Prioritizing Third-Party Reverse Logistics Suppliers Based on Agility: A DEMATEL and TOPSIS Approach

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Abstract- Efficient implementation of reverse logistics necessitates the establishment of a well-suited logistics network to facilitate the execution of reverse supply chain activities. As a result, an increasing number of industries are opting to outsource their reverse logistics services, leading to significant reductions in organizational logistics costs. When organizations choose to outsource their reverse logistics activities to third-party suppliers, a fundamental consideration is the presence of an efficient third-party reverse logistics provider (PRLP3) with a compatible logistics network. This research focuses on the supplier selection criterion of supplier agility. Through an extensive literature review, relevant indicators influencing reverse logistics agility were identified. Subsequently, employing the Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique, the interrelationships and impacts of these indicators on each other were determined. Finally, utilizing the Technique for Order of Preference by Similarity to an Ideal Solution (TOPSIS) method, third-party options were prioritized based on their agility. The findings of this study will contribute valuable insights to organizations seeking to optimize their reverse logistics processes by identifying the most agile third-party supplier capable of seamlessly integrating with their logistics network. Such a selection approach can lead to improved reverse logistics performance and cost-efficiency for organizations in diverse industries.

Keywords- Reverse logistics implementation; Third-party suppliers; DEMATEL; TOPSIS; Cost-efficiency.

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1. Introduction

In the contemporary business landscape characterized by ever-shortening product life cycles and a heightened focus on return management, product return policies with rapid response times, and efficient restocking of finished goods have become imperative. As a response to these challenges, the concept of reverse logistics has emerged, addressing the management and investigation of backward flows in the supply chain. However, it appears that this critical aspect has not received adequate attention across various industries in our country. Over the past two decades, numerous companies and industries in developed nations have undertaken extensive research in this domain, acknowledging reverse logistics as a pivotal process within their supply chains. The topic of supply chain, including the significance of reverse logistics, holds significant relevance and is actively discussed within today's industry landscape (Wijewickrama, Chileshe, Rameezdeen, & Ochoa, 2021).

In the context of today's dynamic and rapidly changing markets, the survival and success of supply chains are contingent upon their capability to effectively address environmental challenges. The indispensable tool to accomplish this feat is agility, which empowers supply chains with the capacity to adeptly and proactively respond to the intricacies and uncertainties of the business landscape. By embracing agility, supply chains can enhance their resilience, optimize performance, and position themselves advantageously to navigate the complexities of evolving markets, thereby ensuring sustained competitiveness and viability (Korucuk, Tirkolaee, Aytekin, Karabasevic, & Karamaşa, 2023).

Agility in the supply chain is characterized as the inherent capability of a supply chain to promptly and effectively respond to fluctuations in the market and customer demands (Iranmanesh, et al., 2023). In contemporary advanced economies, the emphasis on reverse logistics processes and supply chain management has emerged as a driving force in generating tangible economic value from goods and services while also accommodating environmental sustainability considerations. Successful reverse logistics implementation hinges on the establishment of an appropriate logistics network to facilitate the seamless execution of reverse supply chain activities. Consequently, a growing number of industries are increasingly inclined to outsource their reverse logistics services, leading to substantial reductions in organizational logistics costs (SAYGILI & KARABACAK, 2022).

In their research titled "Evaluation and Measurement of Agility in the Supply Chain," Patel et. al. (Patel, Samuel, & Sharma, 2017) assessed supply chain agility by focusing on key indicators such as flexibility, responsiveness, speed, and competence. Their study aimed to measure the agility of the supply chain and identify the factors that constrain agility within the same supply chain.

In his scholarly inquiry, GÜNGÖR (GÜNGÖR, 2021) conducted a comprehensive examination on the influence of information technology in relation to supply chain agility and its subsequent impact on company performance. The research findings underscored that information technology significantly enhances the supply chain's adeptness in comprehending market dynamics, enabling it to effectively respond to shifts and alterations. Furthermore, the augmentation of supply chain agility was found to yield favorable outcomes for the studied companies, as evidenced by notable improvements in sales performance, market share expansion, enhanced profitability, and heightened levels of customer satisfaction.

