product	Max	Luthra et al. (2017); Mohammadkhani & Mousavi, (2023)
C_5	Environmental competencies	Max	de Almeida (2007); Goodarzi et al. (2022); Haseli et al. (2023); Luthra et al. (2017); Mohammadkhani & Mousavi (2023); Stević et al. (2020)
C_6	Company capacity	Max	Li et al. (2018); Yang et al. (2024)

In this phase, experts assigned importance rankings to each criterion (Step 1). Subsequently, they determined the relative significance, indicating the ratio of importance between the first and second criteria and between the second and third criteria (Step 2). Each expert performed this assessment for all criteria, acquiring rankings and comparative importance values (s_j) as detailed in Table 2. Expert 1 and Expert 3 prioritize the delivery and service of the product, whereas Expert 2 emphasizes reverse logistics practices, and Expert 4 places significance on the cost of reverse logistics.

Table 2. *Criteria ranking by experts and sj values*

Criteria	Experts							
	E1		E2		E3		E4	
	Rank	sj	Rank	sj	Rank	sj	Rank	sj
C_1	4	0.10	2	0.20	2	0.20	1	-

C_2	6	0.15	1	-	3	0.15	3	0.15
C_3	2	0.15	6	0.20	6	0.20	5	0.30
C_4	1	-	3	0.15	1	-	4	0.20
C_5	5	0.30	5	0.30	4	0.25	2	0.10
C_6	3	0.05	4	0.10	5	0.30	6	0.25

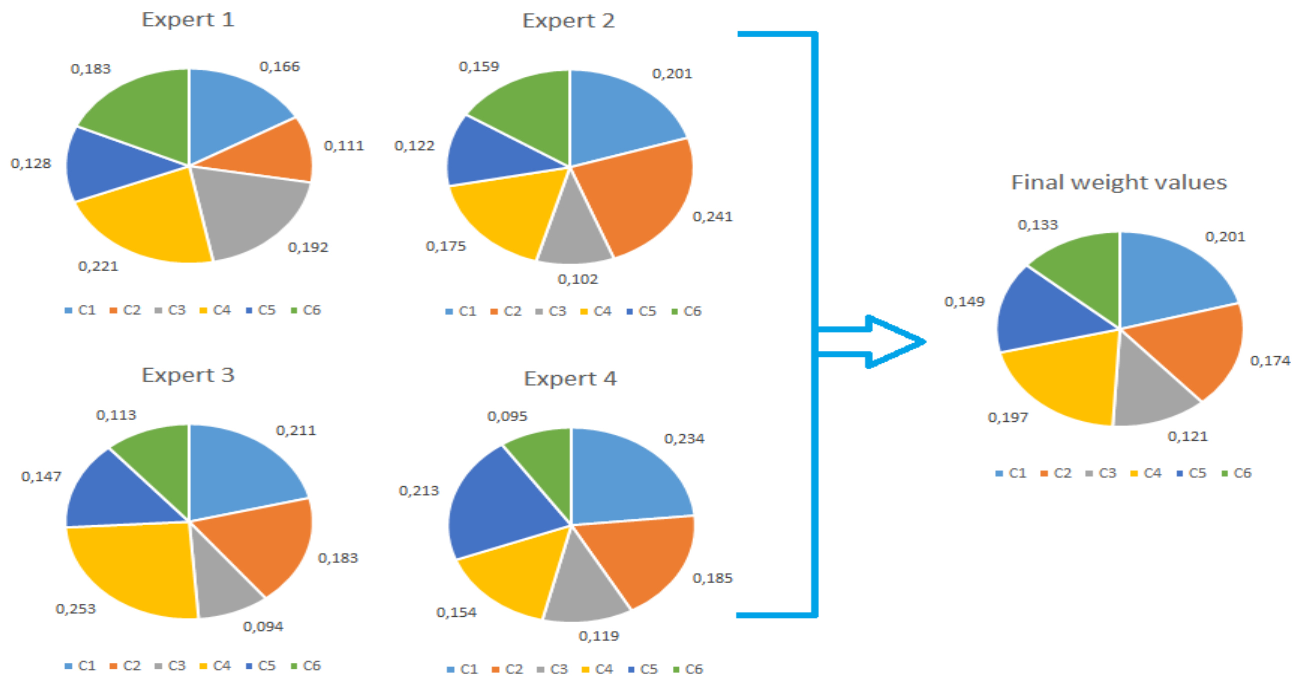
The values of k_j were computed utilizing Equation 1, while the values of q_j were determined employing Equation 2. The ultimate weights (w_j) for each expert were calculated in the next step (Eq. 3). Expert 1 assigns a weight of 0.221 to C_4, while Expert 3 assigns a weight of 0.253 to the same criterion. Expert 2 attributes a weight of 0.241 to C_2, and Expert 4 assigns a weight of 0.234 to C_1. Given that experts exhibit distinct preferences regarding criteria and their weights, the determined weights from each expert were amalgamated using the geometric mean. Table 3 shows the rankings of the criteria obtained, along with their ultimate weights calculated using the geometric mean. Based on the combined criterion weights, the cost of reverse logistics (C_1) emerges as the most pivotal factor, with service quality of reverse logistics (C_3) ranking as the least significant criterion.

