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Quantitative Analysis in Prioritizing Elements for Efficient Logistics Strategies: A Case Study in Eskişehir

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Abstract

Logistics strategies are essential elements in the concepts of designing and operating logistics processes and systems, identifying visions, selecting feasible goals, constructing plans, decisions, and policies that help businesses in achieving their goals. Also, the issues of implementing logistics services in a shorter time, customer suitability, low cost, and customer support from pre- to after-sales have an impact on the customers' service perceptions. By this means, better customer satisfaction can be achieved. However, the importance of factors in logistics strategy according to the customer's perspective needs to be determined. Value-added elements of acquiring internal and external customer satisfaction, decreasing costs, strengthening visibility, and presenting the right product to the right customers in a suitable place, as promotion activity shows the importance of logistics strategies for businesses. In this study, elements effective in forming logistic strategies for manufacturing firms having more than 50 employees in Eskişehir are aimed to prioritize. DEMATEL, as a Multi-Criteria Decision-Making (MCDM) technique, examines the logical relationship of factors, and researching the direct influence matrix in a complex system is handled as a prioritization method. Pythagorean Fuzzy Sets (PFS) are preferred to better explain the judgments of decision-makers in uncertainty by giving more flexibility than fuzzy and Intuitionistic Fuzzy Sets (IFS).

Keywords: Logistics, Forming logistics strategy, Pythagorean fuzzy sets, DEMATEL.

1 | Introduction

With the globalization era, today's businesses are able to supply goods and services to markets all over the world; likewise, they can provide goods and services from these markets. These developments in trade and

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the intense competitive environment have led the companies to organize their supply chain within the scope of a strategic partnership. This situation has changed the quality and quantity of logistics activities [1]. In some studies, environmental concerns have been noted, but most of them have focused primarily on the field of marketing and logistics strategy [2]. Determination of how competitive advantages are obtained and their basis is the working area of strategic management research. Sustainable competitive advantage in providing a level for an enterprise can be achieved by defining and implementing a strategy that will differentiate itself from the competitors [3].

Logistics strategies contain logistics systems design, operation, determination of the vision, selection of the appropriate targets for this vision, policies, and decisions that the business needs to achieve its aims. Logistic strategies have been described for how these can be achieved [4]. In addition, logistic strategies have needed to focus on three main issues carefully, which are to reduce costs, minimize capital requirements, and improve service quality. Reducing costs is a core strategy, especially aimed at minimizing total transport and storage costs, when logistic functions have been considered. Minimum capital requirements are a strategy aimed at minimizing investment levels to be implemented in a logistics system or department. Providing a high level of service quality increases the costs, but the high level of gains can cover the increase in these costs [5].

Careful decisions, not by chance, must be made for the logistics strategy. So, these questions can be asked: how do organizations make these decisions? Why do organizations build logistics systems on flexibility rather than cost? Why does a business choose to specialize, and why does a similar business choose differentiation? The starting point in determining the logistics strategy is to assess how logistics will contribute to these strategies in order to adapt to higher organizational strategies [6]. Because the distribution function, which is a critical element in the conduct of marketing activities, has a strategic importance, especially in providing the competitive advantage of the companies where product distribution management has operated globally [7].

Realization of logistic services in a short time, suitability to the customer, low cost, and customer support from pre-sale to post-sale have affected the service perception of the customers. In this way, customer satisfaction can be achieved. But which factors are more important than the customer's perspective, and which should take place in a logistics strategy, should be determined in advance [8]. For this reason, the 4P of marketing (product, price, promotion, and distribution), which is frequently used in marketing departments, may be used as a logistics strategy. Logistics has a very effective role in packaging the product, in transaction costs and price, with the contribution of visibility, the product having the right place to meet the right customer in distribution. A specifically defined logistics strategy should include these characteristics [9].

Bowersox and Daugherty have identified three strategic orientations in determining logistics strategy. These are process, market, and information (channel) strategies. In the process strategy, logistics activities have been managed as a system that provides an added value to its customers and supply chain partners. In the market strategy, the minimum part of the logistics activities has been managed through other departments of the enterprise. In the information (channel) strategy, it has been managed as a channel system in coordination with other activities that are different from logistics activities [10]. So, occasionally, logistics strategies can affect all the decisions throughout the supply chain. The application areas of these strategies have been listed respectively as follows: supply chain planning, loading planning on transport vehicles, transportation capabilities planning, route planning, and related programming and storage [11].

