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Prioritizing the Solutions to Reverse Logistics Barriers for the E-Commerce Industry in Pakistan Based on a Fuzzy AHP-TOPSIS Approach

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Abstract: In the past few years, reverse logistics practices have successfully managed to gain more attention in various industries and among supply chain researchers and experts. This is due to globalization, environmental concerns, and customer requirements, which have asserted industries' concerns for reverse logistics management. In E-commerce, the process of reverse logistics originates with parcel refusal, undelivered goods, and exchanges. In developing countries like Pakistan, the adoption and implications of reverse logistics are still at their early stages. E-commerce companies give more attention to forward logistics and ignore logistics' upstream flow in the supply chain. This study aims to identify, as well as list, the barriers and obtain the solutions to those identified barriers, and rank the barriers and their solutions so that logisticians and experts can solve them as per their priority. From the extensive literature review and experts' opinions, we have found 14 barriers in implementing effective reverse logistics. Eight solutions to those barriers were also found from the literature review. This paper proposed the methodology based on fuzzy analytical hierarchy process (fuzzy-AHP), which used to get the weights of each barrier by using pairwise comparison, and fuzzy technique for order performance by similarity to ideal solution (fuzzy-TOPSIS) method, which was adopted for the final ranking of solutions to reverse logistics. The case of the Pakistan E-commerce industry is used in the proposed method.

Keywords: reverse logistics; AHP method; TOPSIS method; reverse logistics barriers; E-commerce supply chain

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1. Introduction

Reverse logistics have received great significance over the last few years. This is evidently due to environmental concerns, global competition, legislation, and corporate social responsibility. The shift of business from traditional to online business has increased the ease for customers to shop. In this digital world, with millions of online businesses, it is pretty easy to purchase anything from all over the world with just one click. Purchasing products online allows customers to buy a variety of products, and if it does not meet their requirements, it can be returned to the seller as simply as how it was bought. Undoubtedly, returns in E-commerce businesses can make a difference between the success and failure of a company, and it directly affects the company's reputation and buyer experience [1]. The E-commerce sites allow customers to make product comparisons based on different attributes such as product specifications, prices, performance, and quality. Due to various choices in E-commerce, it becomes difficult for customers to make an appropriate choice [2]. E-commerce is one of the fastest-growing sectors of the economy. Due to many businesses entering into this business line, this increases the market competition. Companies strive to improve their service quality and customer experience by offering them quality products at affordable prices. E-commerce is a web-based business in which internet data is used to understand the customer's needs and then try to meet their expectations by providing them personalized products [3]. The Council of Logistics Management has defined reverse logistics as "The process of planning, implementing and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for recapturing value or proper disposal" [4]. However, the process of reverse logistics in E-commerce originates when a consumer returns the product. Reverse logistics is the backflow of goods in the supply chain, starting from the customer and moving back to the seller or manufacturer. Moreover, the graphical depiction of the reverse logistics process in E-commerce is presented in Figure 1.

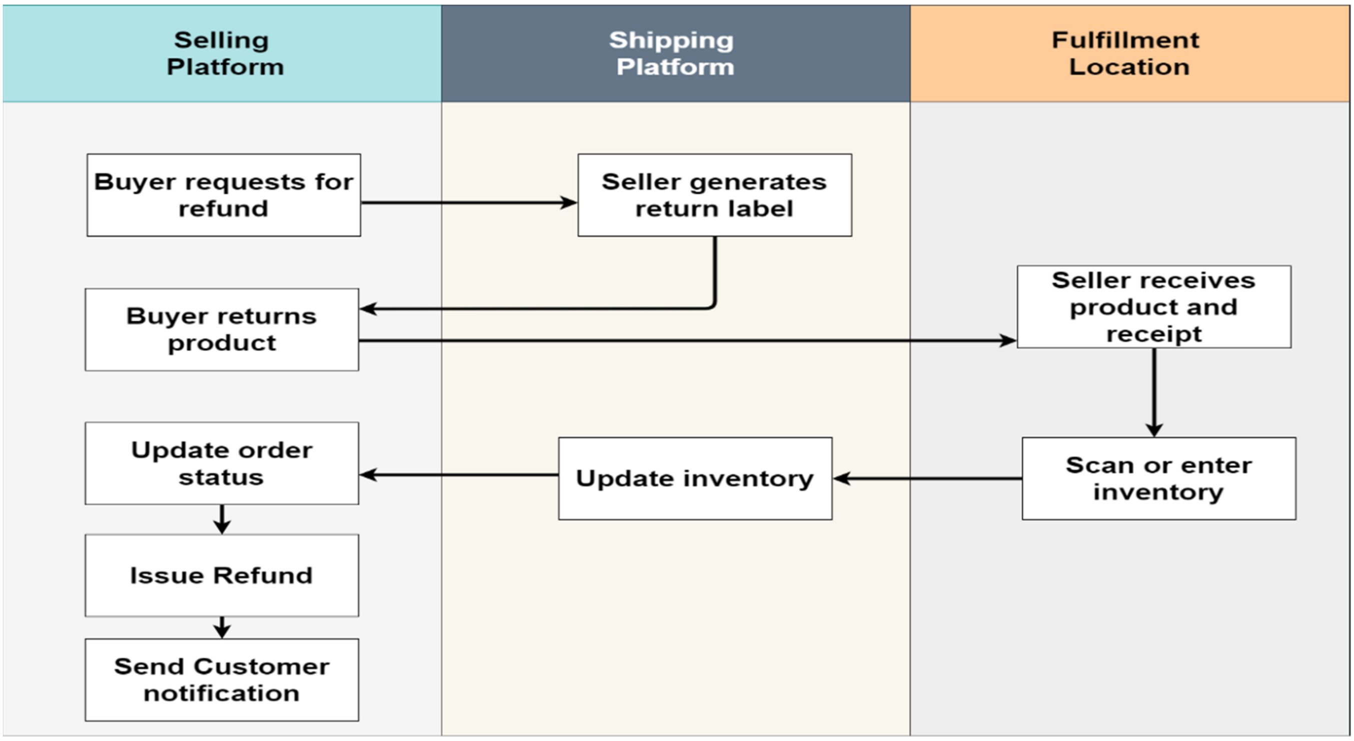

Figure 1. Reverse logistics process in E-commerce.

Reverse logistics management is the key to success for businesses in any industry, especially in the E-commerce industry, where customer retention and satisfaction depend on how effectively the company can manage the returns to increase its customer experiences [5]. Therefore, companies need to look after both the forward and reverse flow of goods in the entire supply chain. The reverse logistics process starts where the formal supply chain ends. Effective reverse logistics programs constructively influence the bottom-line and boost productivity by reusing, remanufacturing, refurbishing, and environmentally friendly disposal of goods [6]. Pakistan is among the eight fastest-growing economies globally, and the penetration of the E-commerce business in Pakistan is swift. According to the Ministry of Commerce report, Pakistan's E-commerce business growth is 35% in the first quarter of the year 2021. Moreover, the E-commerce business in Pakistan subsidized more than 30% of the country's overall GDP [7].

In E-commerce, an important key factor of reverse logistics called reverse management requires more attention to deal with it. If handled efficaciously, it will lead the company to retain customer loyalty [8]. In developing countries like Pakistan, the bothersome thing is that reverse logistics is still not being handled effectively and taken seriously. Due to this, it has become an important matter that needs to be resolved. There are a lot of barriers that need to be identified, which implement reverse logistics practices to be challenging and unsuccessful.

Moreover, the nature of each barrier is different, and it is impossible to solve all barriers at the same time. Therefore, the priority and ranking of barriers and solutions for successfully implementing reverse logistics practices are required [9]. Many noteworthy studies have identified different barriers, factors, and solutions for executing reverse logistics practices in many countries and different industries [10–12]. However, to the best of our knowledge, none of the research studies have been done before on identifying the barriers and their solutions to reverse logistics problems for the E-commerce industry in Pakistan. This research gap drives the goal of this paper, so this study aims to find and prioritize the solutions to barriers of reverse logistics practices in the E-commerce industry of Pakistan.