Given the research's contextual background, resource limitations, and the dynamic nature of the industrial environment in our country, the agility of reverse logistics emerges as a robust and competitive instrument for swift and accurate responses to prevailing conditions. Regrettably, despite its paramount significance, reverse logistics agility has not received the attention it deserves in our country. Additionally, the challenge of selecting a suitable supplier for reverse logistics further complicates matters. Therefore, this study was undertaken with the primary objective of investigating reverse logistics agility indicators using a combined approach of group Decision-Making Trial and Evaluation Laboratory (DEMATEL) and group Technique for Order of Preference by Similarity to an Ideal Solution (TOPSIS) in order to identify the optimal supplier. The intended outcome is to empower company and industry managers with essential insights for effective management and profitability enhancement.

2. Research method

This research focuses on the critical supplier selection criterion of supplier agility. Initially, a comprehensive literature review is conducted to identify the key indicators influencing reverse logistics agility. Subsequently, the Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique is employed to ascertain the interrelationships and mutual influences among these identified indicators (Patel, Samuel, & Sharma, 2017). Finally, employing the Technique for Order of Preference by Similarity to an Ideal Solution (TOPSIS) method, the third-party options are prioritized based on their agility, providing valuable insights for making informed and strategic supplier selection decisions (GÜNGÖR, 2021).

2.1. Indicator Selection

In accordance with expert opinions and a comprehensive analysis of the relevant literature, this study employs a systematic approach to select six key indicators for evaluating reverse logistics agility. These indicators, identified as critical in the field, are presented in Table 1 (Donghong, Wenyan, & Qinghong, 2008).

Table 1: Agile logistics evaluation indicators

Indexes	Explanation
Time (C_1)	Exploring Time Factors and Organizational Aspects in Reverse Logistics Implementation: Market Opportunity Identification, System Commencement, Flow, and Activity Organization
Cost (C_2)	Cost of Research and Development and Recycled Product Reproduction
Power (C_3)	Stability of the quality of remanufactured products, customer satisfaction
Flexibility (C_4)	Ability to create remanufacturing system, flexible delivery time
Intra-organizational participation (C_5)	The ability to cooperate and communicate with foreign reverse logistics companies, the sense of awareness of colleagues
Management communication (C_6)	The company's ability to innovate, internal cooperation in the company, employee satisfaction from working in the reverse logistics department

In this study, an integrated approach is applied to assess the relationship between indicators, considering their impact and effectiveness. Initially, the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method is employed to determine the interrelationships among the indicators (Si, You, Liu, & Zhang, 2018). Subsequently, utilizing the Technique for Order of Preference by Similarity to an Ideal Solution (TOPSIS) method, the indicators are ranked based on the data obtained from the DEMATEL analysis (Chakraborty, 2022). This comprehensive methodology ensures a robust evaluation and prioritization of the indicators, providing valuable insights for decision-making processes.

3. Results and discussion

3.1. Determining the effectiveness of indicators with the DEMATEL method

3.1.1. Determining the decision-making team

A team consisting of three decision-makers, including the quality manager, the production manager, and the R&D department manager, was assembled to conduct the ranking of reverse logistics agility indicators. In this research, equal importance and value were assigned to the opinions provided by the participating experts.

3.1.2. Analyzing Interrelationships Among Criteria: A Group DEMATEL Method Approach

The interrelationships among the indicators were assessed using the DEMATEL technique (Si, You, Liu, & Zhang, 2018) to examine the degree of their mutual influence. Initially, decision-makers determined the relationships between the indicators, and subsequently, expert opinions were utilized to derive the total communication matrix (T matrix) which is presented in Table 2.

Table 2: Total communication matrix

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	0.1580	0.3933	0.4244	0.5065	0.2747	0.2557
C_2	0.1990	0.2974	0.5656	0.4787	0.2769	0.3840
C_3	0.3045	0.5440	0.4559	0.4877	0.4052	0.4751
C_4	0.3058	0.4732	0.6080	0.4061	0.3538	0.4912
C_5	0.2865	0.4500	0.6421	0.5206	0.2624	0.3774
C_6	0.1997	0.3532	0.5122	0.3898	0.2700	0.2423

The T matrix enables the determination of both the total influence and individual influence of each criterion. The total intensity of an element, considering both its role as an infiltrator and its vulnerability to influence, is denoted by $C_i + r_i$. A positive value of $r_i - C_i$. indicates that the criterion acts as an infiltrator, while a negative value implies that it is under the influence of other elements or functions as a recipient. The precise positioning of each element within the final hierarchy is determined based on the columns $(C_i + r_i)$ and $(r_i - C_i)$.

