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Interdependent Influences of Reverse Logistics Implementation Barriers in the Conditions of an Emerging Economy

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Abstract: This research paper aims to investigate the interdependent influences of barriers to implementing reverse logistics in the broad spectrum of processing activities in the conditions of an emerging economy. An effort was made to approach these barriers (i.e., organizational and management barriers, technical and technological barriers, and economic, financial, and market barriers) based on the relevant literature, predominant attitudes, and experts' opinions, thus contributing to the body of knowledge in this domain. Determining the intensity of interdependent influences and the importance of barriers for implementing reverse logistics was performed to determine the most important (key) barriers that can be practically applied as guidelines for decision making. The Fuzzy DEMATEL method was used to determine the intensity of these influences on a sample of manufacturing companies in the Republic of Serbia. The results indicate that the most critical barriers to the successful implementation of reverse logistics are a lack of management support and cooperation with scientific institutions and professional associations to acquire knowledge and follow trends in the field.

Keywords: Reverse Logistics Barriers; interdependent influences; manufacturing industry; emerging economy; Fuzzy DEMATEL

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1. Introduction

This research paper aims to investigate the presence and intensity of the interdependent influence of reverse logistics implementation barriers in the conditions of increased market uncertainty, i.e., the conditions of an emerging economy, that characterizes the economy of Serbia. This specifically means that the research was conducted where businesses face unique challenges related to resource constraints, infrastructure, regulatory environments, and collaboration opportunities, which can hinder the adoption and success of reverse logistics practices. The need for this research arises from the fact that despite the growing number of scientific papers dealing with reverse logistics [1–3], and especially the application of multicriteria decision-making methods in this field [4–8], the research conducted in this area so far needs to be intensified and expanded.

Previous studies have been limited by the fact that they mainly focus on specific activities (the electronics industry, automotive industry, and construction industry) and examine only several developed economies (USA, UK, China, India, Australia, and Brazil) [6,7,9–13]. Some researchers express their concern about the absence of such research in developing countries since reverse logistics is starting to be developed and applied here [14–19], especially emphasizing the need for and importance of more research in this field to define and analyze critical barriers to reverse logistics implementation and assess their interdependent influences [9,12].

The additional incentive comes from the fact that the research that has been carried out in the territory of the Republic of Serbia was not empirical. This paper presents a systematization of key reverse logistics implementation barriers based on relevant literature sources and the prevailing views and opinions in this scientific field.

The primary goal of this research is to identify the interdependent influences of reverse logistics implementation barriers. The secondary goal is to determine the significance of these barriers and single out those of key importance so that they can later be neutralized and used in practical applications as guidelines in the decision-making process when implementing reverse logistics in organizations.

2. Research Methodology

For this research, a systematic literature review (SLR) is carried out, as it allows for the evaluation and interpretation of the contemporary body of research relevant to a research question in a thematic area. Building a correct theoretical base allows for the generation of conclusions and the development of helpful action models, the identification of gaps in current research, and the definition of future research areas.

The first step of SLR is to define relevant index bases, combinations of terms to be searched, and how the search results will be recorded. The articles were found in the Science Direct (Elsevier) database and the MDPI database. The keywords used in the search were "Reverse Logistics Barriers" and "DEMATEL." The result of the first search was 327 articles.

To corroborate the suitability of the selected articles, the keywords, content, and theoretical development of the paper were analyzed in detail in the second round. The most relevant papers linking Reverse Logistics Barriers and the DEMATEL method were selected, gathering a core sample of 36 papers for content analysis. Table 1 shows the distribution of articles, mostly across 3 journals and article focus areas. Several other articles, used as references, were added to the research but only to define key terms.

2.1. Reverse Logistics Implementation Barriers

In developing countries or countries with economies in transition, reverse logistics is still at an early stage of development and implementation, as evidenced by the fact that the remains of materials, products, and packaging are mainly disposed of, causing environmental degradation and higher costs. This is in contrast to developed countries, where the rate of reused and recycled products is constantly increasing [9,11,20,21].

There is growing interest in the academic community and the world's leading economies in applying a circular economy, closed-loop supply chains [22], and reverse logistics to neutralize the causes of public concern regarding environmental protection, sustainable development, compliance with legal norms, social responsibility, competitiveness of organizations [4,23], etc. In many developed countries, legislation defines manufacturers' obligations to prevent waste generation and promote the reuse, reprocessing, or recycling of materials such as electronic equipment, chemicals, glass, plastics, heavy metals, etc. Financial and economic reasons, a positive reputation, and the requirements and expectations of users and other stakeholders are incentives for the proactive and sustainable operation of organizations, such as the implementation of reverse logistics in supply chains [24,25].

Numerous examples from the literature [26,27] show the positive impact of reverse logistics on the performance of organizations in the form of cost reduction, generating added value from restored products, a formalized approach to waste management and the environment, etc. Despite these numerous positive effects, the importance of reverse logistics is underestimated, or there is no awareness of its significance in organizations, which is one of the essential preconditions for resisting such changes [28]. The reasons for understanding and treating a concept in this way can be called reverse logistics implementation barriers. Based on previous research, these barriers can be grouped into several characteristic groups.

Rogers and Tibben-Lembke [29] ranked barriers according to their importance, from employee awareness of the importance of reverse logistics in solving business problems, the adopted organizational policy, the lack of a reverse logistics information system, competitive issues, management inattention, a lack of human and financial resources, and non-binding legal norms.

According to the most general classification [30], barriers can be divided according to their internal and external character, where significant internal barriers are the lack of awareness of the importance of reverse logistics and support for its implementation, the risk of failure and doubt in its results, employees' resistance to changes, and a lack of financial resources. Potential external barriers include a lack of adequate legislation in this area, various forms of market barriers, uncertainty of the quality and quantity of product returns, lack of public awareness and support of institutions, etc.