Table 3. *Wj value of each criteria*

Criteria	wj			
	E1	**E2**	**E3**	**E4**
C_1	0.166	0.201	0.211	0.234
C_2	0.111	0.241	0.183	0.185
C_3	0.192	0.102	0.094	0.119
C_4	0.221	0.175	0.253	0.154
C_5	0.128	0.122	0.147	0.213
C_6	0.183	0.159	0.113	0.095

Moreover, Figure 1 illustrates the individual weights assigned to the criteria by each expert, along with the ultimate combined weights for the criteria.

Figure 1. *Final criteria weights*



Once the criterion weights were determined, the WASPAS method prioritized the alternatives. To proceed, generating a decision matrix for the WASPAS technique becomes imperative. To construct this matrix, each expert provided a rating from 1 to 5 (1 being the least and 5 the highest) for each alternative's performance across each criterion (Yücenur & Ipekçi, 2021). Four experts assigned numbers, combined using the geometric mean, to form a decision matrix. To illustrate, the experts individually gave scores of 4, 5, 4, and 4 to the performance of alternative "A_1" based on criterion "C_1". These scores are then aggregated as follows:

$$(4\ x\ 5\ x\ 4\ x\ 4)^{1/4} = 4.229$$

The ratings given to performances in different alternative and criterion pairs were merged similarly, forming the decision matrix shown in Table 4.

Table 4. *Decision matrix*

Alternatives	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**
A_1	4.229	3.464	1.861	3.936	2.913	2.449
A_2	3.936	3.224	1.861	3.663	2.711	2.060
A_3	3.663	2.913	2.000	3.663	2.449	2.213
A_4	3.873	2.913	1.414	3.663	2.449	1.861
A_5	3.722	2.913	2.213	3.130	2.711	2.449

After creating the initial decision matrix, the normalized decision matrix was generated utilizing Eq. (4) for criteria based on benefits and Eq. (5) for criteria based on costs. The resulting normalized decision matrix is presented in Table 5.

Table 5. *Normalized decision matrix*

Alternatives	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**
A_1	0.866	1.000	0.841	1.000	1.000	1.000
A_2	0.931	0.931	0.841	0.931	0.931	0.841
A_3	1.000	0.841	0.904	0.931	0.841	0.904
A_4	0.946	0.841	0.639	0.931	0.841	0.760
A_5	0.984	0.841	1.000	0.795	0.931	1.000

Then, the WSM and WPM were employed to calculate the total relative importance values ($Q_i^{(1)}$ *and* $Q_i^{(2)}$) for each alternative using Eq. (6) and Eq. (7). The combined optimality value for each alternative was computed using Equation (8). The Q_i values were calculated assuming the value of λ is set to 0.5. Table 6 shows the Q_i values and the ranking of the alternatives. A_1 stands out as the top 3PRLP, whereas A_4 is at the lowest tier. The alternatives are ranked in descending order of optimality values, like $A_1 > A_2 > A_5 > A_3 > A_4$.

