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Hybrid Approach: The Hybrid Decision-Making Method for Reverse Logistics Provider Selection

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ABSTRACT

Due to governmental laws and increased environmental consciousness among people aimed at reducing waste, the rise in the return of old goods has gained relevance as a logistics problem. Industry-specific infrastructure, monitoring information systems, and return-handling equipment are often required. Since they specialize in reverse logistics, third-party providers (3PRLPs) are currently in high demand across a wide range of businesses.

The Hybrid decision-making method is a novel and methodical approach to decision-making that aids people or organizations in assessing a group of possibilities in light of several factors. Therefore, in this study, the third-party providers (3PRLPs) who specialize in reverse logistics were ranked utilizing Hybrid decision-making method methodologies.

This study offers a novel method for identifying the best 3PRLP (third-party reverse logistics provider), using a multi-criteria group decision-making (MCGDM) model within the Hybrid decision-making method framework. The study digs into the relationships between the factors considered during this selection process, which finally results in the selection of the best 3PRLP out of a possible pool of six options. The Hybrid decision-making method technique is used in this research to prioritize orders based on how closely they resemble the ideal solution. The practical utility of the model is demonstrated through a case study focused on the battery manufacturing industry in India.

The 3PRLP3 got the first rank and the 3PRLP2 got the last rank. 3PRLP1 is second rank, 3PRLP5 is third rank, 3PRLP6 is fourth rank and 3PRLP4 is fifth rank.

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Introduction

Reverse logistics is the process that involves the movement of materials in the opposite direction, going from the customer back to the supplier or being managed using different approaches. The main objectives of reverse logistics are to either minimize overall costs related to the reverse logistics process or to maximize the value obtained from returned commodities. This practice is widespread across diverse industries such as steel, aircraft, computers, photocopiers, automobiles, plastics, carpets, paper, chemicals, appliances, and medical products. The growing fascination with product reutilization arises not solely due to heightened environmental consciousness and legal regulations, but also because involvement in reutilization endeavors has demonstrated profitability across numerous sectors. To effectively establish reverse logistics, it's essential to create a suitable logistics network designed for executing activities within the reverse supply chain. This includes tasks such as gathering, assessing, warehousing, disassembling, recycling, remanufacturing, restoring, repairing, and disposing of items. A primary challenge linked with the execution of reverse logistics operations is the level of uncertainty regarding the timing and volume of products involved. Reverse logistics can occur either within the existing network or through dedicated providers specializing in reverse logistics services. Outsourcing reverse logistics allows companies to concentrate on their primary strengths.

• Outsourcing reverse logistics can lead to cost reduction as third-party providers leverage economies of scale, unavailable to individual companies.

• By outsourcing reverse logistics, companies can decrease their asset holdings and allocate the freed capital for more productive purposes.

• Reverse logistics outsourcing enhances cycle time and delivery performance, ultimately boosting customer satisfaction in post-sales service.

Selecting a reverse logistics provider is a intricate process that encompasses numerous factors, various decision models, collective decision-making, and different levels of uncertainty. Determining the best approach to assess and pick a third-party reverse logistics provider (3PRLP) presents challenges, prompting companies to utilize diverse methods to tackle this challenge. As a result, the central concern in the selection process is to establish a suitable approach for identifying the most appropriate reverse logistics provider. However, this selection process must initiate with well-defined criteria and a clear understanding of how these criteria interact. This paper focuses on developing a decision-making tool for the selection of a 3PRLP, aiming to address this critical aspect of the process.

Reverse logistics third-party service providers (3PRLPs) are essential to contemporary supply chain management. For businesses looking to maximize resource utilization, reduce costs, adhere to regulations, and improve customer satisfaction, the ability of reverse logistics providers to manage the backward movement of resources and products has become increasingly important. Reverse logistics encompasses the handling of product returns, recycling, and remanufacturing, refurbishing, and proper disposal. Although many companies concentrate on their core strengths, they frequently lack the specialized infrastructure and expertise required to effectively manage these activities within the reverse supply chain. This is where 3PRLPs come into play, offering a range of benefits:

1. **Expertise**: 3PRLPs bring valuable experience and domain knowledge in managing the complexities of reverse logistics. They are well-versed in handling returned products, evaluating their condition, and determining the appropriate disposition, whether it's recycling, repair, or resale.

2. **Cost Efficiency**: 3PRLPs can leverage economies of scale, making reverse logistics more cost-effective for companies. These providers often have established networks, facilities, and processes, leading to reduced handling and processing costs.

3. **Resource Optimization**: By outsourcing reverse logistics to specialized providers, companies can optimize their asset base. They can reduce the need for maintaining excess inventory to handle potential returns, allowing them to deploy released capital for other productive purposes.

4. **Risk Mitigation**: 3PRLPs can help companies navigate regulatory compliance and environmental standards, reducing the risk of legal issues or reputational damage due to mishandled returns or improper disposal.