Moreover, it is necessary to rank and prioritize the solutions and the barriers in effective reverse logistics programs. These can be easily identified and resolved by E-commerce businesses on a priority basis. It is impossible to rank those solutions and barriers with personal feelings, and there is vagueness in the solution. It is difficult for decision-makers to decide under uncertainty and ambiguity [13]. Therefore, to resolve this issue, this paper proposed a methodology based on fuzzy analytical hierarchy process, in which pairwise comparisons were used to find the weights of each barrier and fuzzy technique for order performance by similarity to the ideal solution is applied to get the final ranking of solutions for reverse logistics execution programs. Moreover, the significance and contribution of the paper are given below:

The findings of this research study assist E-commerce companies in Pakistan resolve the top barriers in reverse logistics executions and adopting solutions for those barriers based on their preferences. This will lead E-commerce businesses to retain more customers and get a competitive advantage.

This study also helps government bodies, policymakers, and logistics managers to develop policies according to the actual ranking of barriers that causes the problem in the successful implementation of reverse logistics practices. Moreover, this study is opening the gate for new researchers and reactionaries in this field.

The paper is further divided into the following sections: Section 2 presents a detailed literature review on the reverse logistics barriers, their solutions, method choice, and assortment. Section 3 defines the methodology and proposed framework of methods. The applications of proposed methods to prioritize the barriers and ranking of solutions to E-commerce reverse logistics are given in Section 4. Section 5 highlights the discussions and elaborates the results of the case study. Finally, the conclusions of this study are given in the last section.

2. Literature Review

This section reviews the literature on reverse logistics in Pakistan, specifically in the E-commerce industry, identifying and explaining the barriers and solutions to reverse logistics. Finally, it justifies the methods adopted by this study through a literature review.

2.1. Position of Reverse Logistics in Pakistan

In recent years, Pakistan has tried to expand digitalization in the country with the aim of increase in economic growth. Undoubtedly, business enhancement accounts for any country's economic growth, especially in developing countries like Pakistan, where 98% of the businesses are small and medium enterprises (SMEs) [14]. With the development of e-businesses, the government of Pakistan has introduced policies, but unfortunately, there is no formal policy for reverse logistics implementation in e-businesses. Henceforth, the adoption and application of reverse logistics practices are in their early phase in the E-commerce industry of Pakistan. Almost all of the e-businesses in Pakistan use outsourcing logistics, especially SMEs, who are more likely to adopt this strategy to decrease operational costs. In this model, businesses give access to all logistics activities to a third party responsible for handling logistics throughout the supply chain [15]. However, effective reverse logistics management is a crucial issue, and several barriers need to be identified and tackled correctly. There are very few studies have been carried out on implementing reverse logistics practices. Waqas et al. [16] have identified the critical factors of reverse logistics and its barriers to Pakistan's manufacturing industry. Mushtaq et al. [17] studied reverse logistics route selection in the electronic industry of Pakistan. Waqas et al. [18] found the impact of reverse logistics barriers on sustainable firm performance and took the case of Pakistan's manufacturing industry. However, there is no such literature on E-commerce reverse logistics barriers and solutions for successfully implementing reverse logistics practices in the E-commerce industry, specifically in the Pakistani context.

2.2. Barriers to Reverse Logistics

Many noteworthy studies have identified various barriers to reverse logistics. Bouzon et al. [19] studied twenty-six barriers to reverse logistics and found that economic and financial related barriers are top obstacles for reverse logistics implementations. Chileshe et al. [20] identified sixteen barriers to implementing reverse logistics: legislation-related barriers, lack of top management support, and ignorance of health and safety were the most significant problems. Prakash et al. [13] identified that the lack of coordination with 3PL providers, lack of systems to monitor returns, and customer perception towards reverse logistics were the key barriers to reverse logistics execution in the electronic business of India. According to Bouzon et al. [21], the lack of company policies against reverse logistics, limited forecasting and planning, low importance to reverse logistics, and low top management involvement are critical issues in reverse logistics implementation. Kaviani et al. [22] examined the lack of government policies and economic-related issues as barriers to reverse logistics in the automotive industry in Iran. Pumpinyo and Nitivattananon [23] compiled four reverse logistics barriers: finance-related issues, labor management, lack of technology, and legal issues. According to Ali et al. [24], lack of involvement from top management, financial constraints, and lack of infrastructure were the most significant barriers for the computer industry in Bangladesh. Rameezdeen et al. [25] managed to identify twelve barriers to implementing reverse logistics: lack of environmental concern, poor return policies, and lack of planning and forecast were the key barriers. Prakash and Barua [26] highlighted four barriers in their paper: strategic barriers, policy barriers, infrastructural barriers, and market-related barriers. Dashore and Sohani [27] highlighted five barriers: lack of top management commitment, lack of experience and training, lack of government policies, lack of financial resources, and lack of coordination between supply chain partners. Shaharudin et al. [28] have found that poor service quality, lack of top management commitment, and lack of technological infrastructure were the most significant barriers to reverse logistics. Bhat and Rajashekhar [29] identified twenty-one barriers in which lack of resources, lack of customer orientation, poor service quality, and lack of management commitment were considered the top priority barriers in the manufacturing industry in India. According to Lau and Wang [30], lack of enforceable law, the high cost for adopting reverse logistics practices, poor government policies, and economic-related barriers caused difficulties in implementing reverse logistics. Moktadir et al. [31] identified 18 barriers requiring advanced technology, lack of interest and support from top management, lack of legislation, and lack of support from third parties in the supply chain that were the top obstacles to implementing reverse logistics in the footwear manufacturing in Bangladesh. Waqas et al. [16] addressed the most critical factors: lack of finance, lack of digitalization, poor information systems, poor return policies, and lack of community pressure.

From an extensive literature review, the barriers to implementing reverse logistics are pointed out. Moreover, the barriers nominated for this study are categorized into five significant barriers, and each main barrier is further divided into sub-barriers. Table 1 explains the barriers to reverse logistics implementations used by this study, along with their sources.

Table 1. Barriers to reverse logistics.

Code	Barriers	References
MB	**Management-related barriers**	
MB1	Lack of commitment from top management	[4,21,32]
MB2	Poor organizational culture	[10,11,14,19]
MB3	More concerned on foreword logistics	[19,20]
IB	**Infrastructure barriers**	
IB1	Lack of infrastructure (storage and transportation)	[33,34]
IB2	Lack of technological infrastructure to adopt RL	[6,9,17]
CB	**Coordination barriers**	
CB1	Lack of coordination with 3PLP	[17,34,35]
CB2	Lack of coordination with customer	[22,30]
CB3	Poor service quality/Lack of integration	[11,24,36]
PB	**Policy Barriers**	
PB1	Poor return policies	[22,37]
PB2	Lack of government policies for RL	[27,32,34]
FB	**Financial and economic barriers**	
FB1	Higher cost of adopting RL	[16,18]
FB2	Lack of funds for product return management	[1,7,38]
FB3	Expenditure of collecting used products	[21,32]
FB4	Limited forecasting and planning in RL	[10,11,33]

2.3. Reverse Logistics Solutions

In the last few years, different studies have proposed various solutions for removing the barriers to reverse logistics implementation. Sirisawat and Kiatcharoenpol [9] have identified fourteen solutions to tackle the reverse logistics barriers. Top management awareness and support, establishing a good relationship with other supply chain members, investing in reverse logistics technology, and implementing return avoidance strategies are robust solutions. According to Prakash and Barua [34], developing infrastructure support and facilities, a strategic focus on avoiding returns, developing closed-loop supply chains by integrating reverse logistics, and creating, developing, and investing in reverse logistics technology are top priority solutions for effectively implementing reverse logistics practices. Prajapati et al. [33] identified twenty-one solutions to eliminate the barriers in reverse logistics implementation. Top solutions were cooperative and explicit policies for reverse logistics, standardized reverse logistics processes, and customer awareness. Agarwal et al. [39] compiled four major solutions to reverse logistics barriers: collaboration between the various stakeholders to successfully implement reverse logistics successfully, robust legislation and policies for return management, and standardized reverse logistics process. Mangla and Luthra [37] recognized 25 factors for successfully implementing reverse logistics practices. Top management support, training and education for reverse management, and coordination with the customer were the significant factors. In the study of Li et al. [35], they found that positive relationships and coordination with third-party logistics providers were critical success factors for business. In addition, strong government policies and environmental-oriented activities lead businesses to overcome and manage reverse logistics. Sirisawat and Kiatcharoenpol [40] managed to identify fourteen solutions for reverse logistics barriers; most important were to establish e-collaboration among supply chain members, develop infrastructure for reverse logistics management, determine clear polices, and strategic collaboration with reverse logistics partners.