Table 6. *Ranking results*

Alternatives	**$Q_i^{(1)}$**	**$Q_i^{(2)}$**	**Q_i**	**Rank**
A_1	0.956	0.979	0.968	1
A_2	0.885	0.909	0.897	2
A_3	0.859	0.883	0.871	4
A_4	0.817	0.837	0.827	5
A_5	0.873	0.894	0.883	3

$Q_i^{(1)}$: Weighted Sum Model, **$Q_i^{(2)}$**: Weighted Product Model, **Q_i**: Optimality value of alternatives, **λ**=0.5

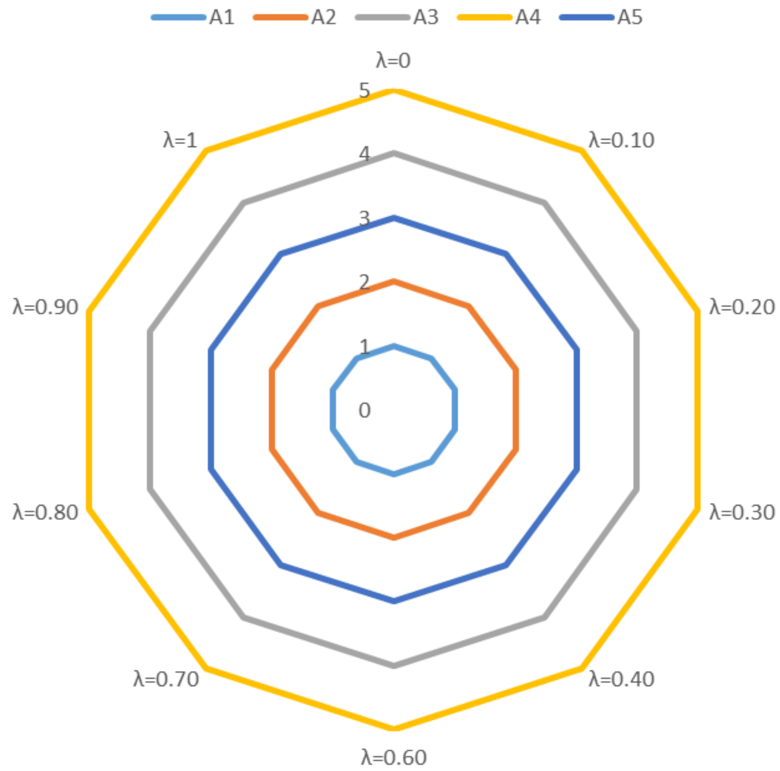
Yücenur & Ipekçi (2021) stated that the WASPAS technique enables the examination of the rankings' consistencies among alternatives through internal consistency analysis. Thus, to assess result consistency, the decision alternatives' relative importance values were established using various λ values, leading to a reordering of the alternatives. Table 7 presents various λ values and corresponding updated rankings based on these values. The consistency and reliability of the results are evident as the rankings of the alternatives remain unchanged across five different λ values (0, 0.25, 0.5, 0.75, 1). The findings indicated that A_1 is the best 3PRLP, while A_4 ranks at the bottom.

Table 7. *Alternative λ Values and Rankings*

Alternatives	λ=0	Rank	λ=0.25	Rank	λ=0.75	Rank	λ=1	Rank
A_1	0.97927	1	0.97339	1	0.96164	1	0.95576	1
A_2	0.90873	2	0.90272	2	0.89071	2	0.8847	2
A_3	0.88288	4	0.87684	4	0.86477	4	0.85873	4
A_4	0.83655	5	0.83178	5	0.82223	5	0.81745	5
A_5	0.89435	3	0.88891	3	0.87801	3	0.87256	3

Figure 2 also illustrates that the ranking outcomes remain consistent across ten distinct λ values.

Figure 2. *Alternative λ Values and Rankings*



DISCUSSION

This study used the SWARA-WASPAS integrated framework to evaluate reverse logistics service providers. The main objective of the study is to perform the selection and performance evaluation of 3PRLPs that can operate effectively in supply chain management processes and support sustainability principles. The findings of the study show that the SWARA-WASPAS integrated framework is an effective tool for evaluating reverse logistics providers. This framework supports multi-criteria decision-making processes while enabling more informed decisions by focusing on critical factors such as sustainability, cost effectiveness and operational efficiency. The findings emphasize that this framework is a valuable tool for improving decision-making in supply chain management processes and finding logistics solutions that comply with sustainability principles. This study provides a basis for further research and application in the field of reverse logistics management.