5. Improved Customer Satisfaction: Efficient reverse logistics positively impact after-sales service. 3PRLPs can streamline return processes, reducing cycle times, and ensuring the timely handling of returned products. This, in turn, enhances customer satisfaction and loyalty. Selecting the right 3PRLP is a critical decision for companies seeking to outsource reverse logistics. The selection process involves various factors, including the provider's capabilities, industry expertise, geographical coverage, track record, and cost structure. Companies must carefully assess these criteria and understand how they interact to ensure a successful partnership with a 3PRLP.Collaborating with a 3PRLP not only enhances operational efficiency but also contributes to sustainability goals by facilitating responsible disposal and recycling practices. As businesses increasingly focus on environmental responsibility and operational excellence, the role of third-party providers specializing in reverse logistics will continue to grow, shaping the future of supply chain management.

2. MATERIALS AND METHODS

Alternative parameters: Here alternative parameters taken as 3PRLP1, 3PRLP2, 3PRLP3, 3PRLP4, 3PRLP5 and 3PRLP6. 3PRLP stands for "Third-Party Reverse Logistics Provider." It refers to businesses or service providers who focus on providing all-inclusive solutions for controlling the supply chain's reverse flow of materials, goods, and assets. These providers handle tasks such as product returns, recycling, remanufacturing, refurbishing, repair, and proper disposal. 3PRLPs play a crucial role in helping organizations optimize their reverse logistics processes, reduce costs, ensure regulatory compliance, and enhance overall efficiency. Key functions and benefits of 3PRLPs include:

1. **Expertise**: 3PRLPs possess specialized knowledge and experience in reverse logistics, enabling them to efficiently manage the complexities involved in handling returned items and products.

2. **Cost Efficiency**: By leveraging economies of scale, 3PRLPs can offer cost-effective solutions, often reducing the overall expenses associated with reverse logistics activities for their clients.

3. **Resource Optimization**: Outsourcing reverse logistics to a 3PRLP allows companies to optimize their asset utilization, minimize excess inventory, and release capital for other productive purposes.

4. **Risk Mitigation**: 3PRLPs help companies navigate compliance with environmental regulations, reducing the risk of

legal issues or reputational harm due to improper handling or disposal of products.

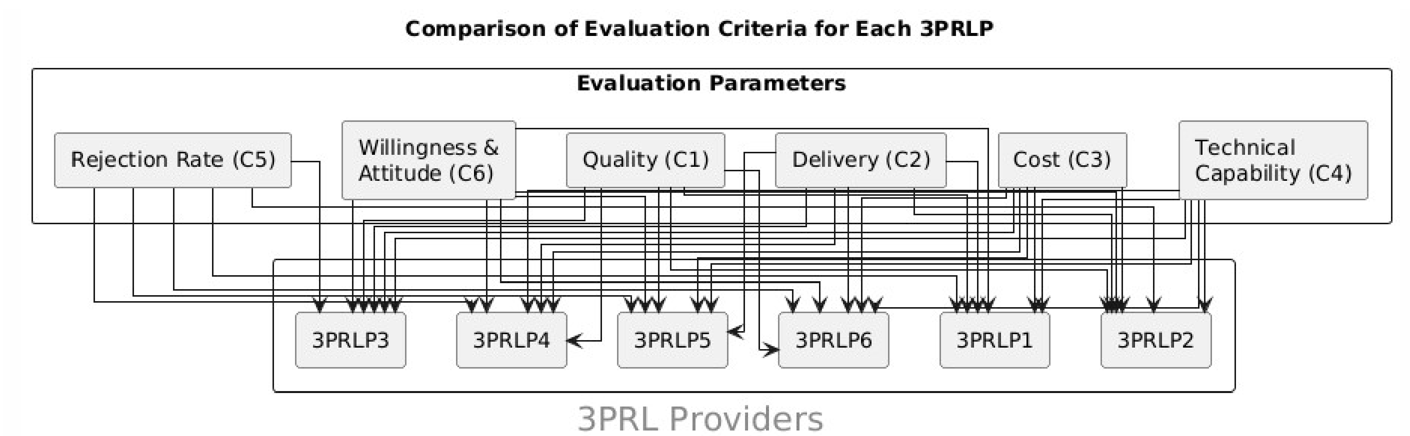
5. **Customer Satisfaction**: Efficient reverse logistics positively impact customer satisfaction, as 3PRLPs can streamline return processes, reduce cycle times, and ensure timely handling of returned items. Selecting the right 3PRLP is a critical decision for companies looking to improve their reverse logistics operations. Companies typically consider factors such as the provider's capabilities, industry expertise, geographic coverage, track record, and cost structure when making this choice. As companies focus on sustainability, efficient resource management, and streamlined supply chain processes, the role of third-party reverse logistics providers becomes increasingly important. They help organizations achieve their business objectives while adhering to environmental and regulatory standards, ultimately contributing to a more responsible and efficient supply chain management ecosystem.

Here alternative parameters taken as 3PRLP1, 3PRLP2, 3PRLP3, 3PRLP4, 3PRLP5 and 3PRLP6.

Evaluation parameters: Quality, Delivery, Reverse logistics Cost, Rejection rate, Technical Capability, Inability to meet future requirement and Willingness and Attitude.