Abdulrahman and Subramanian [31] and Abdulrahman and others [10] divided these barriers into four groups and highlighted the most important ones in each group: management barriers—lack of commitment from top management; financial barriers—lack of initial capital and capital for reverse logistics operational costs; political barriers—lack of binding legal norms and support (incentives) by the state; and infrastructural barriers—lack of technical and technological capacities for monitoring the product return process. Azadnia et al. [32] identified environmental barriers, and Kaviani et al. [12] similarly identified other barriers and grouped them as financial and economic, technology and infrastructure, governance and supply chain process, policy and regulation, market and social, management and organizational, and knowledge and experiences. The comprehensive review by Prakash and Barua [33] classified barriers into managerial, organizational, economic, legal (legislative), technological, infrastructural, and market, while Wang et al. [34] added commitment and societal and operational barriers as necessary.

After analyzing the research mentioned above and the ways of grouping barriers and using the criteria of origin, i.e., the type of influence they exert on the process of reverse logistics implementation in organizations, for the present research, the barriers are grouped into organizational and management barriers; technical and technological barriers; and economic, financial, and market barriers. Organizational and management barriers are manifested by difficulties in the planning, decision making, and management of reverse logistics activities and can often be crucial for reverse logistics implementation since issues such as a lack of management support, commitment [34], responsibility, and initiation by top management [8], a lack of employee training and expertise, and resistance to change by employees inevitably lead to failure to improve the organization's performance related to reverse logistics implementation [35].

Shortcomings and limitations manifest as technical and technological barriers in terms of the infrastructural, technical, and technological capacities of the organization, which result in reduced ability to return or withdraw products from the market efficiently [10,36]. A lack of proper technology and infrastructure is one of the crucial barriers to implementing closed-loop supply chains or reverse logistics [32,34].

Financial and economic barriers, such as staff training costs, the cost of product return mechanisms, a lack of incentive tax policy [10], a lack of financial resources, high costs, and low return on investment often block reverse logistics investments. They diminish the importance of such initiatives for environmental protection and reduce confidence that their application can result in an increased return and rate of return on investment [30]. Political barriers can be viewed as external and internal stakeholders, where most of them stem from the non-existent, inadequate, or non-incentive legislation in the subject area [10] or the lack of mechanisms for its implementation. Academia and practitioners have discussed that inappropriate and slow-changing legislation can negatively affect reverse logistics implementation while supportive policy and regulation provide a better framework [32]. In the case of typical market barriers, the non-existence or non-application of adequate (supportive) legal norms also affects users' awareness of the possibilities and importance of the need to reuse and restore the value of used products and establish cooperation within supply chains [35].

Table 1 provides an overview of the identified reverse logistics implementation barriers [35] based on the literature review, with references indicating their sources.

Table 1. Identified reverse logistics implementation barriers—a literature review.

Barriers	Literature Source Reference
Lack of awareness of the importance of reverse logistics and its benefits	[9,18,30,33,37–49]
Lack of support and commitment of management to the implementation of reverse logistics	[4,8,10,16–18,29–31,33,38,39,41–45,47,48,50–55]
Resistance to change by employees	[4,13,18,28,30,33,38,41–43,46,48,56]
Lack of employee training, incompetence, and lack of qualified employees	[8–11,28–31,33,37–48,50–53,55,57]
Lack of systems for performance measurement and management	[9,12,17,28,30,31,33,39–45,47,51,55,58]
Fear of failure regarding the implementation of reverse logistics	[39,44,47,48]
Lack of corporate social responsibility of organizations	[17,18,44,47,48]
Lack of common understanding of best practices within the organization	[10,31,33,38,51]
Lack of adequate waste management practices	[4,10,12,33]
Lack of strategic planning, goals, and plans regarding the implementation of reverse logistics	[4,8,13,18,33,41–43,50,51]
The organization's policy does not emphasize the importance of reverse logistics	[4,13,17,18,29,33,38,41–43,45]
Reverse logistics does not have priority over other activities and investments of the organization	[8,29,30,38,43]
Lack of cooperation with scientific institutions and professional associations to acquire knowledge and follow trends in the field	[6,13,30,46,57]
Inadequate internal and external communication in the organization and exchange of information on reverse product flows	[9,30,33,40,52]
Lack of capacity within the organization in terms of facilities and equipment for the implementation of reverse logistics	[4,9,10,13,16,30,31,33,38,40,50,55,56]
Lack of adequate technological and IT systems for the implementation of reverse logistics and monitoring of reverse product flows	[4,9–13,16,17,28,29,31,33,37–48,51,53,57,58]
Difficulties in ensuring the required and uniform product quality	[9,28,40,42,43,45,53,54]
Complexity of reverse logistics operations	[9,30,40]
Non-application and difficulties in designing products suitable for recycling and/or reuse	[39,44,47,59]
Difficulties in cooperation and engagement of "third parties" for the application of reverse logistics (Third Party Logistics—3PL)	[4,9,10,12,16,18,33,37,39,40,44,51]
Lack of initial capital for the implementation of reverse logistics	[7,10,12,18,29–31,50,52]
Lack of funds for employee training	[6,10,12,31,42,45]
Lack of funds and investments in storage and material handling activities	[4,10,31,33]
Lack of funds for reverse product flow monitoring systems	[10,31]
High salary costs of employees in the field of reverse logistics	[42,53,59]
Uncertainty regarding the realized profit from the implementation of reverse logistics	[4,9,30,38–41,44,49,56,57]
High initial and operating costs of reverse logistics	[4,8,11,13,16,30,33,37–39,41,44,46–48,51–54]
Lack of economies of scale	[4,9,12,33,40,41,51,55]
Financial burden of additional tax liabilities	[9,13,31,40,45,54]
Lower economic value of the product at the end-of-life stage	[33]

Table 1. *Cont.*

Barriers	Literature Source Reference
Lack of financial resources to expand production	[57]
Higher costs due to the use of eco-friendly packaging	[39,44]
High costs of storage and disposal of hazardous materials	[39,44,47,48]
Inaccessibility of banking funds for the implementation of "green" technologies	[13,18,39,44,47,48]
High procurement and maintenance costs and lack of investment in technological and IT systems for reverse logistics	[4,13,33,42,45,46]
Costs of collecting used products	[13,16,18,44]
Lack of public awareness of environmental protection needs	[4,10,13,31,33,51]
No organization in the area of waste management and the existence of many informal practices	[4,9,31,33,40,41,51,59]
Lack of adequate standards and practices in the field of recycling and reuse of products	[4,6,8,13,33,57,59]
Inadequate interpretation, difficulties in interpreting and applying legal norms in the field	[9,30,40,59]
Lack of motivating regulations in the field	[6,7,9,11,16,31,32,40,45,49,50,58,59]
Difficulties in holding producers from other countries accountable	[9,13,31,40]
Lack of support from professional associations and NGOs	[7,13,31,38]
Users not aware of the rights and possibilities of product returns and its benefits	[4,6,13,31,33,44,51]
Perception of poorer product quality by users and promotion of the use of new products	[4,9,12,13,33,38,40,41,59]
Reverse logistics is not considered a critical aspect of market competitiveness and performance	[9,10,12,13,17,40,58]
Uncertainty of returns and demand for products	[4,8,11,18,33,41,54,55,59]
Lack of user awareness of the importance of reverse logistics	[39,47,48,51,52,56]
Uncertainty regarding the quality and quantity of returned products	[4,8,12,18,30,33,43,49,51,54]