We have identified eight solutions to reverse logistics barriers from a detailed literature review and experts' opinions. Table 2 explains the solutions with their sources.

Table 2. Solutions to barriers of reverse logistics implementation.

Code	Solutions	References
S1	Top management support and awareness	[16,41]
S2	Determine clear policies and processes	[4,19,24,42]
S3	Develop infrastructure and facilities for supporting reverse logistics activities	[11,40,41]
S4	Establish e-collaboration among supply chain members	[5,6,36]
S5	Develop a good relationship with third-party logistics providers	[27,36]
S6	Provide visual details of actual products on the E-commerce platform	[5,13,19]
S7	Standardized reverse logistics process	[9,16,26,35]
S8	Improve quality issues with customer coordination	[12,18]

2.4. Method Choice

Numerous studies have adopted different multi-criteria decision-making methods such as fuzzy AHP, fuzzy TOPSIS, fuzzy VIKOR, etc., in solving different uncertain problems. Kaczmarek et al. [43] used MICMAC, fuzzy AHP, and TOPSIS methods to select the most critical factors affecting sustainable manufacturing. Prakash et al. [13] applied the fuzzy AHP method to prioritize the barriers in reverse logistics implementation in the Indian electronics industry. Tavana et al. [42] used integrated fuzzy AHP and SWOT methods to select the best third-party logistics providers to manage reverse logistics. Wang et al. [44] applied fuzzy AHP and fuzzy VIKOR methods evaluation and selections of third-party logistics providers to achieve sustainability in the supply chain. Chiang and Tzeng [32] implemented fuzzy AHP-TOPSIS methods to select sustainable and long-term third-party logistics providers. Zhou et al. [38] applied the fuzzy AHP to assess and prioritize GSCM practices in Pakistan's business industry. Canineo et al. [36] used the fuzzy AHP method to highlight Brazil's reverse logistics indicators. Vinodh et al. [41] used integrated fuzzy AHP-TOPSIS for highlighting and defining of most appropriate plastics reprocessing procedure. Prakash and Baura [26] identified and prioritized the reverse logistics barriers using the fuzzy AHP method and IRP framework. Moktadir et al. [31] applied the fuzzy AHP method for examining the reverse logistics barriers in the footwear industry. Sirisawat and Kiatcharoenpol [9] implemented fuzzy AHP and TOPSIS methods to solve the reverse logistics obstacles in Thailand's electronic industry by prioritizing RL solutions. Faizi et al. [45] proposed new aggregation operations based on Hamacher aggregation operations for I2TL elements to solve MCGDM problems, and these aggregation operations help solve group decision-making problems. Kizielewicz et al. [46] extend the fuzzy TOPSIS method used to evaluate and select alternatives by using similarity measures of triangular fuzzy numbers (TFNs) instead of calculating distance from the positive–negative ideal solution. Shekhovtsov et al. [47] extended the SPOTIS method that can be used in the handling of uncertainty and incompleteness of data in decision making problems, also they make a comparison with other MCDM methods such as COMET and TOPSIS, to show the validity of the proposed method and check its application in real decision making problems. Salabun et al. [48] proposed the new consistency coefficient for decision matrix in MCDM which is helpful for decision making process because it easy to determine the logical consistency and expert's response.

There are various multi-criteria decision-making methods have adopted by researchers and applied to solving various problems in different industries. These MCDM approaches and hybrid methods of MCDM helps decision-makers rank and choose the best alternative in different situations. However, very few studies have used the hybrid approach of fuzzy AHP and the E-commerce industry. The purpose of choosing these methods is evident. Combining fuzzy AHP and fuzzy TOPSIS improves the multi-criteria decision-making process by integrating more than one method. Very few studies have been found in the past that work on prioritizing barriers and ranking their solutions. So, to overcome this shortcoming, we proposed the hybrid methodology based on fuzzy AHP and fuzzy TOPSIS, which mainly identify and prioritize the solutions to the barriers in reverse logistics implementation in the E-commerce industry of Pakistan.

3. Research Methodology

This study has adopted a three-stage methodology for prioritizing both solutions and barriers for reverse logistics implementation. In the first stage, the current status of the E-commerce industry is defined, the reverse logistics barriers and solutions to those barriers for successfully implementing reverse logistics practices have been identified. The second phase of this study used the fuzzy analytical hierarchy (fuzzy AHP) method to find the weights for criteria and sub-criteria designed for reverse logistics barriers, also prioritize those barriers. After that, the fuzzy TOPSIS method was used to prioritize and rank the solutions of reverse logistics. The combination of these methods was used to improve the multi-criteria decision-making process [9,34]. The schematic diagram of the research methodology is presented in Figure 2.