Quality: A critical aspect that can have a big impact on an organization's entire supply chain performance, customer happiness, and sustainability efforts is the calibre of a Third-Party Reverse Logistics Provider (3PRLP).Assessing the quality of a 3PRLP involves considering several key aspects: Expertise and Experience: A high-quality 3PRLP should have a proven track record in handling reverse logistics activities. Their experience in managing returned products, refurbishing, remanufacturing, and responsible disposal is essential. Industry Knowledge understands the specific industry or sector in which the 3PRLP operates is crucial. Different industries have unique requirements and regulations for reverse logistics, and a knowledgeable provider is better equipped to meet that needs. Efficiency: A quality 3PRLP should offer efficient and streamlined processes for managing returned items. This includes quick cycle times, timely processing, and effective handling of returned products. Environmental Responsibility is Sustainable practices are becoming increasingly important. A high-quality 3PRLP should prioritize environmentally responsible handling of returns, recycling, and disposal, aligning with the organization's sustainability goals. Network and Coverage is An effective 3PRLP should have a well-established network, including collection points, processing facilities, and a wide coverage area.

Delivery: The successful delivery of services by a Third-Party Reverse Logistics Provider (3PRLP) entails the proficient execution of reverse logistics operations and the offer of value-added solutions to the organization that has delegated these tasks. The effectiveness of this delivery relies on several critical factors that Efficiency: The 3PRLP should display efficiency in handling the reverse movement of materials, products, and assets. This includes timely handling of returned items, quick cycle times for refurbishing or remanufacturing, and ensuring that the overall process does not create unnecessary delays. Accuracy: Accurate tracking and handling of returned products are essential. The 3PRLP should maintain accurate records, ensuring that each item is properly documented, assessed, and processed according to the established criteria. Communication: Effective communication between the organization and the 3PRLP is vital. The provider should keep the organization informed about the status of returns, processing, and any issues that may arise during the reverse logistics process. Sustainability: If the organization has sustainability goals, the 3PRLP should deliver services in an environmentally responsible manner. This includes proper disposal or recycling of items, adhering to relevant environmental regulations, and promoting sustainable practices.



Reverse logistics costs: It refer to the expenses incurred by a company when managing the reverse flow of products, materials, or assets within the supply chain. These costs are associated with various activities involved in handling returned items, recycling, remanufacturing, refurbishing, repair, and disposal. Evaluating and managing reverse logistics costs is crucial for organizations seeking to optimize their processes, enhance profitability, and meet sustainability goals.

Rejection rate: The rejection rate is a vital metric employed to evaluate the quality and effectiveness of a manufacturing or production process. It measures the percentage of products or items that do not meet the specified criteria and are rejected during inspection, quality control, or testing. A high rejection rate indicates a potential issue in the production process, leading to inefficiencies, increased costs, and potential customer dissatisfaction.

Technical capability: It refers to an individual's or organization's ability to effectively understand, apply, and utilize technical knowledge, skills, and resources to achieve specific goals, tasks, or objectives. It encompasses the expertise, proficiency, and capacity to work with technology, engineering principles, scientific methods, and specialized tools or equipment.

Inability to meet future requirement: The supply chain and overall operational performance of an organization may suffer significantly if a Third-Party Reverse Logistics Provider (3PRLP) is unable to meet future requirements. When a 3PRLP falls short in meeting future needs, several challenges may arise: Inefficiencies: An inadequate 3PRLP might struggle to handle increasing return volumes, process items in a timely manner, or adapt to changing requirements. This can lead to inefficiencies in the reverse logistics process, resulting in delays, increased costs, and decreased overall supply chain efficiency. Quality Issues: If a 3PRLP can't maintain or improve the quality of returned products, it can negatively impact customer satisfaction. Items that are not properly refurbished or remanufactured may lead to dissatisfied customers or potential product recalls, harming the organization's reputation.

Willingness and Attitude: The willingness and attitude of a Third-Party Reverse Logistics Provider (3PRLP) are critical factors that can significantly influence the success of the partnership and the overall effectiveness of reverse logistics operations. An affirmative and proactive attitude, coupled with a strong willingness to understand and align with the organization's goals and values, are essential for a positive and productive working relationship.

HYBRID DECISION-MAKING METHOD: The Hybrid decision-making method is a decision-making technique designed to help individuals or organizations evaluate a set of alternatives based on multiple criteria. It provides a structured approach for making choices when there are complex and often conflicting factors to consider. The method was introduced by Iranian scholar Reza Mohammadyari Hybrid decision-making method in the late 1990s and has been applied in various fields, such as business, engineering, project management, and environmental assessments.

The Hybrid decision-making method involves several key steps:

1. **Criteria Identification**: Precisely outline the criteria or factors that hold relevance in the decision-making process. These criteria encapsulate various facets that must be taken into account when assessing the available alternatives.

2. **Criterion Weighting**: Allocate weights to individual criteria to signify their relative importance during the decision-making process. This action aids in conveying the significance of each criterion within the ultimate decision.