The importance of creating logistic strategies in all the processes mentioned above plays an active role in providing logistical support activities without interruption and providing a competitive advantage with cost advantage. The formation of a logistics strategy is considered a multi-criteria decision-making problem where logistics planning at operational and strategic levels and process efficiency are combined with quantitative and qualitative elements.

The elements that form logistics strategies provide economic benefits. Efficient usage of business resources can be defined as follows: through reduced logistics costs, higher customer service satisfaction level, forming time utility, fulfilling the logistics needs that rise with production/quantity elasticity, efficient usage of technological developments in logistics processes, and constructing place utility [12–17]. Accordingly, the aforementioned elements that are very effective for forming logistics strategy can also be considered vital for businesses; furthermore, no study prioritized elements in the logistics strategy process according to the authors' view.

This study aims to prioritize the factors that affect the formation of logistic strategies in manufacturing enterprises having 50 or more employees in Eskişehir. The Pythagorean fuzzy DEMATEL method has been used for this study. In the second section, the importance of logistics strategy and a comprehensive literature review on logistics strategy have been discussed. In the third part, information about the Pythagorean fuzzy and DEMATEL methods has been presented. And the application part of the study has been given in the following stage. In the last part, suggestions have been made about the results and future studies.

2 | Literature Review

Some studies on logistics strategies are as follows: McGinnis and Kohn [18] discussed the impact of logistics strategies on the internal and external environment of the business and the competition it provides in terms of time. Cooper and Ellram [19] discussed logistics strategies in supply chain management. Clinton et al. [20] studied the importance of logistics strategies on logistics management in American and Canadian firms. Stock et al. [21] revealed the relationships between logistics, strategy, and structure in production enterprises. Savitskie [22] discussed the impact of logistics strategies and logistics technologies on logistics performance. Bilginer and Kayabaşı [23] investigated competitive perspective levels of logistics activities in production enterprises. Spillan et al. [24] studied the factors of different-sized firms providing cost advantage, increasing customer satisfaction, and better coordinating channel activities with logistic strategies. Erten [25] studied the application level of logistics process management in a public institution. McGinnis et al. [26] studied the structure of the logistics strategy models in Third World Countries. Beškovnik and Twrdy [27] discussed the level of implementation of green logistics strategies in Northern Europe and the development of green transport corridors.

Yıldız et al. [28] studied the factors that lead businesses to logistics activities. Dinter [29] discussed critical success factors in logistics information strategies. Kolinska and Cudzilo [30] have emphasized the importance of logistics activities in the supply chain to improve efficiency. Bakan and Şekkeli [31] studied the effects of logistics sub-strategies on customer relationship ability and logistics innovation ability. Akis [32] studied the impact of the competitiveness of the logistics sector in Turkey. Erdal and Korucuk [33] conducted a comparative analysis on the determination of innovation priorities in the logistics sector. Sağlam [34] conducted a thesis on the possible effects on Turkey's export performance of an integrated logistics strategy. Mendes et. al. [35] evaluated logistics strategies for perishable food products with decision support systems. Qin et. al. [36] examined the optimal combination between sales mode and logistics service strategy in the e-commerce market. Korucuk et. al. [37] selection of the optimal capacity strategy by rating the complexity in supply chain dynamics in food enterprises during COVID-19. Korucuk et. al. [38] investigated the ideal smart network strategies for logistics companies and made recommendations. Aytekin et. al. [39] used a T-spherical fuzzy-based methodology to select the optimal sustainable green strategy for logistics companies.

In the literature research, logistic strategies had been addressed in one dimension. In this study, the importance levels of strategies with Multi-Criteria Decision-Making (MCDM) techniques have been examined.

3 | Methodology

3.1 | Pythagorean Fuzzy Sets

The Pythagorean Fuzzy Set (PFS) was developed by Yager [40] as a generalization of Intuitionistic Fuzzy Sets (IFS) in order to better deal with conditions for degrees of membership and non-membership having value greater than 1. PFS, as an extension of IFS, can handle indeterminate and uncertain judgments of human beings more flexibly and efficiently. PFS can be defined as a fuzzy set having Pythagorean membership grades. Let X be a fixed set. A PFS L is a mathematical object having the form as below:

$$\mathrm{L}: \{< \mathrm{x}, \mu_{\mathrm{L}}(\mathrm{x}), \mathrm{v}_{\mathrm{L}}(\mathrm{x}) >; \mathrm{x} \in \mathrm{X}\}, \tag{1}$$

where the function $\mu_L(x): x \to [0,1]$ represents the degree of the membership and $v_L(x): x \to [0,1]$ symbolizes the degree of non-membership of the element $x \in X$ to L respectively, for every $x \in X$,