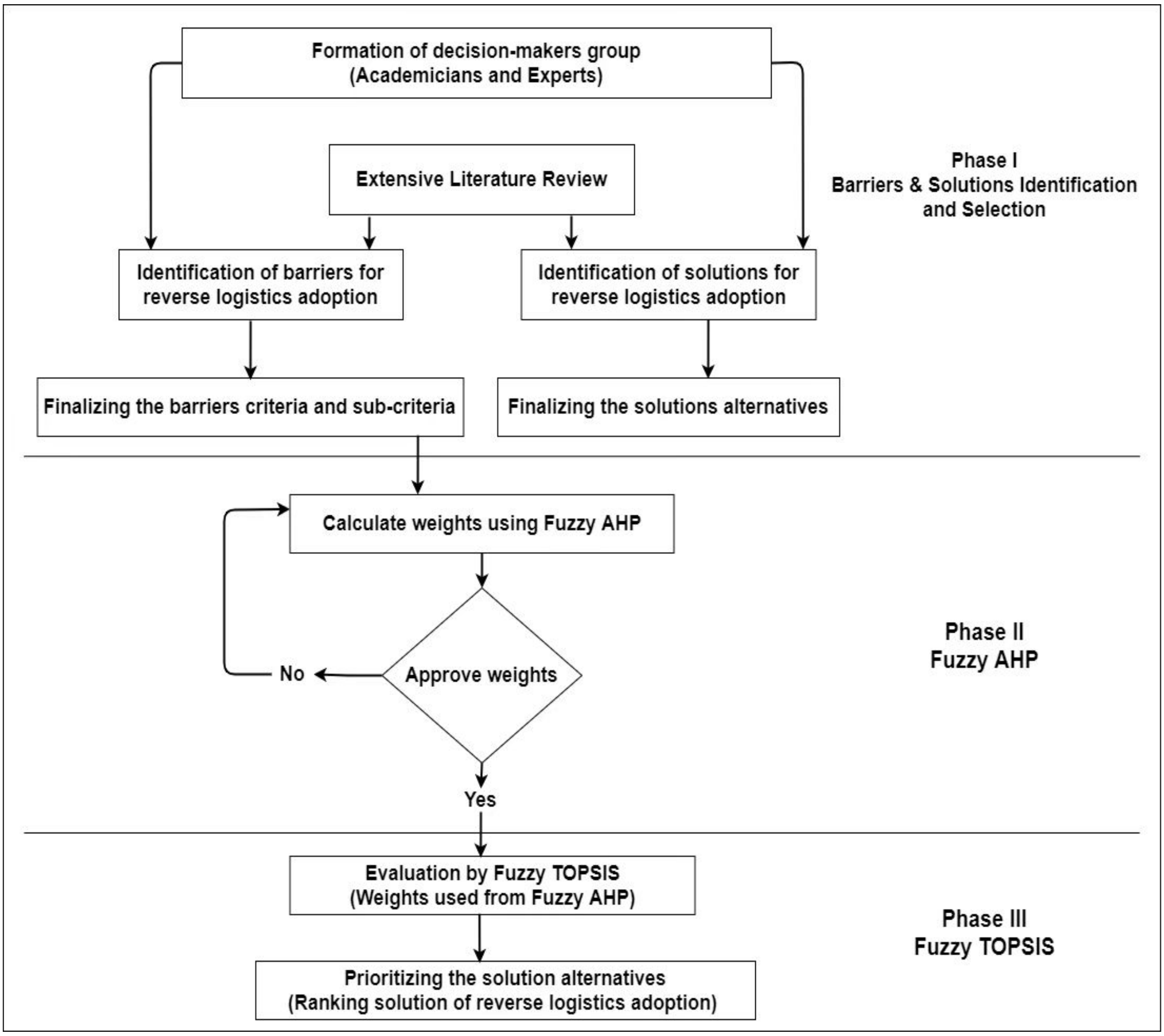

Figure 2. Methodology for prioritizing solutions to reverse logistics implementation barriers.

3.1. Stage 1: Identification of Reverse Logistics Barriers and Solutions

In this step, the E-commerce barriers to reverse logistics adoption, solutions to overcome those barriers have been identified through extensive literature review, and evaluated by experts, researchers, and academicians. Figure 3 demonstrates the identified barriers and solutions to reverse logistics adoption.

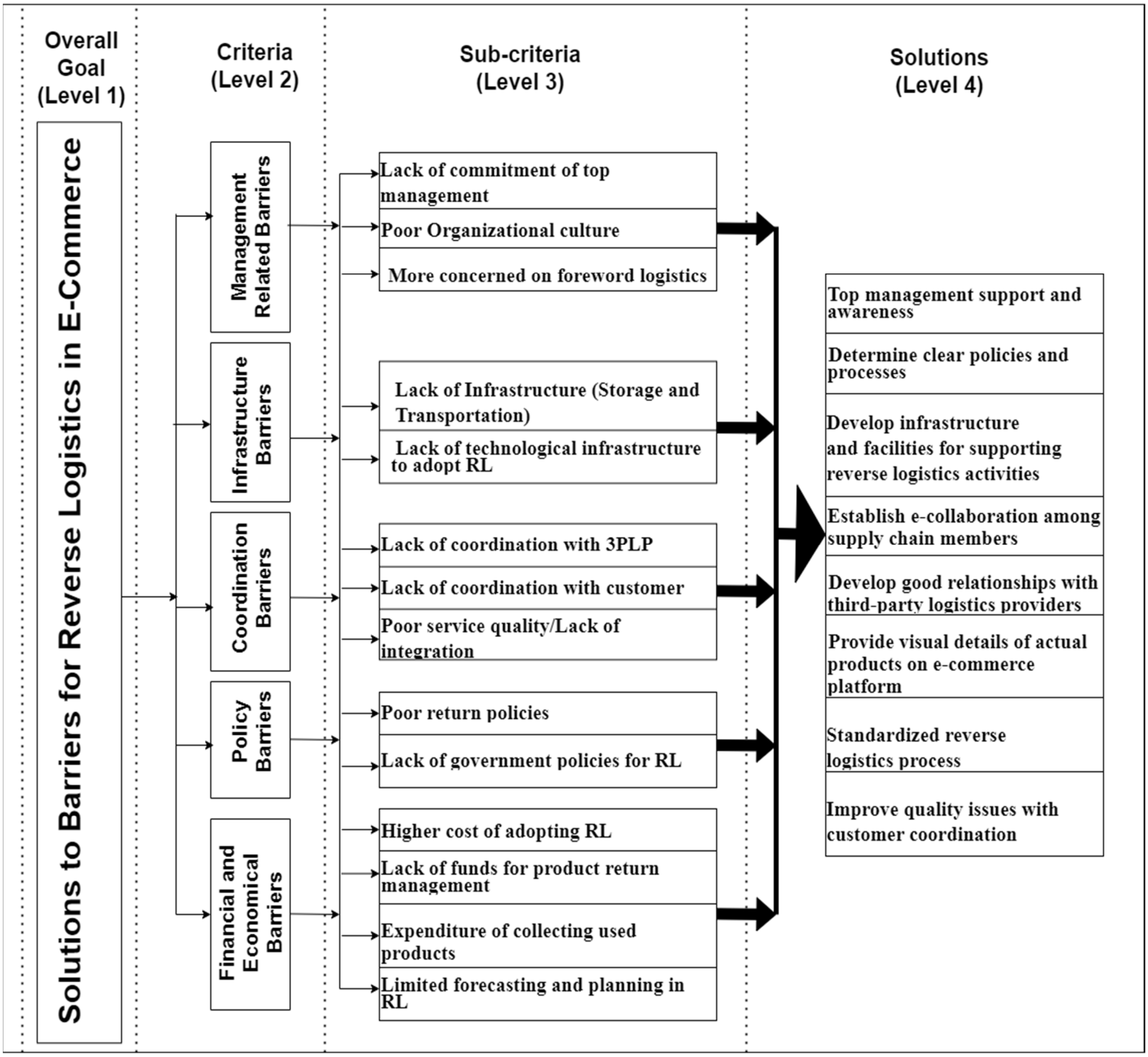

Figure 3. Identified barriers and solutions to reverse logistics adoption.

3.2. Stage 2: Fuzzy Analytical Hierarchy Process

Saty first proposed the Analytical hierarchy process AHP method in 1980 [49]. It was the most widely used method for solving multi-criteria decision-making and complex decisions [50]. However, this method has some shortcomings in the usability of AHP in a crisp environment, the judgment scale is unbalanced, and the selection of judgment is subjective. Henceforth, the fuzzy approach can be used to resolve these types of situations. This method has high applicability due to the fuzzy AHP method, including an undefined and vague judgement of experts by utilizing linguistics variables [34]. In the fuzzy AHP method, fuzzy triangular fuzzy numbers (TFNs) are used for the pairwise comparison scale of fuzzy AHP. Chang [51] presented the extent method used for the synthetic extent analysis adopted in this study.

Definition 1. *If* $\overset{>}{A}_1 = (l_1, m_1, u_1)$ *and* $\overset{>}{A}_2 = (l_2, m_2, u_2)$ *are representing two fuzzy triangular numbers, then algebraic operations can be expressed as follows [34]:*

$$\overset{>}{A}_1 + \overset{>}{A}_2 = (l_1, m_1, u_1) + (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \tag{1}$$

$$\overset{>}{A}_1 - \overset{>}{A}_2 = (l_1, m_1, u_1) - (l_2, m_2, u_2) = (l_1 - l_2, m_1 - m_2, u_1 - u_2) \tag{2}$$

$$\overset{>}{A}_1 \times \overset{>}{A}_2 = (l_1, m_1, u_1) \times (l_2, m_2, u_2) = (l_1 l_2, m_1 m_2, u_1 u_2) \tag{3}$$

$$\overset{>}{A}_1 \div \overset{>}{A}_2 = \frac{(l_1, m_1, u_1)}{(l_2, m_2, u_2)} = \left(\frac{l_1}{l_2}, \frac{m_1}{m_2}, \frac{u_1}{u_2}\right) \tag{4}$$

$$\overset{>}{A}_1^{\;-1} = (l_1, m_1, u_1) = \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}\right) \tag{5}$$

According to the method of extent analysis of Chang (1992) used by [34]

$$M_{gi}^1,\ M_{gi}^2,\ M_{gi}^3, \ldots,\ M_{gi}^m i = (1, 2, 3, 4, 5, \ldots n,)$$

And all $M_{gi}^j (j = 1, 2, 3, 4, 5, \ldots, m)$ are TFNs, which are shown in Table 3.