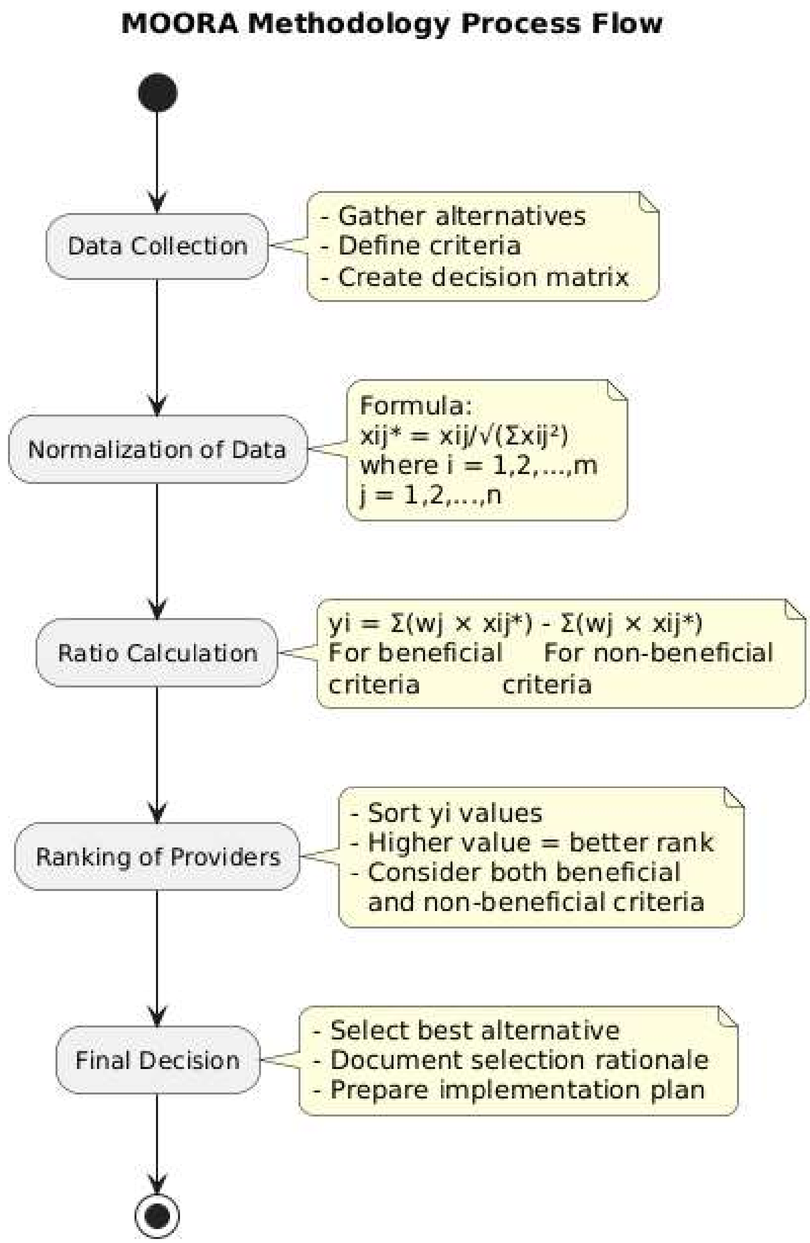
3. **Rating the Alternatives**: Evaluate each alternative against the established criteria. This involves assigning scores or ratings to each alternative based on how well it performs on each criterion. The scoring can be subjective or based on available data.

4. **Normalization**: Normalize the scores to ensure they are on a consistent scale. This step makes it easier to compare the alternatives and eliminates any bias caused by differences in the original scales.

5. **Calculating the Hybrid decision-making method Index**: Multiply the normalized score of each criterion by its weight then add these values to determine the Hybrid decision-making method Index for each alternative. The alternatives are ranked using this index.

6. **Ranking Alternatives**: Arrange the alternatives in order of their Hybrid decision-making method Index values. The alternative possessing the highest Hybrid decision-making method Index is regarded as the most favorable selection in accordance with the designated criteria and their assigned weights.

The Hybrid decision-making method is particularly useful when there are multiple criteria with varying levels of importance, and it provides a structured way to compare alternatives based on these criteria. It helps decision-makers make more informed and rational decisions by considering all relevant factors and weighing them appropriately. The Hybrid decision-making method has found applications in various real-world scenarios, such as investment decisions, project selection, supplier evaluation, environmental impact assessments, and other situations where a comprehensive evaluation of alternatives are necessary.



STEP 1: Design of decision matrix and weight matrix

For a MCDM problem consisting of m alternatives and n criteria, let $D = x_{ij}$ be a decision matrix, where $x_{ij} \in \mathbb{R}$

$$\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

The weight vector may be expressed as.

$w_j = [w_1 \dots w_n]$, where $\sum_{j=1}^{n} (w_1 \dots w_n) = 1$

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}$$

$where\ i \in [1, m] and\ j \in [1, n]$

STEP 3: Weighted normalized decision matrix

$W_{nij} = w_j n_{ij}$

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STEP 4: Calculation of Performance value

The performance value of each alternative is calculated as

$$y_i = \sum_{j=1}^{g} N_{ij} - \sum_{j=g+1}^{n} N_{ij}$$

Where g is the number of benefit criteria and (n - g) is the cost criteria.