Based on the combined weights assigned to each criterion, the reverse logistics cost emerges as the most significant factor, while the criterion of reverse logistics service quality is recognized as the least critical. In support of these findings, Yang et al. (2024) stated that for those seeking RL services, there exists the potential to enhance the efficiency of constrained enterprise resources. This optimization could result in obtaining more professional services with reduced inputs, leading to a further decrease in logistics costs. Yang et al. (2022) indicated that organizations opt to implement RL systems due to the extended processing cycle for returns and the elevated costs associated with returns. Furthermore, Min & Ko (2008) claimed that considering tradeoffs between cost and service could assist third-party logistics providers (3PLs) in pinpointing the optimal logistics balance—where they can minimize costs while maximizing customer satisfaction. Li et al. (2018) found that the top-performing 3PRLP achieved the highest cognitive score in areas such as environmental sustainability, variable outsourcing costs, and company capacity. Also, Mohammadkhani & Mousavi (2023) concluded that of all the selection criteria for 3PRLPs, risk criteria garnered the greatest weighting. The risk dimension holds the highest position compared to other dimensions. Consequently, this criterion possesses the capacity to impact the selection of other dimensions within 3PRLPs.

CONCLUSION AND FUTURE RESEARCH DIRECTIONS

In the past ten years, the importance of RL operations in managing closed-loop supply chains has been highlighted due to rising production costs, environmental concerns, and stricter environmental regulations. Consequently, certain companies are leaning towards outsourcing their RL operations to third parties as a strategic approach. Within this scenario, the primary challenge encountered in outsourcing is effectively assessing and choosing a proficient third-party RL provider, considering the multifaceted nature of this decision (Li et al., 2018). Therefore, this study aimed to assist a milk and dairy products manufacturer in Antalya that opted to transition its reverse logistics operations to a logistics service provider, aiding them in selecting the most suitable 3PL. A collective decision was reached by a panel of four experts who identified six criteria and five alternatives. The study employed an integrated approach utilizing SWARA-WASPAS. Criterion weights were established using the SWARA technique, and the WASPAS method was employed to rank the alternatives. According to the aggregated criterion weights, the reverse logistics cost (C_1) is the most crucial factor. In contrast, the service quality of reverse logistics (C_3) is identified as the least important criterion. A_1 is the leading option among the 3PRLP, while A_4 holds the lowest position. The ranking follows a descending order of optimality values, with A_1 being superior to A_2, A_5, A_3, and finally, A_4. In order to evaluate the consistency of results, different λ values were employed. The results consistently demonstrate reliability, as the rankings of the alternatives remain constant across various λ values.

Several potential avenues for future research have been highlighted. Firstly, due to its practicality, the method suggested can be utilized across various industries for other selection processes or evaluations. Secondly, to improve decision-making accuracy in the selection problem, the extended investigation can incorporate a comprehensive set of attributes. Thirdly, the suggested decision-making approach applies to various decision-making domains, including portfolio selection, transportation service providers, and inventory issues. Finally, enhancing the suggested decision-making approach is achievable by integrating it with optimization models like vehicle routing, facility planning, and transportation planning. This integration ensures that the outcomes contribute effectively to the design of the RL network.

REFERENCES

Agarwal, S., Kant, R., & Shankar, R. (2020). Evaluating solutions to overcome humanitarian supply chain management barriers: A hybrid fuzzy SWARA – Fuzzy WASPAS approach. *International Journal of Disaster Risk Reduction*, *51*.

Ahmadi, S., Shokouhyar, S., Amerioun, M., & Salehi Tabrizi, N. (2024). A social media analytics-based approach to customer-centric reverse logistics management of electronic devices: A case study on notebooks. *Journal of Retailing and Consumer Services*, *76*.

Büyüközkan, G., & Çifçi, G. (2012). A novel hybrid MCDM approach based on fuzzy DEMATEL, fuzzy ANP and fuzzy TOPSIS to evaluate green suppliers. *Expert Systems with Applications*, *39*(3), 3000–3011.

Cheng, Y. H., & Lee, F. (2010). Outsourcing reverse logistics of high-tech manufacturing firms by using a systematic decision-making approach: TFT-LCD sector in Taiwan. *Industrial Marketing Management*, *39*(7), 1111–1119.

de Almeida, A. T. (2007). Multicriteria decision model for outsourcing contracts selection based on utility function and ELECTRE method. *Computers and Operations Research*, *34*(12), 3569–3574.