Table 3. TFNs of linguistics comparison matrix.

Linguistics Variables	Assigned TFN
Equal	(1,1,1)
Very low	(1,2,3)
Low	(2,3,4)
Medium	(3,4,5)
High	(4,5,6)
Very high	(5,6,7)
Excellent	(6,7,8)

The steps of Chang's analysis are explained below:

Step 1. The fuzzy synthetic extent (S_i) value with respect to *ith* criterion is defined as:

$$S_i = \sum_{j=1}^{m} M_{gi}^j \times \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right]^{-1} \sum_{j=1}^{m} M_{gi}^j = \left(\sum_{j=1}^{m} l_{ij}, \sum_{j=1}^{m} m_{ij}, \sum_{j=1}^{m} u_{ij}\right)\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^j\right]^{-1} = \left(\frac{1}{\sum_n^{i=1}\sum_m^{j=1} u_{ij}}, \frac{1}{\sum_n^{i=1}\sum_m^{j=1} m_{ij}}, \frac{1}{\sum_n^{i=1}\sum_m^{j=1} l_{ij}}\right) \tag{6}$$

where l is the lower limit value, m is the most promising value, and u is the upper limit value.

Step 2. The degree of Possibility of $S_2 = (l_2, m_2, u_2) \geq (l_1, m_1, u_1)$ can be defined as:

$$V(S_2 \geq S_1) = _{y \geq x}^{sup} \left[\min\left(\mu_{s_1}(x), \mu_{s_2}(y)\right)\right]$$

where x and y represent the values on an axis of the membership function of each criterion, this expression can be seen in Equation (7) below:

$$V(S_2 \geq S_1) = \begin{cases} 1 & if\ m_2 \geq m_1 \\ 0 & if\ l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & otherwise \end{cases} \tag{7}$$

where μd is the highest intersection point μ_{s_1} and μ_{s_2}, the graphical presentation can be seen in Figure 4.

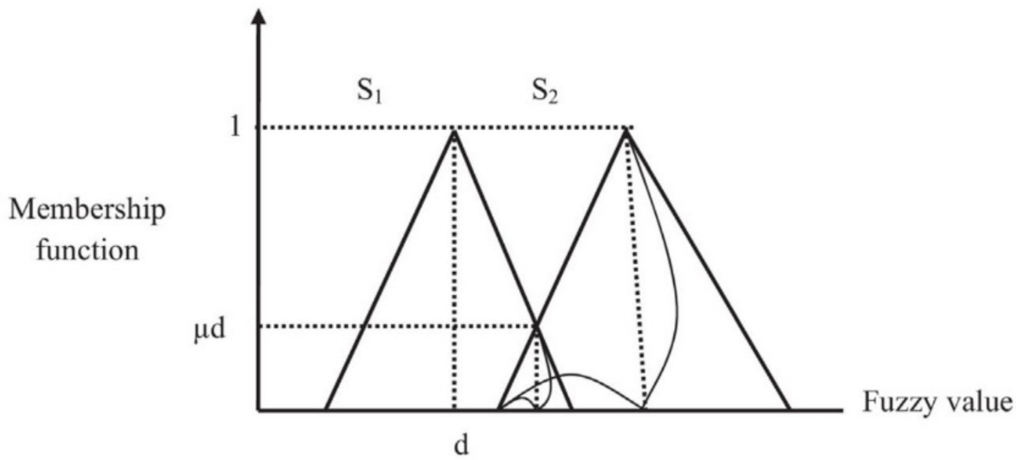

Figure 4. The intersection of fuzzy numbers.

To compare S_1 and S_2, both $V(S_1 \geq S_2)$ and $V(S_2 \geq S_1)$ are required.

Step 3. The degree of Possibility for a convex fuzzy number S to be greater than k convex fuzzy numbers $S_i = (i = 1, 2, 3, \ldots k)$ can be defined as:

$$V(S \geq S_1, S_2, \ldots, S_k\ ) \ = V[(S \geq S_1), (S \geq S_2), \ldots, (S \geq S_k)] = \min V(S \geq S_i),\ i = 1, 2, 3, \ldots, k \tag{8}$$

Assume that $d'(A_i) \ = \min V(S_i \geq S_k)$.

For $k = 1, 2, 3, \ldots, n\ k \neq i$, so the weight vectors are given in Equation (9) as,

$$W' = \left(d'(A_1), d'(A_2), \ldots, d'(A_m)\right)^T \tag{9}$$

Step 4. Via normalization, the normalized weight vectors are given in Equation (10) as,

$$W = (d(A_1), d(A_2), \ldots, d(A_m))^T \tag{10}$$

where W is the non-fuzzy number.

3.3. Stage 3: Fuzzy TOPSIS Method

The TOPSIS (technique for order preference by similarity to ideal solution) method was first developed by Hwang and Yoon [52]. The ideal and worst hypothetical plans are formed through each plan, and afterwards comparing the distance between each plan and the ideal and worst plan is chosen. TOPSIS is an ordinarily utilized assessment strategy for multi-objective decision-making, which has been widely utilized in transportation. It has been extensively used in risk assessment and other disciplines [9,28,40]. This method has simple calculation and clear thinking. The combination of the TOPSIS method and fuzzy set becomes the fuzzy TOPSIS method. Its calculation steps are entirely consistent with the TOPSIS method. Its calculation steps are as follows:

Step 1: determine the evaluation grade value for linguistics variables according to relevant standards. See Table 4 for the evaluation grade value. Each expert constructs a fuzzy decision matrix according to Table 4.

Table 4. Linguistics variables rankings.

Linguistics Variables	Assigned TFN
Very low	(1,2,3)
Low	(2,3,4)
Medium	(3,4,5)
High	(4,5,6)
Very high	(5,6,7)
Excellent	(6,7,8)

Step 2: construct an aggregate decision matrix.

If the fuzzy decision matrix for each decision expert is $\widetilde{X}_{abN} = (l_{abN}, p_{abN}, u_{abN})$, where, $a = 1, 2, \cdots, m$, $b = 1, 2, \cdots, n$. Let the fuzzy aggregation decision of each solution with respect to each criterion can be $\widetilde{X}_{ab} = (l_{ab}, p_{ab}, u_{ab})$, where

$$a = \min_N\{l_{abN}\}, b = \frac{1}{N}\sum_{n=1}^{N} p_{abN}, c = \max_N\{u_{abN}\} \tag{11}$$

Step 3: Construct a normalized aggregation decision matrix.

The normalized aggregate decision matrix is defined as follows:

$$\widetilde{B} = [p_{ij}]_{m\times n} \tag{12}$$

where $a = 1, 2, \cdots, m$, $b = 1, 2, \cdots, n$.

$$\text{For benefit indicators}: \ \widetilde{p} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right),\ c_j^* = \max c_{ij} \tag{13}$$

$$\text{For } \cos\text{t indicators}: \ \widetilde{p} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right),\ a_j^- = \min a_{ij} \tag{14}$$

Step 4: Establish a weighted normalized aggregation decision matrix.