The alternatives are ranked from best to worst based on higher to lower y_i values.

3. RESULT AND DISCUSSION

Table1. Decision-maker's rating value

Decision-maker's rating value							
	Quality	Delivery	Reverse logistics Cost	Rejection rate	Technical Capability	Inability to meet future requirement	Willingness and Attitude
3PRLP1	5.4	7.933	7.9332	7.5332	1.3334	8.6664	5.8
3PRLP2	0.9334	0.933	6.3666	6.5666	7.9332	8.2998	3.0333
3PRLP3	3.0333	7.933	8.2998	1.7	8.2998	4.6	5.8
3PRLP4	8.2998	4.6	1.3334	9.0664	8.499	8.6664	1.5
3PRLP5	9.033	4.2	4.6	6.2	8.0998	8.4998	1.3334
3PRLP6	1.7	3.067	5.8	0.7667	6.5666	1.3334	2.6667

The provided Table 1 displays the assessments made by the decision-maker for various criteria in the selection of Third-Party Reverse Logistics Providers (3PRLPs). Each 3PRLP is evaluated across the following criteria: Quality, Delivery, Reverse logistics Cost, Rejection rate, Technical Capability, Inability to meet future requirement, and Willingness and Attitude. The ratings assigned fall on a scale from 0 to 10, where higher values signify superior performance in each respective criterion.

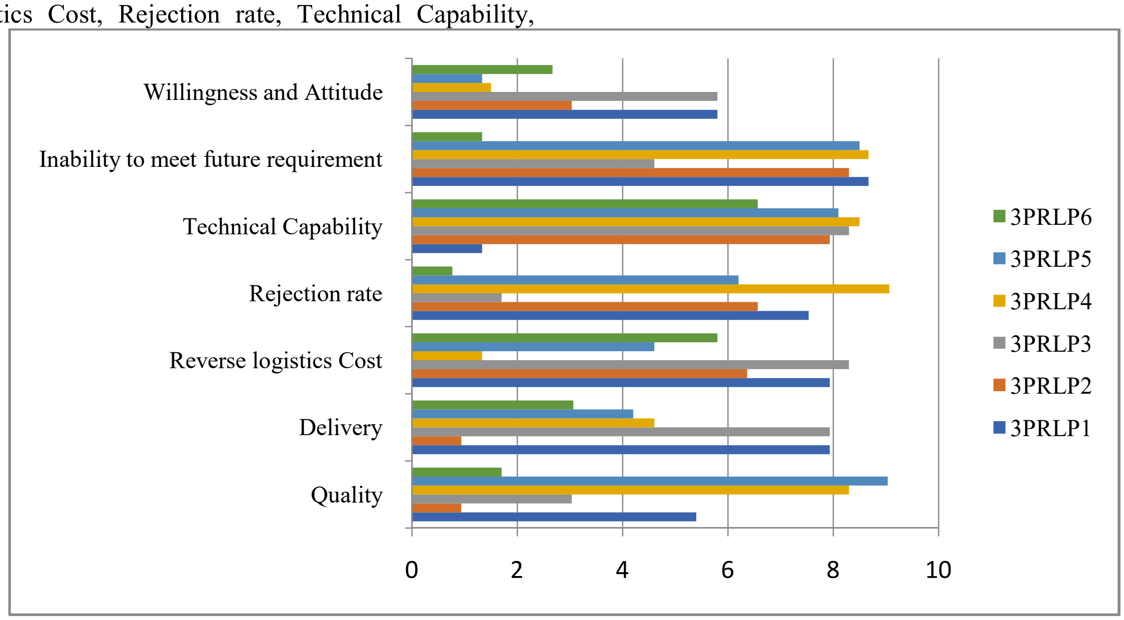

Figure 1. Decision-makers rating value

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Table 2. Square root of matrix

Square root of matrix						
29.16	62.9356622	62.93566	56.7491	1.777956	75.10649	33.64
0.871236	0.87123556	40.5336	43.12024	62.93566	68.88668	9.200909
9.200909	62.9356622	68.88668	2.89	68.88668	21.16	33.64
68.88668	21.16	1.777956	82.19961	72.233	75.10649	2.25
81.59509	17.64	21.16	38.44	65.60676	72.2466	1.777956
2.89	9.40464889	33.64	0.587829	43.12024	1.777956	7.111289
192.6039	174.947209	228.9339	223.9868	314.5603	314.2842	87.62015

Table 2 presents the square root of a matrix involving the assessment of Third-Party Reverse Logistics Providers (3PRLPs). Each 3PRLP is evaluated across the same set of criteria: Quality, Delivery, Reverse logistics Cost, Rejection rate, Technical Capability, Inability to meet future requirement, and Willingness and Attitude.