Table 2 shows the items that were used in the research instrument, which is part of a previously realized, more comprehensive research [35], now supported and confirmed by modern literary sources and modified and adapted to the needs of this research. These items (barriers) were defined based on the literature review (Table 1) and their semantic analysis.

Table 2. Reverse logistics implementation barriers.

Barriers	Barrier Groups
B01—Lack of expertise and knowledge on reverse logistics on the part of management	Organizational and management barriers (OMB)
B02—Lack of expertise and knowledge on reverse logistics on the part of employees	
B03—Resistance to changes (organizational and technical-technological) on the part of employees	
B04—Inadequate internal and external communication in the organization on reverse flows of products	
B05—Lack of cooperation with scientific institutions and professional associations to acquire knowledge and follow trends in the field	
B06—Lack of management support	

Table 2. *Cont.*

Barriers	Barrier Groups
B07—Lack of adequate technical and technological capacities	Technical and technological barriers (TTB)
B08—Lack of systems for measuring and managing reverse logistics performance	
B09—Difficulties in ensuring the required and uniform product quality	
B10—Difficulties in designing products suitable for recycling and/or reuse	
B11—Lack of financial resources	Economic, financial and market barriers (EFB)
B12—High initial cost and operating costs of reverse logistics	
B13—Lack of banking funds for "green technologies," lack of state incentives (e.g., tax reliefs) and legal norms	
B14—Presence of risks (uncertainties) regarding the functioning of reverse logistics and benefits that would be realized	
B15—Consumer impression that used (e.g., recycled) products are of poorer quality	
B16—Users' lack of knowledge about the rights and options for returning used products to the manufacturer	

2.2. The DEMATEL Method in Reverse Logistics Studies

To efficiently manage the process of reverse logistics implementation in an organization, it is necessary to study the factors that may affect that process comprehensively. When there are several different reverse logistics implementation barriers and a significant number of them have an interdependent influence, applying management measures that would neutralize specific barriers would have a distinct influence on the occurrence and intensity of the other barriers. Management must define priorities in implementing these measures and criteria, based on which it will influence barriers, which is a classic example of Multiple-Criteria Decision Making (MCDM). It is necessary to determine the intensity of the mutual influences of the mentioned barriers, which provide the basis for decision making. The DEMATEL method (Decision-Making Trial and Evaluation Laboratory) is based on multi-criteria decision making. As a comprehensive method for analyzing and solving complex and interdependent problems, it is intensively applied in the field of reverse logistics and supply chains, especially when determining the interdependent influences of reverse logistics implementation factors. DEMATEL's ability to identify, analyze, and visualize the interdependent influences among reverse logistics implementation factors makes it particularly advantageous for understanding and addressing the complex barriers in this field, offering insights that are not as easily obtained through other MCDM methods. Furthermore, the computational complexity of DEMATEL is generally on a low level, making it suitable for practical use in decision-making scenarios involving interdependent factors. Its operations, largely involving matrix manipulations and data processing, are efficient enough to be handled by standard computational resources, even for moderately large problem sizes. This makes DEMATEL an accessible and efficient tool for analyzing complex systems where understanding factor interdependencies is crucial [5,21,22,39,40,50,54,57,60–67].

The flowchart of the proposed algorithm is indicated in Figure 1, while the control parameters of the algorithm are given in Table 3. The DEMATEL method is based on graph theory. It enables visual planning and problem-solving so that relevant factors can be divided into causal and consequential categories to understand their interrelationships better. The graph shows the contextual relationship between the system elements, in which the number represents the strength of a factor's influence [68]. The procedure for calculating the intensity of these factors' mutual influences using the DEMATEL method is defined according to previous recommendations [21,22,39,40,57,61–74].

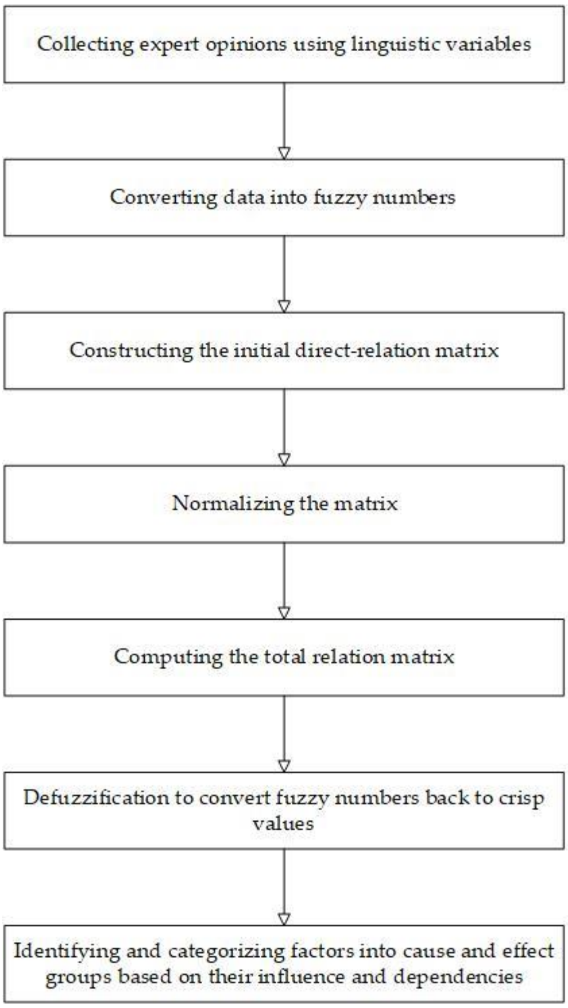

Figure 1. The flowchart of the proposed algorithm.