The weighted normalized aggregate decision matrix is

$$\widetilde{V} = [\widetilde{v}_{ij}]_{m\times n} \quad a = 1, 2, \cdots, m,\ b = 1, 2, \cdots, n \tag{15}$$

where, $\widetilde{V} = \widetilde{p} \times w_j$.

Step 5: Determine the positive ideal solution and the negative ideal solution.

For Positive ideal solution:

$$A^+ = \{v_1^+, \cdots, v_n^+\},\ \text{where } v_j^+ = \begin{cases} \max(v_{ij}) j \in J \\ \min(v_{ij}) j \in J' \end{cases} \tag{16}$$

For Negative ideal solution:

$$A^- = \{v_1^-, \cdots, v_n^-\},\ \text{where } v_j^- = \begin{cases} \min(v_{ij}) j \in J \\ \max(v_{ij}) j \in J' \end{cases} \tag{17}$$

Step 6: Calculate the distance between each plan and the positive ideal solution and the negative ideal solution.

$$d_i^+ = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^+\right)^2},\ i = 1, 2, \cdots, m d_i^- = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_{ij}^-\right)^2}, i = 1, 2, \cdots, m \tag{18}$$

Step 7: Calculate closeness.

$$CC_j = \frac{d_i^-}{d_i^+ + d_i^-}, i = 1, 2, \cdots, m \tag{19}$$

Step 8: Sort the choices as per the similarity degree and select the best choice.

4. Application of the Proposed Method for Reverse Logistics Adoption in PAKISTAN'S E-Commerce Industry

4.1. Phase 1: Problem Explanation

Embracing reverse logistics is acquiring more consideration due to its benefits to the organization and environment. The E-commerce industry in Pakistan is moving towards adopting reverse logistics practices. Still, only a few can successfully adopt reverse logistics because companies face various barriers while implementing reverse logistics. Henceforth, they need to prioritize and rank those barriers as they arise, which may cause a problem in reverse logistics. It is necessary to consider the most important solutions that can tackle the barriers associated with implementing E-commerce reverse logistics practices.

Therefore, this study prioritizes barriers and ranks the solutions to reverse logistics adoption in the E-commerce business of Pakistan. The critical steps of the proposed methodology are described below.

4.2. Phase 2: Identification of Reverse Logistics Barriers and Solutions for Adopting Reverse Logistics

For this purpose, seven academic experts have been selected as decision-makers, and barriers and solutions were identified through literature review and expert's opinion. This research study has selected five criteria and 14 sub-criteria used to prioritize the reverse logistics barriers see (Table 1). Eight solutions to resolve those barriers have been prioritized and ranked (Table 2). Moreover, the questionnaire forms used for data collection from experts are given in Appendix A of the paper.

4.3. Phase 3: Fuzzy AHP Method to Calculate the Weights of Barriers to Reverse Logistics Adoption

The decision-makers evaluate the criteria and sub-criteria defined above based on TFNs given in Table 3. The fuzzy decision matrix and fuzzy pairwise comparisons of criteria and sub-criteria, along with their calculated weights, are given in Tables 5–10.

Table 5. The calculated fuzzy evaluation matrix of the main criteria.

	MB	IB	CB	PB	FB	Weight	Rank
MB	(1,1,1)	(2,3,4)	(0.25,0.33,0.5)	(0.25,0.33,0.5)	(0.33,0.5,1)	0.138	5
IB	(0.25,0.33,0.5)	(1,1,1)	(2,3,4)	(3,4,5)	(0.33,0.5,1)	0.238	1
CB	(2,3,4)	(0.25,0.33,0.5)	(1,1,1)	(2,3,4)	(0.25,0.33,0,5)	0.21	3
PB	(2,3,4)	(0.2,0.25,0.33)	(0.25,0.33,0.5)	(1,1,1)	(1,2,3)	0.183	4
FB	(1,2,3)	(1,2,3)	(2,3,4)	(0.33,0.5,1)	(1,1,1)	0.231	2

Table 6. Calculated pairwise comparison matrix of sub-criteria (MB).

	MB1	MB2	MB3	Weight	Rank
MB1	(1,1,1)	(3,4,5)	(0.25,0.33,0.5)	0.419	1
MB2	(0.2,0.25,0.33)	(1,1,1)	(1,2,3)	0.226	3
MB3	(2,3,4)	(0.33,0.5,1)	(1,1,1)	0.355	2

Table 7. Calculated pairwise comparison matrix of sub-criteria (IB).

	IB1	IB2	Weight	Rank
IB1	(1,1,1)	(1,2,3)	0.692	1
IB2	(0.33,0.5,1)	(1,1,1)	0.308	2

Table 8. Calculated pairwise comparison matrix of sub-criteria (CB).

	CB1	CB2	CB3	Weight	Rank
CB1	(1,1,1)	(1,2,3)	(0.33,0.5,1)	0.318	2
CB2	(0.33,0.5,1)	(1,1,1)	(2,3,4)	0.384	1
CB3	(1,2,3)	(0.25,0.33,0.5)	(1,1,1)	0.298	3

Table 9. Calculated pairwise comparison matrix of sub-criteria (PB).

	PB1	PB2	Weight	Rank
PB1	(1,1,1)	(0.33,0.5,1)	0.359	2
PB2	(1,2,3)	(1,1,1)	0.641	1

Table 10. Calculated pairwise comparison matrix of sub-criteria (FB).

	FB1	FB2	FB3	FB4	Weight	Rank
FB1	(1,1,1)	(0.2,0.25,0.33)	(1,2,3)	(3,4,5)	0.303	2
FB2	(3,4,5)	(1,1,1)	(3,4,5)	(0.25,0.33,0.5)	0.379	1
FB3	(0.33,0.2,1)	(0.2,0.25,0.33)	(1,1,1)	(2,3,4)	0.212	3
FB4	(0.2,0.25,0.33)	(2,3,4)	(0.25,0.33,0.5)	(1,1,1)	0.106	4

The fuzzy synthetic extent of five criteria is calculated by Equation (6) is shown in Table 11. After that, Equation (7) was used to calculate the value for the degree of Possibility (V-value), which are shown in Table 12, then we used Equation (7) to calculate the minimum (V-values), which are shown below:

$$\text{m(MB)} = \min \cdot V(S_1 = S_k) = \min(0.58, 0.7, 0.82, 0.64) = 0.58$$

Table 11. Fuzzy synthetic extent values of criteria.

Criteria				Calculations	Results
MB	=	(3.83,5.16,7)	×	(1/49.33,1/36.73,1/25.69)	(0.077,0.140,0.272)
IB	=	(6.58,8.83,11.5)	×	(1/49.33,1/36.73,1/25.69)	(0.133,0.240,0.447)
CB	=	(5.5,7.66,10)	×	(1/49.33,1/36.73,1/25.69)	(0.111,0.208,0.389)
PB	=	(4.45,6.58,8.83)	×	(1/49.33,1/36.73,1/25.69)	(0.090,0.179,0.343)
FB	=	(5.53,8.5,12)	×	(1/49.33,1/36.73,1/25.69)	(0.108,0.231,0.467)

Table 12. (V-values) for Criteria.

	MB	IB	CB	PB	FB
MB		1	1	1	1
IB	0.582		0.889	0.774	0.973
CB	0.702	1		0.887	1
PB	0.825	1	1		1
FB	0.643	1	0.924	0.818	

The same process is used for other criteria, similarly

$$m(IB) = 1, m(CB) = 0.88, m(PB) = 0.77, \text{ and } m(FB) = 0.97$$

so, the weight vector of each criteria is given below:

$$W' = (0.58, 1, 0.88, 0.77, 0.97)^T$$

Through normalization, the final weights of the criteria are obtained, which are:

$$W = (0.138, 0.238, 0.21, 0.183, 0.231)$$

Due to the same process for weight calculation of other criteria, the calculation process of reaming criteria is not presented here. However, the weights of other criteria and final results of pairwise comparison of criteria and sub-criteria are presented in Table 13.