Efendigil, T., Önüt, S., & Kongar, E. (2008). A holistic approach for selecting a third-party reverse logistics provider in the presence of vagueness. *Computers and Industrial Engineering*, *54*(2), 269–287.

Eydi, A., & Rastgar, S. (2022). A DEA model with dual-role factors and fuzzy data for selecting third-party reverse logistics provider, case study: Hospital waste collection. *Ain Shams Engineering Journal*, *13*(2).

Goodarzi, F., Abdollahzadeh, V., & Zeinalnezhad, M. (2022). An integrated multi-criteria decision-making and multi-objective optimization framework for green supplier evaluation and optimal order allocation under uncertainty. *Decision Analytics Journal*, *4*, 100087.

Govindan, K., Kadziński, M., Ehling, R., & Miebs, G. (2019). Selection of a sustainable third-party reverse logistics provider based on the robustness analysis of an outranking graph kernel conducted with ELECTRE I and SMAA. *Omega (United Kingdom)*, *85*, 1–15.

Guarnieri, P., Sobreiro, V. A., Nagano, M. S., & Marques Serrano, A. L. (2015). The challenge of selecting and evaluating third-party reverse logistics providers in a multicriteria perspective: A Brazilian case. *Journal of Cleaner Production*, *96*, 209–219.

Guggeri, E. M., Ham, C., Silveyra, P., Rossit, D. A., & Piñeyro, P. (2023). Goal programming and multi-criteria methods in remanufacturing and reverse logistics: Systematic literature review and survey. *Computers and Industrial Engineering*, *185*.

Haq, M., Moazzam, M., Khan, A. S., & Ahmed, W. (2023). The impact of reverse logistics process coordination on third party relationship quality: A moderated mediation model for multichannel retailers in the fashion industry. *Journal of Retailing and Consumer Services*, *73*.

Haseli, G., Torkayesh, A. E., Hajiaghaei-Keshteli, M., & Venghaus, S. (2023). Sustainable resilient recycling partner selection for urban waste management: Consolidating perspectives of decision-makers and experts. *Applied Soft Computing*, *137*.

Jauhar, S. K., Amin, S. H., & Zolfagharinia, H. (2021). A proposed method for third-party reverse logistics partner selection and order allocation in the cellphone industry. *Computers and Industrial Engineering*, *162*.

Jayant, A., Gupta, P., Garg, S. K., & Khan, M. (2014). TOPSIS-AHP based approach for selection of reverse logistics service provider: A case study of mobile phone industry. *Procedia Engineering*, *97*, 2147–2156.

Jharkharia, S., & Shankar, R. (2007). Selection of logistics service provider: An analytic network process (ANP) approach. *Omega*, *35*(3), 274–289.

Kafa, N., Hani, Y., & El Mhamedi, A. (2015). An integrated sustainable partner selection approach with closed-loop supply chain network configuration. *IFAC-PapersOnLine*, *28*(3), 1840–1845.

Kannan, G., Pokharel, S., & Kumar, P. S. (2009). A hybrid approach using ISM and fuzzy TOPSIS for the selection of reverse logistics provider. *Resources, Conservation and Recycling*, *54*(1), 28–36.

Keršulienė, V., Kazimieras Zavadskas, E., & Turskis, Z. (2010). Selection of rational dispute resolution method by applying new step-wise weight assessment ratio analysis (SWARA). *Journal of Business Economics and Management*, *11*(2), 243–258.

Krumwiede, D. W., & Sheu, C. (2002). A model for reverse logistics entry by third-party providers. *Omega, 30*.

Li, Y. L., Ying, C. S., Chin, K. S., Yang, H. T., & Xu, J. (2018). Third-party reverse logistics provider selection approach based on hybrid-information MCDM and cumulative prospect theory. *Journal of Cleaner Production*, *195*, 573–584.

Luthra, S., Govindan, K., Kannan, D., Mangla, S. K., & Garg, C. P. (2017a). An integrated framework for sustainable supplier selection and evaluation in supply chains. *Journal of Cleaner Production*, *140*, 1686–1698.

Luthra, S., Govindan, K., Kannan, D., Mangla, S. K., & Garg, C. P. (2017b). An integrated framework for sustainable supplier selection and evaluation in supply chains. *Journal of Cleaner Production*, *140*, 1686–1698.