Table 3. Normalized Data

Normalized Data							
	Quality	Delivery	Reverse logistics Cost	Rejection rate	Technical Capability	Inability to meet future requirement	Willingness and Attitude
3PRLP1	0.389	0.6	0.524	0.503	0.075	0.489	0.62
3PRLP2	0.067	0.071	0.421	0.439	0.447	0.468	0.324
3PRLP3	0.219	0.6	0.549	0.114	0.468	0.259	0.62
3PRLP4	0.598	0.348	0.088	0.606	0.479	0.489	0.16
3PRLP5	0.651	0.318	0.304	0.414	0.457	0.479	0.142
3PRLP6	0.122	0.232	0.383	0.051	0.37	0.075	0.285

According to the following criteria: Quality, Delivery, Reverse Logistics Cost, Rejection Rate, Technical Capability, Inability to Meet Future Requirements, Willingness and Attitude, Figure 2 shows the normalized data for each Third-Party Reverse Logistics Provider (3PRLP). To make it easier to compare the relative performance of each 3PRLP across the criteria, the data has been rescaled to fall within a range of 0 to 1. As an illustration, the values for 3PRLP1 are as follows: Quality: 0.389; Delivery: 0.6; Cost of reverse logistics: 0.524; Rejection rate: 0.503; Technical Capability: 0.075; Inability to satisfy future requirements: 0.489; Willingness and Attitude: 0.62.

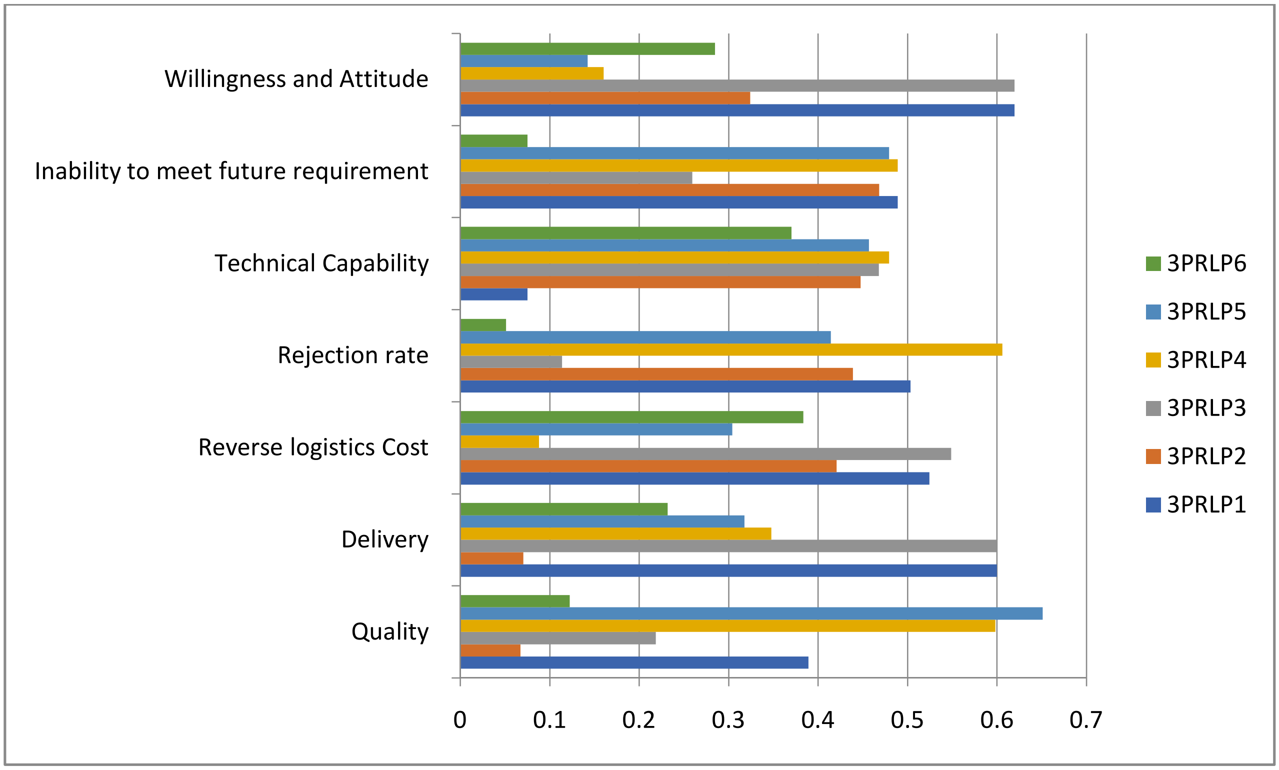

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Table 4. The relative importance of each criterion during the decision-making process is established by these

weights						
0.14	0.14	0.14	0.14	0.14	0.14	0.14
0.14	0.14	0.14	0.14	0.14	0.14	0.14
0.14	0.14	0.14	0.14	0.14	0.14	0.14
0.14	0.14	0.14	0.14	0.14	0.14	0.14
0.14	0.14	0.14	0.14	0.14	0.14	0.14
0.14	0.14	0.14	0.14	0.14	0.14	0.14

The weights assigned for the evaluation of Third-Party Reverse Logistics Providers (3PRLPs) are shown in Table 4. The relative importance of each criterion during the decision-making process is established by these weights. Each of the seven criteria—Quality, Delivery, Reverse Logistics Cost, Rejection Rate, Technical Capability, Inability to Meet Future Requirements, and Willingness and Attitude—will receive the same amount of weight (0.14 or 14%) from the decision-maker. This equal weighting strategy makes the assumption that all of these factors will be given weight equal to one another. For each Third-Party Reverse Logistics Provider (3PRLP), the Hybrid decision-making method Index can be calculated using the previously provided normalized data and these weights.