Table 3. The control parameters of the algorithm.

Parameter	Value	Determination Method
Threshold Value	0.321	Set based on the calculation
Fuzzy Membership Function	Triangular	Based on the literature review
Normalization Factor	1/Max Sum	Ensures all matrix elements are between 0 and 1

Numerous organizations have embraced collaborative decision making to identify an acceptable solution in actual decision-making situations. However, in complex system-related decision-making problems, the assessment provided by specialists or decision makers regarding a particular object's qualitative characteristics is invariably expressed in linguistic terms rather than as precise numerical values derived from experience and knowledge. Because such verbal judgments are imprecise, it is not easy to compute further analysis. Fuzzy set theory can, therefore, be used to quantify vague ideas related to people's subjective assessments [75–77].

Group decision making is crucial to arriving at an acceptable solution. An acceptable result could be reached since a consensus depends on several people's responses. Fuzzy aggregation, which includes the defuzzification approach, is necessary to deal with the uncertainty of research since human judgment regarding fuzzy linguistic variables is fuzzy numbers. Defuzzification turns fuzzy numbers into crisp values by choosing a specific crisp element based on the fuzzy set produced. The fuzzy minimum and maximum are used to establish the left and right scores, and the membership functions are used to calculate the weighted average for the total score.

Perform Normalization:

$$\begin{gathered} xa_{1ij}^k = \left(a_{1ij}^k - \min a_{1ij}^k\right) / \Delta_{min}^{max} \\ xa_{2ij}^k = \left(a_{2ij}^k - \min a_{2ij}^k\right) / \Delta_{min}^{max} \\ xa_{3ij}^k = \left(a_{3ij}^k - \min a_{3ij}^k\right) / \Delta_{min}^{max} \\ \text{Where } \Delta_{min}^{max} = max\ r_{ij}^n - min\ l_{ij}^n \end{gathered} \tag{1}$$

Compute right (rs) and left (ls) normalized values:

$$\begin{gathered} xls_{ij}^k = xa_{2ij}^k / \left(1 + xa_{2ij}^k - xa_{1ij}^k\right) \\ xrs_{ij}^k = xa_{3ij}^k / \left(1 + xa_{3ij}^k - xa_{2ij}^k\right) \end{gathered} \tag{2}$$

Compute total normalized crisp values:

$$\begin{gathered} x_{ij}^k = xls_{ij}^k\left(1 - xls_{ij}^k\right) + xrs_{ij}^k * xrs_{ij}^k / \left(1 - xls_{ij}^k + xrs_{ij}^k\right) \\ \overset{\sim}{\omega}_{ij}^k = min\ a_{ij}^n + x_{ij}^n \Delta_{min}^{max} \end{gathered} \tag{3}$$

Integrate crisp values from different opinions of k respondents:

$$\overset{\sim}{\omega}_{ij}^k = 1/k\left(\overset{\sim}{\omega}_{ij}^1 + \overset{\sim}{\omega}_{ij}^2 + \ldots + \overset{\sim}{\omega}_{ij}^k\right) \tag{4}$$

Application of the DEMATEL method:

Step 1: Generating matrices of scores (attitudes) of experts—$x_1, x_2, \ldots., x_e$

If it is assumed that there are e experts in the considered research and n factors to be considered, each expert should indicate (evaluate) the degree of influence that factor i exercises on factor j. The comparative analysis of pairs, i.e., mutual influence of the i-th and j-th factors, evaluated by the k-th expert is denoted as ${x_{ij}}^k$, where $i = 1, \ldots, n$; $j = 1, \ldots, n$; $k = 1, \ldots, e$. The value of each pair ${x_{ij}}^k$ is a triangular fuzzy number, where the scale shown in Table 4 is used.

Table 4. The fuzzy linguistic scale.

Linguistic Variable	Influence Score	Corresponding Triangular Fuzzy Numbers
No influence	0	0; 0.1; 0.3
Very low influence	1	0.1; 0.3; 0.5
Low influence	2	0.3; 0.5; 0.7
High influence	3	0.5; 0.7; 0.9
Very high influence	4	0.7; 0.9; 1

Each expert's answers are presented by an $n \times n$ non-negative matrix, where each element of the k-th matrix in the expression $x^k = [{x_{ij}}^k]_{n \times n}$ denotes a non-negative integer, where $k = 1, \ldots, e$. The matrices $x_1, x_2, \ldots., x_e$ represent the answers of each of the experts, in which the diagonal elements of the answer matrix are all set to zero since the same factors have no mutual influence.

Step 2: Calculating the matrix of average values of experts' scores (Average Matrix)—A

Based on the matrices of answers $x^k = [{x_{ij}}^k]_{n \times n}$ given by all experts, a matrix of experts' scores $A = [aij]_{n \times n}$ is formed, which represents the mean value of the attitudes of all the examined experts, for each element of the matrix A.

Step 3: Calculate the normalized influence matrix (Initial Direct-Relation Matrix)—D

Matrix D is calculated based on matrix A, where all major diagonal elements equal zero. Based on matrix D, the initial influence a certain factor exerts on and receives from another factor is shown. If we consider that

$$s = \max\left(\max_{1\le i\le n}\sum_{j=1}^{n} a_{ij};\ \max_{1\le j\le n}\sum_{i=1}^{n} a_{ij}\right) \tag{5}$$

then D = A/s. Since the sum of each *i*-th row of the matrix A represents the total direct effects that the factor *i* exerts on other factors, the expression

$$\max_{1\le i\le n}\sum_{j=1}^{n} a_{ij} \tag{6}$$

represents the largest direct effects of a particular factor on the other factors. Also, since the sum of each *j*th column of the matrix A represents the total direct effects factor j received from the other factors, the expression

$$\max_{1\le j\le n}\sum_{i=1}^{n} a_{ij} \tag{7}$$

represents the most significant total direct effects that a particular factor received from other factors. Matrix D is obtained when each element of matrix A is divided by the value *s*. Each element of matrix D has a value in the interval of 0–1.