Table 13. Final ranking of reverse logistics barriers practices.

Criterion	Weight	Sub-Criterion	Weight	Finalized Weight	Global Rank
Management-related barriers	0.138	MB1	0.419	0.057828	10
		MB2	0.226	0.031188	13
		MB3	0.355	0.049016	11
Infrastructure barriers	0.238	IB1	0.692	0.164692	1
		IB2	0.308	0.073066	5
Coordination barriers	0.21	CB1	0.318	0.06678	7
		CB2	0.384	0.08064	4
		CB3	0.298	0.06258	9
Policy Barriers	0.183	PB1	0.359	0.065797	8
		PB2	0.641	0.117303	2
Financial and economic barriers	0.231	FB1	0.303	0.069996	6
		FB2	0.379	0.087649	3
		FB3	0.212	0.048976	12
		FB4	0.106	0.024489	14

4.4. Phase 4: Fuzzy TOPSIS Method for Ranking and Sorting the Solutions of Reverse Logistics Adoption

Table 4 shows the correspondence between linguistic variables and fuzzy triangular numbers. The solutions are compared with each barrier to developing this matrix which is shown in Table 14. Decision-makers use Table 4 to perform the fuzzy evaluation on the solution, shown in Table 15. Here only one expert evaluation matrix is given due to space constraints. After that, Equation (11) is used to find the fuzzy aggregate decision matrix. The results are shown in Table 16. This paper considered all barriers as cost criteria, so Equation (14) is used to get the normalized fuzzy decision matrix shown in Table 17. In the next stage, the weights obtained by the fuzzy AHP method are used in the calculation Equation (15) to obtain the weighted normalized aggregate decision matrix, as shown in Table 18. Since this article regards the standards as cost standards, the fuzzy positive ideal solution is defined as $A^+(0,0,0)$ and the fuzzy negative ideal solution is defined as $A^-(0,0,0)$, and then the Equation (18) is used to calculate the distance between the positive ideal solution and the negative ideal solution, and then use Equation (19) to obtain the closeness coefficient CC_i, as shown in Table 19. The results obtained by using the above methodology are given below.

Table 14. Linguistics variables evaluation matrix for solutions.

	MB1	MB2	MB3	...	...	FB1	FB2	FB3	FB4
S1	H	H	M	...	...	H	M	L	H
S2	M	H	H	...	...	VH	H	M	M
S3	H	VH	M	...	...	H	VH	M	M
...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...
S6	M	M	L	...	...	VH	VH	L	VH
S7	VH	M	E	...	...	VH	H	L	L
S8	H	H	M	...	...	H	M	H	H

Table 15. TFN evaluation matrix for solutions.

	MB1	MB2	MB3	...	...	FB1	FB2	FB3	FB4
S1	(4,5,6)	(4,5,6)	(3,4,5)	...	...	(4,5,6)	(3,4,5)	(2,3,4)	(4,5,6)
S2	(4,5,6)	(4,5,6)	(4,5,6)	...	...	(5,6,7)	(4,5,6)	(3,4,5)	(3,4,5)
S3	(4,5,6)	(5,6,7)	(3,4,5)	...	...	(4,5,6)	(5,6,7)	(3,4,5)	(3,4,5)
...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...
S6	(3,4,5)	(3,4,5)	(2,3,4)	...	...	(5,6,7)	(5,6,7)	(2,3,4)	(5,6,7)
S7	(5,6,7)	(3,4,5)	(6,7,8)	...	...	(5,6,7)	(4,5,6)	(2,3,4)	(2,3,4)
S8	(4,5,6)	(4,5,6)	(3,4,5)	...	...	(4,5,6)	(3,4,5)	(4,5,6)	(4,5,6)

Table 16. Aggregate decision matrix for solutions.

	MB1	MB2	MB3	...	...	FB1	FB2	FB3	FB4
S1	(3,4.14,6)	(2,4.28,7)	(2,4.28,6)	...	...	(3,4.85,7)	(2,4.57,7)	(2,3.71,6)	(2,4.85,7)
S2	(2,3.85,5)	(2,4,7)	(2,4.71,7)	...	...	(3,5.42,7)	(2,4.28,6)	(2,3.85,6)	(2,4.28,6)
S3	(1,4.42,6)	(1,3.85,7)	(2,4.51,7)	...	...	(2,4.28,6)	(2,4.57,7)	(2,3.71,6)	(2,4.28,7)
...	...	...			...	...	...	...	...
...	...	...	...	...	...	...	...	...	...
S6	(2,4.28,7)	(1,3.71,7)	(2,3.71,5)	...	...	(3,5.14,7)	(2,4.85,7)	(1,3.71,7)	(3,5,7)
S7	(2,5,7)	(1,3.71,7)	(3,5,8)	...	...	(3,5.28,7)	(2,4.42,6)	(2,3.85,6)	(1,4.28,7)
S8	(2,4.57,7)	(1,3.85,6)	(2,4.28,7)	...	...	(3,4.71,6)	(3,5,7)	(2,3.85,6)	(2,4.57,7)

Table 17. Normalized fuzzy decision matrix for solutions.

	MB1	MB2	MB3	...	...	FB1	FB2	FB3	FB4
S1	(0.16,0.24,0.33)	(0.14,0.23,0.5)	(0.16,0.23,0.5)	...	...	(0.28,0.41,0.66)	(0.14,0.21,0.5)	(0.16,0.26,0.5)	(0.14,0.20,0.5)
S2	(0.2,0.26,0.5)	(0.14,0.25,0.5)	(0.14,0.21,0.5)	...	...	(0.28,0.36,0.66)	(0.16,0.23,0.5)	(0.16,0.26,0.5)	(0.16,0.23,0.5)
S3	(0.16,0.22,1)	(0.14,0.26,1)	(0.14,0.22,0.5)	...	...	(0.33,0.46,1)	(0.14,0.21,0.5)	(0.16,0.26,0.5)	(0.14,0.23,0.5)
...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...
S6	(0.14,0.23,0.5)	(0.14,0.26,1)	(0.2,0.26,0.5)	...	...	(0.28,0.38,0.66)	(0.14,0.20,0.5)	(0.14,0.27,1)	(0.14,0.2,0.33)
S7	(0.14,0.2,0.5)	(0.14,0.26,1)	(0.12,0.2,0.33)	...	...	(0.28,0.37,0.66)	(0.16,0.22,0.5)	(0.16,0.26,0.5)	(0.14,0.23,1)
S8	(0.14,0.21,0.5)	(0.16,0.26,1)	(0.14,0.23,0.5)	...	...	(0.33,0.42,0.66)	(0.14,0.2,0.33)	(0.16,0.26,0.5)	(0.14,0.21,0.5)

Table 18. Weighted normalized fuzzy decision matrix for solutions.

	MB1	MB2	MB3	...	...	FB1	FB2	FB3	FB4
S1	(0.009,0.013,0.019)	(0.004,0.007,0.015)	(0.007,0.011,0.024)	...	...	(0.019,0.028,0.046)	(0.012,0.018,0.043)	(0.007,0.012,0.024)	(0.003,0.004,0.012)
S2	(0.011,0.015,0.028)	(0.004,0.007,0.015)	(0.006,0.010,0.024)	...	...	(0.019,0.025,0.046)	(0.014,0.020,0.043)	(0.007,0.012,0.024)	(0.003,0.005,0.012)
S3	(0.009,0.012,0.578)	(0.004,0.008,0.031)	(0.006,0.010,0.024)	...	...	(0.023,0.032,0.069)	(0.012,0.018,0.043)	(0.007,0.012,0.024)	(0.003,0.005,0.012)
...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...
S6	(0.008,0.013,0.028)	(0.004,0.007,0.031)	(0.009,0.012,0.024)	...	...	(0.019,0.026,0.046)	(0.012,0.017,0.043)	(0.006,0.013,0.048)	(0.003,0.004,0.012)
S7	(0.008,0.011,0.028)	(0.004,0.007,0.031)	(0.005,0.009,0.016)	...	...	(0.019,0.025,0.046)	(0.014,0.019,0.043)	(0.007,0.012,0.024)	(0.003,0.005,0.024)
S8	(0.008,0.012,0.028)	(0.004,0.007,0.031)	(0.006,0.011,0.024)	...	...	(0.023,0.029,0.046)	(0.012,0.017,0.028)	(0.007,0.012,0.024)	(0.003,0.005,0.012)

Table 19. Final ranking of solutions to reverse logistics adoption.