Table 5. Weighted normalized decision matrix

Weighted Normalized Decision Matrix							
	Quality	Delivery	Reverse logistics Cost	Rejection rate	Technical Capability	Inability to meet future requirement	Willingness and Attitude
3PRLP1	0.054	0.084	0.073	0.07	0.011	0.068	0.087
3PRLP2	0.009	0.01	0.059	0.061	0.063	0.066	0.045
3PRLP3	0.031	0.084	0.077	0.016	0.066	0.036	0.087
3PRLP4	0.084	0.049	0.012	0.085	0.067	0.068	0.022
3PRLP5	0.091	0.044	0.043	0.058	0.064	0.067	0.02
3PRLP6	0.017	0.032	0.054	0.007	0.052	0.011	0.04

The weighted and normalized decision matrix for evaluating Third-Party Reverse Logistics Providers (3PRLPs) using the given criteria and weights is shown in table 5. The weighted normalized decision matrix provides a thorough assessment of each 3PRLP by combining the normalized performance values for each criterion with the set weights. Taking into account the relative relevance of the criteria, this matrix makes it easier to compare providers based on their total performance. This data can be used to rank the 3PRLPs and help the decision-maker choose the best third-party reverse logistics provider by taking into account the mentioned factors and their related weights.

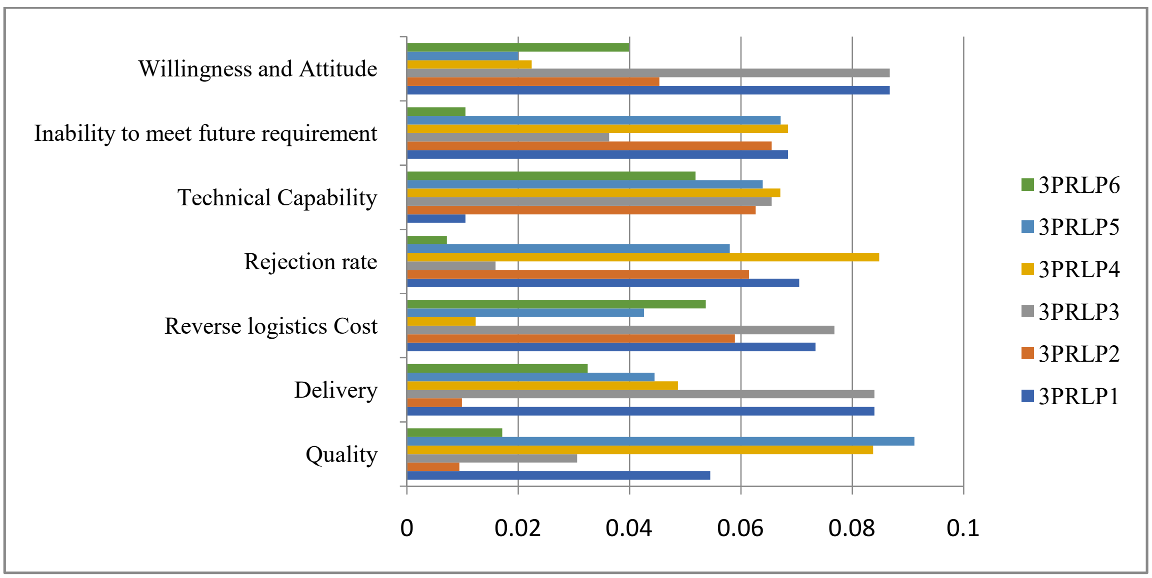

Figure 3. Weighted Normalized Decision Matrix

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Table 6. Assessment value

	Assessment value
3PRLP1	0.141379328
3PRLP2	0.016777718
3PRLP3	0.175462861
3PRLP4	0.05994247
3PRLP5	0.12014368
3PRLP6	0.096103203

The derived evaluation values for each Third-Party Reverse Logistics Provider (3PRLP) using the weighted normalized decision matrix are shown in table 6. When the defined criteria, their normalized values, and the allotted weights are taken into account, these assessment values show how each 3PRLP performed overall. The weighted normalized values for each criterion specific to each 3PRLP are added to obtain the assessment values. This makes it possible to rank providers according to their overall effectiveness when compared to the predetermined criteria and the weights assigned to each.