Table 3: DEMATEL results

Indexes	Total row (r)	Total columns (C)	C+r	r-C
Time	2.0126	1.4535	3.47	0.56
Cost	2.2016	2.5110	4.71	-0.31
Power	2.6724	3.2082	5.88	0.54
Flexibility	2.6381	2.7371	5.38	-0.1
Intra-organizational participation	2.5390	1.8953	4.43	0.64

Management communication	1.9672	2.2257	4.2	-0.26

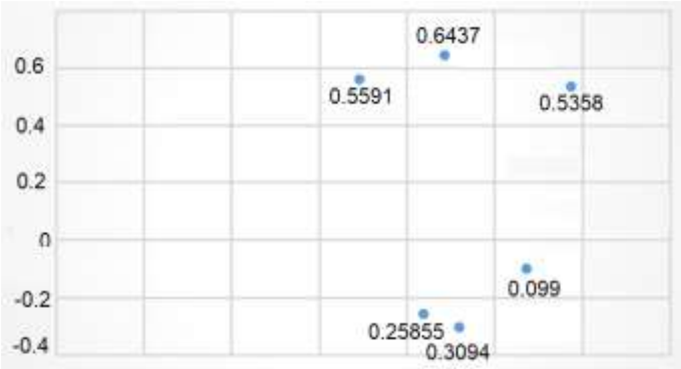

Figure 1: Diagram resulting from group DEMATEL method

In the diagram resulting from the DEMATEL method (Figure 1), it is observed that C3 (power) possesses the highest value of $(C_i + r_i)$ among the indicators, signifying its paramount importance and prioritization for system improvement and advancement. Conversely, C2 exhibits the most negative value with $(r_i - C_i)$, signifying its high effectiveness, necessitating a lower position in the ranking and consequently the lowest priority in management considerations. Notably, factor C5 (participation within the organization) displays the most positive $(r_i - C_i)$ value, indicating its utmost effectiveness and prominence among the criteria under assessment.

3.2. Prioritization and ranking by TOPSIS method

The independent importance of the criteria was initially gathered from experts through the use of linguistic variables (Table 4). Subsequently, these expert opinions were transformed into quantitative values using the corresponding numerical representations in the table.

Table 4: Linguistic variables

1	**3**	**5**	**7**	**9**
Very low	Low	Medium	High	Very high

Table 5: The importance of each criterion from the point of view of experts according to the output of DEMATEL

	DM1	**DM2**	**DM3**
C_1	3	5	1
C_2	5	3	3

C_3	7	9	9
C_4	5	7	7
C_5	3	5	5
C_6	3	1	3

Based on the data provided in Table 5, the average opinions for each criterion were calculated to determine their respective importance (Table 6).

Table 6: The average importance of indexes according to experts' opinion

Criteria	Importance	Criteria	Importance
C_1	3	C_4	6.3
C_2	3.6	C_5	4.3
C_3	8.3	C_6	2.3

3.2.1. Selecting the optimal reverse logistics provider using Group TOPSIS:

In this section, the available options are prioritized through the application of the TOPSIS method, which constitutes a multi-criteria group decision-making technique. To facilitate this process, the linguistic variables from the table below are employed.

Table 7: Linguistic variables

linguistic variables	Point
Very Weak	1
Weak	2
Weak Medium	3
Fair	5
Good Medium	7
Good	8
Very Good	9

Table 8: Performance evaluation by experts

	RLP1	RLP2	RLP3
C_1	7	9	7
C_2	7	8	8
C_3	5	9	9

C_4	9	5	7
C_5	8	7	5
C_6	9	7	8

The performance evaluation of the options concerning the criteria was conducted by computing the average opinion of all experts. The resulting average scores are presented in the table below.

Table 9: Average rating of three 3 PRPL based on six criteria

	RLP1	RLP2	RLP3
C_1	6.3	8	7.6
C_2	7.6	8.3	6.6
C_3	8	7.6	4.3
C_4	6.6	6.6	8.6
C_5	6	5	7
C_6	7.6	7.3	9

The criteria under consideration exhibit both positive and negative aspects. For instance, cost is associated with a negative aspect, indicating that a lower cost is preferable for better performance. Conversely, power is characterized by a positive aspect, implying that higher power corresponds to better performance. To evaluate reverse logistics suppliers, the existing criteria are thoroughly reviewed with respect to their positive and negative aspects, as outlined in Table 10.