Step 4: Computing the matrix of total influences—T

Matrix T, an $n \times n$ matrix, is calculated as follows: $T = D \times (I - D)^{-1}$. In this case, I represents a unit matrix $n \times n$.

The value r_i represents the sum of the *i*-th row of the matrix T and shows the direct and indirect effects of factor *i* on other factors. The notation c_j represents the sum of the *j*-th column of matrix T and shows the total direct and indirect effects, which factor *j* received from the other factors. The expression $(r_i + c_j)$ represents the importance of the factor, i.e., the degree of influence a particular factor has on the observed problem. The expression $(r_i - c_j)$ denotes the intensity of the influence of the effects of a factor on other factors. If the expression $(r_i - c_j)$ is positive, factor *i* influences other factors, i.e., the change conditioned by the action on factor *i* causes the change in other factors. If the observed expression is negative, factor *i* is influenced by the effects of other factors.

Step 5: Determining the limit value of the importance of factor influence (Threshold Value) *p* and constructing diagrams of mutual influences of the observed factors

Based on the opinion of the respondents (experts) or researchers, the lowest value of the importance of the influence of the factor *p* is determined, which filters low values of the intensity of the influence among the factors of the matrix T, i.e., the values that are lower than the defined threshold value. The elements of the matrix T, i.e., the values lower than the determined value of *p*, have a value of zero, and the other elements of the matrix T, which are higher than the value of *p*, retain the existing value. If the defined value of *p* is too low, the presentation of the system structure will be inadequate, complex, and difficult for decision makers to understand. The value of *p*, which is set too high, simplifies the structure of the system but can lead to the neglect and oversight of important influences in the system.

Based on the determined value of *p* and filtered values in the matrix T, a diagram of the mutual influences of the observed factors is constructed. This diagram enables an easier understanding of factor relations in the observed system and facilitates the decision-making process based on the results obtained by applying this method.

2.3. Development and Collection of the Survey Questionnaire

The development of the research instrument is based on the use of key elements in terms of reverse logistics implementation barriers, as described in Section 2.1. This was the basis of forming a matrix with items with a format of 16 × 16.

The study involved selecting respondents who were experts in the field of logistics to ensure the credibility and relevance of the research findings. The selection process began with identifying respondents from the academic community, specifically three university professors who specialized in quality, effectiveness, and logistics. These professors played a crucial role in the initial phase of the research by analyzing and validating the questionnaire designed for the study. Their expertise ensured that the questionnaire was both accurate and comprehensive, addressing all relevant aspects of reverse logistics. Once they confirmed that no further changes were necessary, the professors themselves filled out the questionnaire, thereby setting a benchmark for the research.

Following this, the study was expanded to include ten respondents from various companies in the Republic of Serbia, all of whom belonged to the processing sector. This sector includes industries such as automotive, food and beverage production, metal production and processing, and computer equipment manufacturing. These industries were chosen due to their significant involvement in logistics and supply chain activities, making them pertinent to the study of reverse logistics.

The respondents selected from these companies were experienced professionals who had worked in logistics roles for many years. Many of them were in managerial positions, overseeing logistics operations within their organizations. Their extensive experience meant they were well-acquainted with the concept of reverse logistics and understood its importance in the broader context of logistics functions and supply chain management within their organizations.

To ensure that the respondents fully understood the purpose and requirements of the study, they were provided with clear guidelines before completing the questionnaire. This helped standardize the responses and ensured that the data collected were consistent and reliable. In total, 13 completed questionnaires were collected by the end of the research process.

The sample size and composition were carefully considered to ensure that the research findings were representative of the processing sector in the Republic of Serbia. The study adhered to established sampling methods and guidelines as recommended in the relevant literature [40,54,61,64,78–80]. The sample was deemed to be representative of the research population, providing a solid foundation for drawing conclusions about the barriers to reverse logistics implementation in this context.

3. Results

After the evaluation score matrices were formed, the matrix of average values of the experts' scores—matrix A—was calculated. This matrix represents the mean value of the scores of all the experts included in the study and is presented in Table A1 as an excerpt (only sums of the columns and sums of the rows).

The next step involved calculating the normalized influence matrix—matrix D—using the formula D = A/s. The value of *s* represents the maximum sum of all rows and columns and is 5.828, as shown in Table A1.

After calculating the normalized impact matrix, the total impact matrix—matrix T—was calculated. Table A2 shows the matrix of total influences for the observed barriers (as an excerpt, only sums of the columns and sums of the rows).

It can be observed, as shown in Table A3, that barriers B13, B14, B12, B06, B09, B11, and B05 (ranked by the values of their intensity of influence (IFI), from the strongest to the weakest), belong to the group of factors whose effects influence (EI) other factors. The barriers B01, B15, B16, B07, B04, B08, B02, B10, and B03 belong to a group of factors that are influenced (receives influence—RI) by the effects of other factors. From the aspect of the significance of reverse logistics implementation barriers for organizations, the most significant barriers are B01, B05, B06, B02, and B03.

To construct a diagram of interdependent influences of the observed factors, the threshold value of the importance of the influence of factors (Threshold Value) *p* is defined, which represents the lowest value of the importance of interdependent influences of the observed factors, i.e., a "filter" of the values of intensity of influence among the factors. All elements from matrix T smaller than the defined *p* value are assigned a value of 0, while the others retain the existing value. Some authors say this value can be defined based on expert opinion or calculations. It is defined according to the recommendations in the literature [61–64,80–83] as the average value of the T matrix and is 0.321. Based on that, a filtered matrix of total interdependent influences was formed. Figure 2 shows a diagram of the interdependent influences of barriers to the implementation of reverse logistics, formed based on the values from Table A3 (the position of points in the diagram coordinate system) and based on the values from the filtered matrix of total interdependent influences (connection of points based on *p* values of the importance of factor influence). The diagram enables a graphical display of data to facilitate the observation and understanding of the relationship of factors in the observed system. Each link line indicates the influence between the two variables, and the arrowhead indicates which variable is influenced by the other in the relationship shown. In the case of a connection, the arrowheads on both sides indicate the mutual influence of the observed variables.