Min, H., & Ko, H. J. (2008). The dynamic design of a reverse logistics network from the perspective of third-party logistics service providers. *International Journal of Production Economics*, *113*(1), 176–192.

Mishra, A. R., & Rani, P. (2021). Assessment of sustainable third party reverse logistic provider using the single-valued neutrosophic Combined Compromise Solution framework. *Cleaner and Responsible Consumption*, *2*.

Mohammadkhani, A., & Mousavi, S. M. (2022). Assessment of third-party logistics providers by introducing a new stochastic two-phase compromise solution model with last aggregation. *Computers and Industrial Engineering*, *170*.

Mohammadkhani, A., & Mousavi, S. M. (2023). A new last aggregation fuzzy compromise solution approach for evaluating sustainable third-party reverse logistics providers with an application to food industry. *Expert Systems with Applications*, *216*.

Palmgren, R., Pohjalainen, E., Wahlström, M., Hinkka, V., & Ruohomäki, I. (2023). Identifying reverse logistics and related regulations in the circular supply chain of sustainable floor coverings. *Transportation Research Procedia*, *72*, 2370–2376.

Prakash, C., & Barua, M. K. (2016a). A combined MCDM approach for evaluation and selection of third-party reverse logistics partner for Indian electronics industry. *Sustainable Production and Consumption*, *7*, 66–78.

Prakash, C., & Barua, M. K. (2016b). An analysis of integrated robust hybrid model for third-party reverse logistics partner selection under fuzzy environment. *Resources, Conservation and Recycling*, *108*, 63–81.

Ravi, V., Shankar, R., & Tiwari, M. K. (2005). Analyzing alternatives in reverse logistics for end-of-life computers: ANP and balanced scorecard approach. *Computers and Industrial Engineering*, *48*(2), 327–356.

Rostamzadeh, R., Esmaeili, A., Sivilevičius, H., & Nobard, H. B. K. (2020). A fuzzy decision-making approach for evaluation and selection of third party reverse logistics provider using fuzzy aras. *Transport*, *35*(6), 635–657.

Sremac, S., Stević, Ž., Pamučar, D., Arsić, M., & Matić, B. (2018). Evaluation of a third-party logistics (3PL) provider using a rough SWARA-WASPAS model based on a new rough dombi aggregator. *Symmetry*, *10*(8).

Stević, Ž., Pamučar, D., Puška, A., & Chatterjee, P. (2020). Sustainable supplier selection in healthcare industries using a new MCDM method: Measurement of alternatives and ranking according to COmpromise solution (MARCOS). *Computers and Industrial Engineering*, *140*.

Stock, J. (1992). *Reverse logistics*. Council of Logistics Management.

Tasoglu, G., & Ilgin, M. A. (2024). A simulation-based genetic algorithm approach for the simultaneous consideration of reverse logistics network design and disassembly line balancing with sequencing. *Computers and Industrial Engineering*, *187*.

Thibbotuwawa, A., Nanayakkara, P. R., Fernando, W. M., Jayalath, M. M., Perera, H. N., & Nielsen, P. (2023). A Reverse Logistics Network Model for Handling E-commerce Returns. *IFAC-PapersOnLine*, *56*(2), 138–143.

Yang, Q., Yan, W. M., Liu, M., Deveci, M., Garg, H., & Chen, Z. S. (2024). A hybrid generalized TODIM approach for sustainable 3PRLP selection in electronic manufacturing industry. *Advanced Engineering Informatics*, *59*.

Yang, Y., Fu, Y., Lin, J., & Huang, G. Q. (2022). An attitudinal consensus method under uncertainty in 3PRLP selection. *Computers and Industrial Engineering*, *172*.

Yücenur, G. N., & Ipekçi, A. (2021). SWARA/WASPAS methods for a marine current energy plant location selection problem. *Renewable Energy*, *163*, 1287–1298.

Zarbakhshnia, N., Wu, Y., Govindan, K., & Soleimani, H. (2020). A novel hybrid multiple attribute decision-making approach for outsourcing sustainable reverse logistics. *Journal of Cleaner Production*, *242*.

Zavadskas, E. K., Turskis, Z., Antuchevičienė, J., & Zakarevičius, A. (2012). Optimization of weighted aggregated sum product assessment. *Electronics & Electrical Engineering*, *6*(12), 3–6