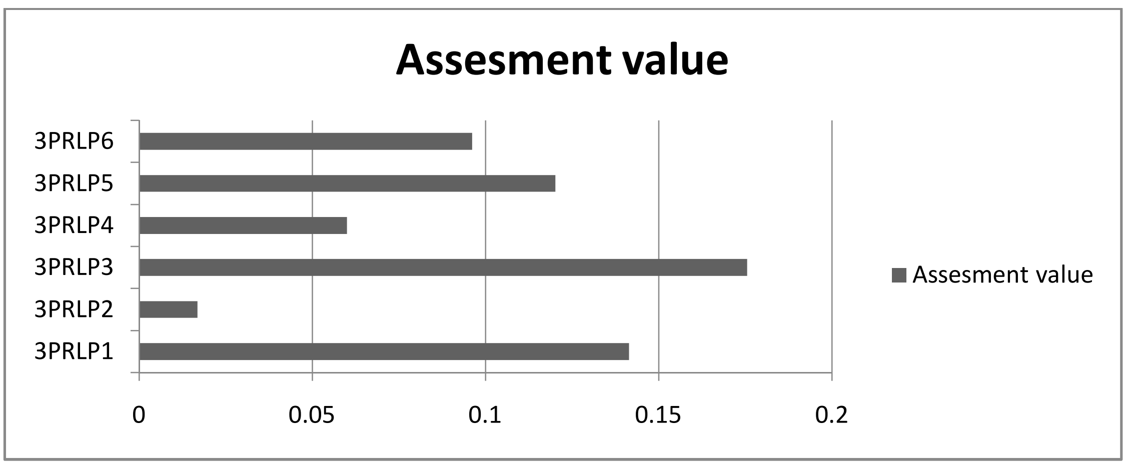

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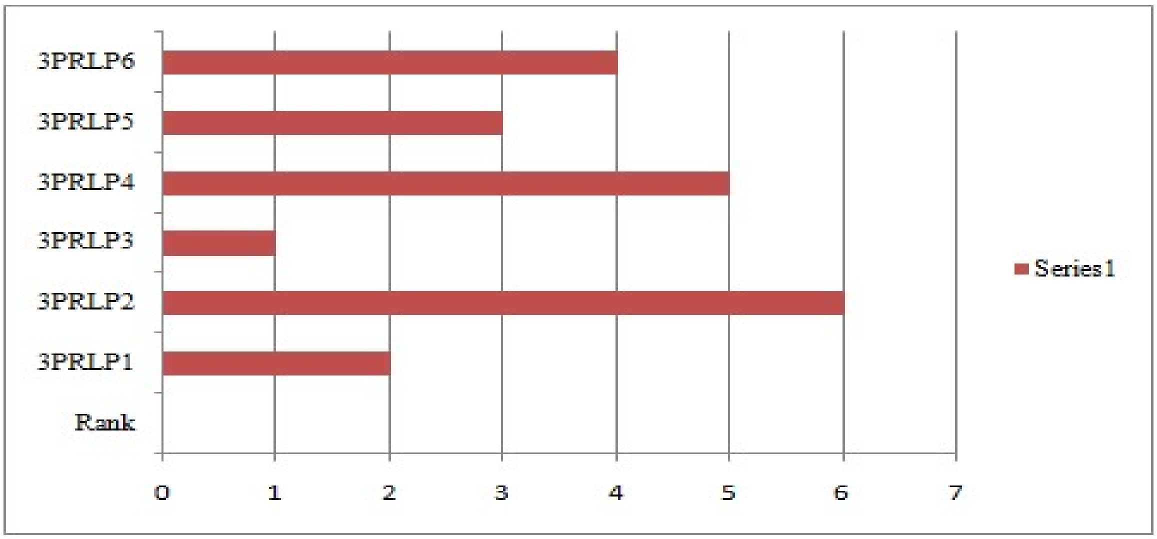
Table 7. Rank

Rank	
3PRLP1	2

3PRLP2	6
3PRLP3	1
3PRLP4	5
3PRLP5	3
3PRLP6	4

Table 7 displays the ranking of the Third-Party Reverse Logistics Providers (3PRLPs). In this ranking, 3PRLP3 has secured the top rank, while 3PRLP2 has been assigned the lowest rank. 3PRLP1 occupies the second rank, followed by 3PRLP5 in the third rank, 3PRLP6 in the fourth rank, and 3PRLP4 in the fifth rank. This ranking is based on the evaluation of the providers using the specified criteria and their respective weights.



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4. CONCLUSION

A well-designed and effectively controlled reverse logistics system can provide a significant opportunity for companies to boost profits and satisfy customers. Many businesses are opting to outsource their reverse logistics tasks to streamline their core operations and achieve cost-efficiency. Consequently, the selection of the appropriate reverse logistics provider becomes a critical decision within the broader supply chain system. The analysis underscores the importance of strong Engineering/Technical Capability for transport companies (referred to as 3PRLP) in effective reverse logistics operations, leading to cost reduction and improved preparedness for future demands. When dealing with situations where performance values can't be precisely quantified, the use of linguistic variables proves to be highly beneficial. This paper introduces the Hybrid Decision-Making Method as a comprehensive approach for resolving such complex scenarios. This method not only enables the establishment of a ranking order among potential reverse logistics providers (3PRLP) but also allows for the assessment of their overall capabilities. Crucially, this proposed method offers more objective information for the selection and evaluation of 3PRLPs in the context of reverse logistics. In this ranking, 3PRLP3 has secured the top rank, while 3PRLP2 has been assigned the lowest rank. 3PRLP1 occupies the second rank, followed by 3PRLP5 in the third rank, 3PRLP6 in the fourth rank, and 3PRLP4 in the fifth rank. This ranking is based on the evaluation of the providers using the specified criteria and their respective weights.

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