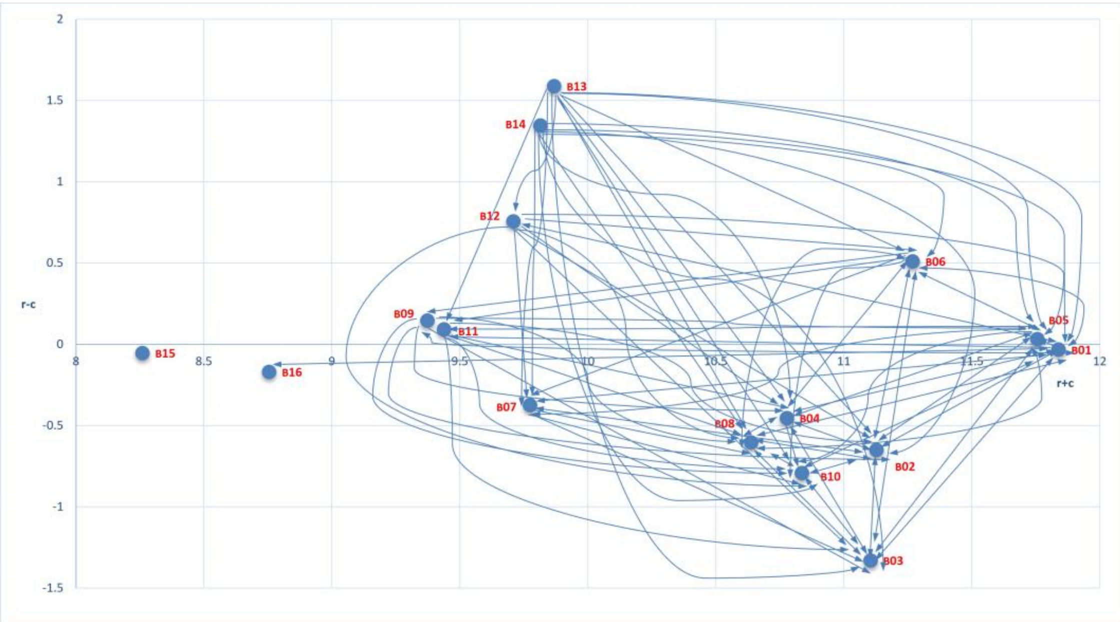

Figure 2. Diagram of interdependent influences of barriers to reverse logistics implementation.

4. Discussion

After analyzing the interdependent influence of reverse logistics implementation barriers, it can be concluded that, according to the level of importance for reverse logistics implementation, the most significant barriers are B01—Lack of expertise and knowledge on reverse logistics on the part of management, B05—Lack of cooperation with scientific institutions and professional associations to acquire knowledge and follow trends in the field, and B06—Lack of management support. They are organizational and management barriers, and considering the aspect of influencing other factors, barriers B05 and B06 belong to the group, which, by their presence, affects other barriers, so they can be considered key in reverse logistics implementation. This clearly shows the importance of supporting the management of organizations in the implementation of reverse logistics, as well as the need for cooperation with experts, following trends, and applying modern knowledge as essential prerequisites for the successful implementation of reverse logistics. The barriers that have been found (i.e., a lack of management support and cooperation with scientific institutions and professional associations to acquire knowledge and follow trends in the field) present significant challenges to the successful implementation of reverse logistics. These barriers may impede competitiveness and delay the adoption of sustainable practices in emerging economies, while they may cause missed chances for innovation and leadership in developed ones. Addressing these barriers requires targeted interventions tailored to the specific needs and contexts of both emerging and developed economies, with a focus on education, collaboration, and policy support. In emerging economies, businesses usually prioritize immediate financial returns over long-term sustainability practices like reverse logistics. The lack of management support may lead to a slower adoption of reverse logistics, which can result in missed opportunities for cost savings, resource efficiency, and environmental benefits. Furthermore, companies in emerging economies that do not embrace reverse logistics may find themselves at a competitive disadvantage in global markets where sustainability is increasingly valued.

Barriers B13—Lack of banking funds for "green technologies", lack of state incentives (e.g., tax reliefs), and legal norms, B14—Presence of risks (uncertainties) regarding the functioning of reverse logistics and benefits that would be realized, B12—High initial cost and operating costs of reverse logistics, and B06—Lack of management support are the factors that have the most decisive influence on other factors. Hence, their change significantly impacts other observed factors (barriers) in practice. Also, no other barrier exerts influence on barrier B13—Lack of banking funds for "green technologies", lack of state incentives (e.g., tax reliefs), and legal norms or on B14—Presence of risks (uncertainties) regarding the functioning of reverse logistics and benefits that would be realized, which indicates that they are independent of the presence of other barriers. A change in political and market conditions, in terms of adequate incentives for applying "green" technologies and incentive legal norms, would positively affect the lower intensity of most of the other observed barriers. Also, likely in the same way, other barriers would be affected by the reduction in risks (uncertainties) present regarding the functioning of reverse logistics and the benefits that would be realized.

Barriers B15—Consumer impression that used (e.g., recycled) products are of poorer quality and B16—Users' lack of knowledge about the rights and options for returning used products to the manufacturer can be considered the least significant in the context of this research because neither their influence on the other observed factors nor the influence of other factors on their appearance and intensification have been identified.

Comparing the results and conclusions obtained with the relevant literature makes it difficult to find agreement. The authors do not agree on the key reverse logistics implementation barriers due to the specifics of their grouping, the methods and techniques used in data analysis, the specific characteristics of the research population, the geography and industry sector, different economic conditions, rules, regulations, etc. [5–10,12,13,16–18,30–32,40,49,51,55,57,84]. However, many of these studies note that, among the significant barriers, there is a lack of sectoral agreements for reverse logistics and adequate legal norms, a lack of knowledge and information about reverse logistics, and a lack of cooperation with scientific and expert organizations regarding the implementation of reverse logistics. Also, the lack of support from the organization's management for implementing reverse logistics is a noticeable barrier, which also entails a lack of dedicated resources for the same activities.

It is critical to raise management awareness through targeted education and government incentives like subsidies and regulatory frameworks to remove barriers to reverse logistics in emerging economies. It is imperative to enhance cooperation among companies, educational institutions, and professional associations using public–private partnerships, knowledge-sharing networks, and certification programs. Investing in local expertise and technology adoption, alongside consumer awareness campaigns, can further support reverse logistics. Continuous improvement and alignment with sustainability objectives will be ensured by tracking developments and putting feedback mechanisms into place.