Table 10: Criteria in terms of positive and negative aspects

Indexes	Positive aspects	Negative aspects
Time (C_1)		X
Cost (C_2)		X
Power (C_3)	X	
Flexibility (C_4)	X	
Intra-organizational participation (C_5)	X	
Management communication (C_6)	X	

First step: formation of the decision matrix

The first step involves the formation of the decision matrix, which entails creating a matrix comprising a series of criteria and options. In this matrix, the criteria are positioned in the columns, and the options are placed in the rows, with each cell representing the evaluation of each option concerning each criterion. Subsequently, the decision matrix is completed with the incorporation of expert opinions. This process is accomplished using either the Likert scale, ordinal scale, or real-numbered scale, providing a comprehensive representation of the expert assessments pertaining to the options and criteria.

Table 11: Formation of the decision matrix

	C_1	C_2	C_3	C_4	C_5	C_6
RLP3	6.3	7.6	8	6.6	6	7.6
RLP2	8	8.3	7.6	6.6	5	7.3
RLP1	7.6	6.6	4.3	8.6	7	9

Second and third step: determining the weighted scale-free matrix

The second and third steps involve determining the weighted scale-free matrix. This is accomplished by normalizing the matrix presented in Table 11. Subsequently, utilizing the normalized matrix from the preceding step, the weight of the criteria obtained through other methods is multiplied with the normalized matrix to obtain the weighted matrix.

Table 12: The weight of indicators according to the opinion of experts (W)

	C_1	C_2	C_3	C_4	C_5	C_6
Weight (W)	3	3.6	8.3	6.3	4.3	2.3

Table 13: Weighted scaleless matrix

	C_1	C_2	C_3	C_4	C_5	C_6
RLP3	0.117	0.158	0.473	0.258	0.232	0.089
RLP2	0.147	0.172	0.448	0.258	0.193	0.087
RLP1	0.141	0.136	0.249	0.333	0.270	0.105

Step 4: Finding positive and negative ideals

In Step 4, the process entails calculating a positive ideal (+S) and a negative ideal (-S) for each index presented in Table 10.

Table 14: Positive and negative ideals

	C_1	C_2	C_3	C_4	C_5	C_6
Positive ideal (+S)	0.117	0.136	0.473	0.333	0.270	0.105
Negative ideal (-S)	0.147	0.172	0.249	0.258	0.193	0.087

The fifth step: calculating the distance from the positive ideal and the negative ideal

In the fifth step, the calculation involves determining the distance of each option from both its positive ideal and negative ideal.

Table 15: Distance from positive ideal and negative ideal

i	d_i^+	d_i^-
1	0.0883	0.2335
2	0.1224	0.1990
3	0.2252	0.1149

The sixth step: calculating the similarity index and ranking the options

In the sixth step, the calculation entails determining the similarity index, which indicates the score of each option. A higher similarity index closer to the value of one suggests the superiority of the corresponding option. Subsequently, the options are ranked based on their similarity indices.

Table 16: Similarity index

Cl1	0.7256
Cl2	0.6191
Cl3	0.4527

Based on the results presented in Table 16, it is evident that the ranking order of the options is as follows: Cl1 holds the top position, followed by Cl2, and finally Cl3. Consequently, RLP1 demonstrates the best performance among the options, RLP2 secures the second position, while RLP3 holds the lowermost rank.

4. Conclusion

The outsourcing of reverse logistics activities by company managers entails the selection of the most agile supplier among potential firms. To achieve this objective, we employed the DEMATEL technique, considering criteria such as time, cost, power, flexibility, intra-organizational participation, and management communication. The results obtained from the DEMATEL technique were subsequently utilized in conjunction with the TOPSIS technique to prioritize the suppliers. Notably, the first, second, and third suppliers received the highest points for reverse logistics outsourcing. Moreover, the DEMATEL technique highlighted the prominence of the strength index as a vital factor, emphasizing its priority for system improvement and development. Given the significance of the topic of reverse logistics agility and its limited attention in current research, it is recommended that future studies explore related aspects such as agile distribution, agile production, and obstacles in green supply chains using alternative methodologies such as ISM AHP and VICOR.

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