Code	Solutions	D+	D−	CCi	Rank
S1	Top management commitment and support	0.2204	34.67719	0.993684	1
S2	Determine clear policies and processes	0.2208	34.68387	0.993674	2
S3	Develop infrastructure and facilities to support reverse logistics activities	0.2196	33.79192	0.993542	4
S4	Develop e-collaboration with supply chain members	0.2729	34.27433	0.992101	7
S5	Develop a good relationship with third-party logistics providers	0.222	34.34531	0.993578	3
S6	Provide visual details of actual products on the E-commerce platform	0.3615	34.53468	0.989641	8
S7	Standardized reverse logistics process	0.2484	34.67381	0.992887	5
S8	Improve quality issues with customer coordination	0.2552	34.64186	0.992687	6

5. Results and Discussion

The fuzzy TOPSIS and fuzzy AHP are powerful MCDM methods that help decision-makers to choose and select the best alternative from reverse logistics adoption barriers and to choose the best solution for solving the reverse logistics adoption barriers by prioritizing and ranking process because it is challenging to select and choose in comparison of which one is more important than the other. In this study, the integration of these methods has been used in which fuzzy AHP was used to give weightage and rank the barriers criteria and sub-criteria. On the other hand, the fuzzy TOPSIS method was used to rank the solutions to reverse logistics implementation.

In this study, this approach was used in reverse logistics adoption of Pakistan's E-commerce industry to increase the awareness of reverse logistics practices, which are ultimately helpful in reducing environmental issues. Furthermore, it helps companies to strengthen their reverse logistics process throughout their supply chain. The highest weightage value has been used to prioritize barriers such that IB > FB > CB > PB > MB has given in Table 5, which indicates that infrastructure barriers are the most prominent barriers to reverse logistics adoption. The ranking of infrastructure barriers sub-criteria is IB2 > IB1, which shows that lack of technological infrastructure barrier to adopting reverse logistics is more important than lack of infrastructure (storage and transportation). Similarly, the ranking of financial barriers sub-criteria is FB2 > FB1 > FB3 > FB4, which indicates that lack of funds for product return management is the most weighted barrier and limited forecasting and planning in reverse logistics is the least weighted barrier of all financial-related barriers. The ranking values of coordinator barriers are CB2 > CB1 > CB3, which shows that lack of coordination with customers is the highest weighted barrier. For the policy barriers, the lack of government policies for reverse logistics has high weightage, of which the ranking values of management-related barriers are MB1 > MB3 > MB2; it shows that lack of commitment of top management is the highest weightage barrier, where the poor organization culture is the least weightage barrier in management-related barriers.

To deal with these barriers, the ranking of the solutions is significant and is presented in this study, to help decision-makers choose the best suitable alternative solution to solve reverse logistics barriers discussed earlier. For ranking of the solutions, the highest CCi value was considered. According to the CCi values, S1 > S2 > S5 > S3 > S7 > S8 > S4 > S6. The CCi values show that top management support and awareness are the most important solutions for reverse logistics adoption barriers. The second most priority solution is to determine clear policies and processes, and the third important solution is to develop a good relationship with the third-party logistics providers. However, the least priority solution is to provide visual details of the actual products on the E-commerce platform. So, the decision-maker should consider these prioritized barriers and solutions while deciding on reverse logistics implementation in Pakistan's E-commerce Industry.

6. Conclusions

Adopting reverse logistics practices arises as environmental concerns increase and green logistics, green production, and waste management grow. Henceforth, it is essential for the Pakistani E-commerce industry to consider the importance of reverse logistics practices and should move towards adopting them. As Pakistan's E-commerce industry is growing and moving towards a good direction, the need for reverse logistics management increases that need to be managed effectively because there are a lot of barriers and several solutions to resolve those barriers in successfully implementing reverse logistics practices; this is made difficult for decision-makers to make the right choice. For this purpose, this study used hybrid fuzzy AHP and fuzzy TOPSIS multi-criteria decision-making methods in which fuzzy AHP was used to prioritize and rank the barriers to reverse logistics implementation, and fuzzy TOPSIS method was used to rank the solutions to overcome these barriers in reverse logistics practices adoption. We have identified 14 barriers and eight solutions to reverse logistics adoption through literature review and experts' views. The results of this study presented that top management support and awareness is the essential solution in the case study of Pakistan's E-commerce industry. This ranking of barriers and solutions is beneficial for policymakers, decision-makers, and logistics managers for developing policies and successfully implementing reverse logistics practices. For future studies, researchers should investigate the Industry 4.0 technologies' involvement in reverse logistics management. Future studies can combine both industrial and government bodies to formulate standardized policies for reverse logistics management. Future researchers can also check the involvement of Industry 4.0 technologies in the management of reverse logistics. Moreover, other MCDM methods such as ANP, ELECTRE, and fuzzy VIKOR would be used to compare the proposed framework results. Also, future studies can use different attributes and extend this study by choosing decision problems of another industry.

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Appendix A

This section of the paper provides the Questionnaire forms used for data collection from experts. Each of the seven experts was asked individually to complete the data form truly to avoid mistakes. Figure A1 presents the values for each linguistic variable, such as (E denotes "equal", VL denotes "very low", etc.). This helps decision-makers to evaluate each criterion with respect to other criteria to make a comparison. For a better understanding of how data were collected from experts, Figure A2 provides the blank data form for the main barriers criteria. All of the experts were asked to complete this form using the values given in Figure A1. The experts have used the data form given in Figure A3 to provide information related to eight solutions.

The same type of data forms was used to collect data for the other criteria and sub-criteria, and due to space limitations, those forms were not given here.

Criteria	MB	IB	CB	PB	FB
	Equal (1,1,1)	Equal (1,1,1)	Equal (1,1,1)	Equal (1,1,1)	Equal (1,1,1)
	Very low (1,2,3)	Very low (1,2,3)	Very low (1,2,3)	Very low (1,2,3)	Very low (1,2,3)
	Low (2,3,4)	Low (2,3,4)	Low (2,3,4)	Low (2,3,4)	Low (2,3,4)
	Medium (3,4,5)	Medium (3,4,5)	Medium (3,4,5)	Medium (3,4,5)	Medium (3,4,5)
	High (4,5,6)	High (4,5,6)	High (4,5,6)	High (4,5,6)	High (4,5,6)
	Very high (5,6,7)	Very high (5,6,7)	Very high (5,6,7)	Very high (5,6,7)	Very high (5,6,7)
	Excellent (6,7,8)	Excellent (6,7,8)	Excellent (6,7,8)	Excellent (6,7,8)	Excellent (6,7,8)

Figure A1. Values used by experts to fill Questionnaire data.

Management related Barriers	-				
Infrastructure Barriers		-			
Coordination Barriers			-		
Policy Barriers				-	
Financial Barriers					-

Figure A2. Questionnaire data form for main criteria barriers.

	Very low (VL) (1,2,3)	Low (L) (2,3,4)	Medium (M) (3,4,5)	High (H) (4,5,6)	Very high (VH) (5,6,7)	Excellent (E) (6,7,8)
S1						
S2						
S3						
S4						
S5						
S6						
S7						
S8						

Figure A3. Questionnaire data form for solutions.

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