By offering an in-depth analysis of the particular obstacles that prevent reverse logistics from being implemented, especially in emerging economies, this research closes gaps in the body of current knowledge. This study highlights the organizational and strategic difficulties that are frequently disregarded, even though the majority of the literature currently in publication focuses on the technical and operational aspects of reverse logistics. By emphasizing the crucial function of management support as well as external partnerships, the study broadens the present comprehension of the elements influencing the adoption of reverse logistics. Additionally, it closes the gap between theory and practice by providing helpful advice specifically suited to the particular difficulties encountered by companies in developing countries. This contributes to a more thorough understanding of reverse logistics by investigating the contextual and systemic elements that affect its effectiveness.

5. Conclusions

To address the critical barriers to the successful implementation of reverse logistics, this research was designed with two primary objectives in mind. The primary goal was to identify and analyze the interdependent influences among various barriers that organizations face when trying to implement reverse logistics. Recognizing that reverse logistics is a complex process involving numerous stakeholders and multifaceted challenges, the study sought to uncover how these barriers interact with and influence each other. To achieve this primary objective, the research began by reviewing the perspectives of the academic community. A thorough literature review was conducted to compile a comprehensive list of potential barriers to reverse logistics. These barriers were then grouped based on their characteristics and potential impacts on the logistics process. The grouping helped in structuring the analysis and understanding the relationships between different barriers. The secondary goal of the research was to assess the relative significance of these barriers and to identify those that are of crucial importance. By determining which barriers are most critical, the study aimed to provide actionable insights that could help organizations prioritize their efforts when implementing reverse logistics. The most critical barriers to the successful implementation of reverse logistics are a lack of management support and cooperation with scientific institutions and professional associations to acquire knowledge and follow trends in the field.

The increased market uncertainty and economic instability characterize the research population environment. However, some authors believe that the research conducted in a growing (developing) economy and market uncertainty may be particularly significant for theoretical development. The obtained research results may indicate unexpected conclusions and phenomena that do not characterize the conditions of developed and stable economies. The information obtained from the present research can benefit organizations operating in similar market conditions by enabling their management to direct resources more efficiently in the decision-making process, considering the reverse logistics implementation barriers identified. Still, improvement can primarily be achieved by raising awareness among the top management and employees about the importance of reverse logistics implementation.

Like other studies, this study has some limitations. This paper analyzes the barriers to reverse logistics implementation but the framework does not indicate any solution for overcoming the barriers. Increased market uncertainty and the instability of the economy are characteristics of the environment of the surveyed organizations. This fact reflects the limitations of this research, which stem from the arguments that the obtained results represent valid information for the transitional economy and organizations in the Republic of Serbia. However, they can be used for research purposes in countries of the same economic status. Furthermore, this research provides a snapshot of the barriers to reverse logistics implementation at a specific point in time. However, the dynamic nature of market conditions, economic stability, and regulatory environments means that these barriers could evolve. Also, certain disadvantages of the DEMATEL method, such as the dependence on expert judgments and limited generalizability, should be considered when making conclusions. These research results represent one of the possible approaches to reverse logistics implementation and, as such, provide a basis for further research in this area.

The same investigation may be performed in the same industry sector but in the context of various countries. Likewise, this list of reverse logistics implementation barriers can be analyzed with different MCDM tools, including the organization perspective and other stakeholder perspectives such as customer perspectives, supply chain partner perspectives, or even government perspectives. The government perspective is critical in the context of involving government departments to gain a more holistic view of the political barriers, legal norms, and strategies for reverse logistics implementation and the benefits that would be realized at the state level in terms of the use of non-renewable resources, waste management, environmental impact, and sustainability in general. Furthermore, the findings of the study could be statistically compared with future research studies to check the similarities and differences. Based on the obtained research results, further research may consider other parameters that could contribute to the implementation of reverse logistics in organizations, such as:

- The most common mistakes in the implementation of reverse logistics in organizations and how they can be prevented.
- The employee competence and experience that is necessary to overcome barriers and how these contribute to the efficient and effective implementation and functioning of reverse logistics.
- The presence of a connection between individual reverse logistics activities, the criteria for selecting adequate options, and the influence on improving the organization's performance.
- Comparisons and a better understanding of experts' attitudes and opinions between developing and developed economies when overcoming reverse logistics implementation barriers.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. The matrix of average values of the experts' scores—A (excerpt).

Sums of the Columns	Sums of the Rows
5.623408058	5.626321315
5.488892873	4.97082107
5.827794653	4.549468852
5.260598647	4.861875878
5.570943513	5.562029209
5.09204943	5.60664724
4.837062849	4.462976677

Table A1. *Cont.*

Sums of the Columns	Sums of the Rows
5.317298085	4.759749961
4.367603812	4.522223869
5.564996732	4.773407048
4.471545243	4.484996502
4.256421822	4.924220551
3.907297234	5.435499165
4.011719221	5.297910542
3.947072962	3.861728738
4.204069922	4.048898441

Table A2. Total impact matrix—T (excerpt).

Sums of the Columns	Sums of the Rows
5.936483288	5.902794762
5.88941195	5.238089444
6.217521505	4.886816995
5.616217674	5.161682413
5.863111086	5.893665099
5.379724257	5.88963136
5.074404165	4.69955839
5.620990503	5.016801103
4.614046171	4.75910513
5.814500902	5.021463096
4.673472737	4.76487518
4.476577083	5.23240806
4.139817559	5.728115936
4.234417682	5.580889116
4.157339513	4.103044428
4.463028557	4.292124121

Table A3. Importance and intensity of influence.

FI	**1**	**4**	**5**	**7**	**2**	**3**	**11**	**8**	**14**	**6**	**13**	**12**	**9**	**10**	**16**	**15**
r + c	11.84	11.13	11.10	10.78	11.76	11.27	9.77	10.64	9.37	10.84	9.44	9.71	9.87	9.82	8.26	8.76
F	B01	B02	B03	B04	B05	B06	B07	B08	B09	B10	B11	B12	B13	B14	B15	B16
R − c	−0.03	−0.65	−1.33	−0.45	0.03	0.51	−0.37	−0.60	0.15	−0.79	0.09	0.76	1.59	1.35	−0.05	−0.17
IFI	RI	RI	RI	RI	EI	EI	RI	RI	EI	RI	EI	EI	EI	EI	RI	RI

Table A4. Fuzzy direct relationship matrix.

	B01	**B02**	**B03**	**B04**	**B05**	**B06**	**B07**	**B08**	**B09**	**B10**	**B11**	**B12**	**B13**	**B14**	**B15**	**B16**
B01	0.00	0.62	0.51	0.46	0.46	0.33	0.35	0.51	0.27	0.36	0.34	0.31	0.30	0.26	0.24	0.31
B02	0.40	0.00	0.62	0.41	0.41	0.32	0.31	0.45	0.25	0.33	0.29	0.22	0.21	0.20	0.25	0.29
B03	0.41	0.40	0.00	0.49	0.47	0.41	0.21	0.31	0.26	0.34	0.20	0.23	0.23	0.18	0.18	0.22
B04	0.48	0.45	0.50	0.00	0.42	0.41	0.23	0.31	0.30	0.35	0.21	0.22	0.17	0.25	0.25	0.32
B05	0.65	0.58	0.54	0.34	0.00	0.42	0.32	0.35	0.24	0.44	0.26	0.24	0.35	0.31	0.24	0.28
B06	0.39	0.55	0.48	0.45	0.51	0.00	0.41	0.41	0.31	0.34	0.40	0.29	0.25	0.29	0.23	0.29
B07	0.30	0.29	0.31	0.29	0.26	0.22	0.00	0.43	0.35	0.43	0.31	0.27	0.25	0.23	0.23	0.29
B08	0.31	0.38	0.40	0.41	0.27	0.35	0.36	0.00	0.32	0.41	0.22	0.32	0.21	0.26	0.25	0.28
B09	0.28	0.28	0.33	0.31	0.26	0.28	0.27	0.29	0.00	0.39	0.43	0.33	0.23	0.27	0.28	0.28

Table A4. *Cont.*

	B01	B02	B03	B04	B05	B06	B07	B08	B09	B10	B11	B12	B13	B14	B15	B16
B10	0.34	0.30	0.37	0.35	0.30	0.32	0.34	0.34	0.34	0.00	0.24	0.32	0.25	0.31	0.33	0.32
B11	0.29	0.30	0.26	0.32	0.42	0.30	0.42	0.32	0.29	0.32	0.00	0.30	0.30	0.20	0.26	0.18
B12	0.34	0.23	0.32	0.21	0.40	0.46	0.42	0.38	0.26	0.35	0.36	0.00	0.35	0.36	0.25	0.23
B13	0.44	0.36	0.34	0.26	0.51	0.36	0.41	0.40	0.24	0.35	0.47	0.42	0.00	0.29	0.30	0.29
B14	0.46	0.33	0.40	0.36	0.36	0.42	0.34	0.34	0.33	0.41	0.29	0.36	0.26	0.00	0.33	0.30
B15	0.31	0.19	0.21	0.28	0.23	0.23	0.20	0.26	0.31	0.39	0.22	0.18	0.25	0.28	0.00	0.33
B16	0.23	0.22	0.24	0.32	0.28	0.25	0.26	0.21	0.31	0.34	0.22	0.25	0.28	0.31	0.32	0.00

Table A5. Normalized fuzzy direct relationship matrix.

	B01	B02	B03	B04	B05	B06	B07	B08	B09	B10	B11	B12	B13	B14	B15	B16
B01	0.00	0.11	0.09	0.08	0.08	0.06	0.06	0.09	0.05	0.06	0.06	0.05	0.05	0.04	0.04	0.05
B02	0.07	0.00	0.11	0.07	0.07	0.05	0.05	0.08	0.04	0.06	0.05	0.04	0.04	0.04	0.04	0.05
B03	0.07	0.07	0.00	0.08	0.08	0.07	0.04	0.05	0.04	0.06	0.04	0.04	0.04	0.03	0.03	0.04
B04	0.08	0.08	0.09	0.00	0.07	0.07	0.04	0.05	0.05	0.06	0.04	0.04	0.03	0.04	0.04	0.05
B05	0.11	0.10	0.09	0.06	0.00	0.07	0.06	0.06	0.04	0.08	0.05	0.04	0.06	0.05	0.04	0.05
B06	0.07	0.09	0.08	0.08	0.09	0.00	0.07	0.07	0.05	0.06	0.07	0.05	0.04	0.05	0.04	0.05
B07	0.05	0.05	0.05	0.05	0.04	0.04	0.00	0.07	0.06	0.07	0.05	0.05	0.04	0.04	0.04	0.05
B08	0.05	0.07	0.07	0.07	0.05	0.06	0.06	0.00	0.06	0.07	0.04	0.06	0.04	0.04	0.04	0.05
B09	0.05	0.05	0.06	0.05	0.04	0.05	0.05	0.05	0.00	0.07	0.07	0.06	0.04	0.05	0.05	0.05
B10	0.06	0.05	0.06	0.06	0.05	0.05	0.06	0.06	0.06	0.00	0.04	0.05	0.04	0.05	0.06	0.05
B11	0.05	0.05	0.05	0.05	0.07	0.05	0.07	0.06	0.05	0.06	0.00	0.05	0.05	0.03	0.04	0.03
B12	0.06	0.04	0.06	0.04	0.07	0.08	0.07	0.06	0.04	0.06	0.06	0.00	0.06	0.06	0.04	0.04
B13	0.07	0.06	0.06	0.05	0.09	0.06	0.07	0.07	0.04	0.06	0.08	0.07	0.00	0.05	0.05	0.05
B14	0.08	0.06	0.07	0.06	0.06	0.07	0.06	0.06	0.06	0.07	0.05	0.06	0.05	0.00	0.06	0.05
B15	0.05	0.03	0.04	0.05	0.04	0.04	0.03	0.05	0.05	0.07	0.04	0.03	0.04	0.05	0.00	0.06
B16	0.04	0.04	0.04	0.05	0.05	0.04	0.04	0.04	0.05	0.06	0.04	0.04	0.05	0.05	0.06	0.00

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