$$0 \leq \left(\mu_L(x)\right)^2 + \left(v_L(x)\right)^2 \leq 1. \tag{2}$$

PFS is characterized by membership and non-membership degrees whose sum of squares is less than or equal to 1. Additionally, the hesitant degree of $x \in X$, $(\pi_L(x))$ is calculated as follows:

$$\pi_L(x) = \sqrt{1 - \left(\mu_L(x)\right)^2 - (v_L(x))^2}. \tag{3}$$

Let $E_1 = L(\mu_{C_1}, v_{C_1})$ and $E_2 = L(\mu_{C_2}, v_{C_2})$ be two Pythagorean Fuzzy Numbers (PFNs) and $\lambda > 0$. Then, the operations on these two PFNs are described as follows:

$$E_1 \oplus E_2 = L\left(\sqrt{\mu_{C_1} + \mu_{C_2} - \mu_{C_1}\mu_{C_2}},\ v_{C_1}v_{C_2}\right). \tag{4}$$

$$E_1 \otimes E_2 = L\left(\mu_{C_1}\mu_{C_2}, \sqrt{v_{C_1} + v_{C_2} - v_{C_1}v_{C_2}}\right). \tag{5}$$

$$\lambda E_1 = \left(\sqrt{1 - \left(1 - \mu_{C_1}^2\right)^{\lambda}}, {v_1}^{\lambda}\right). \tag{6}$$

$$E_1^{\lambda} = \left(\mu_{C_1}^{\lambda}, \sqrt{1 - \left(1 - v_{C_1}^2\right)^{\lambda}}\right). \tag{7}$$

Decision makers' judgments are aggregated via the Pythagorean fuzzy aggregated weighted averaging (PFAWA) approach, which was developed by Zhang [41] and can be explained as follows:

$$\beta_{ij} = \mathrm{PFAWA}\left(\beta_{ij}^1, \beta_{ij}^2, \dots, \beta_{ij}^s\right) = \textstyle\sum_{m=1}^{s} \lambda_m \beta_{ij}^m \left[\sqrt{1 - \prod_{m=1}^{s}(1 - (\mu_{ij}^m)^2)^{\lambda_m}}, \prod_{m=1}^{s}(v_{ij}^m)^{\lambda_m}\right]. \tag{8}$$

where $\beta_{ij}^m = (\mu_{ij}^m, v_{ij}^m)$ as PFN represents the opinion of decision maker $m, (m = 1,2, \dots, s)$ in terms of linguistic terms. The significance of decision makers' judgments according to probability estimation is shown by a weighting approach that assigns a weight (λ_m) to each decision maker, $\lambda_m > 0$ $(m = 1,2, \dots, s)$ and $(\sum_{m=1}^{s} \lambda_m = 1)$.

After that, PFN is transformed into a crisp one via the defuzzification process. For this purpose, the risk preference coefficient as ξ $(\xi \in [0,1])$ showing the importance of hesitancy degree is computed as below [42], [43]:

$$CV_{\beta_{ij}} = 0.5(1 + \mu_{ij} - v_{ij} + (\xi - 0.5) x \pi_{ij}). \tag{9}$$

3.2 | Pythagorean Fuzzy DEMATEL

The DEcision-MAking Trial and Evaluation Laboratory (DEMATEL), which was developed by Geneva Research Centre of the Battelle Memorial Institute between the years of 1972-1976, is used to analyze complex and intertwined problem groups [44]. DEMATEL is a structural model revealing the causal relationships between the factors via diagrams and matrices [45]. Components of the system are visualized by diagrams and matrices in terms of the strength of the influence [46]. The DEMATEL method involves indirect, implicit relationships involving compromise of the cause-and-effect model. The relationship between cause-and-effect factors can be converted into an intelligible structural model via the DEMATEL method [47]. The procedure of the Pythagorean fuzzy DEMATEL method is summarized as follows [43], [47], [48]:

Step 1 (Creating the direct relationship matrix). A direct relation matrix is formed by using the pair-wise comparison scale composed of linguistic terms identified by decision makers. A seven-point Pythagorean fuzzy linguistic scale can be shown as *Table 1*.

Table 1. Seven-point Pythagorean fuzzy linguistic scale [49].

Linguistic Terms	Pythagorean Fuzzy Number
Very low	(0.15,0.85)
Low	(0.25,0.75)
Moderately low	(0.35,0.65)
Medium	(0.5,0.45)
Moderately high	(0.65,0.35)
High	(0.75,0.25)
Very high	(0.85,0.15)

The initial direct relation matrix C_{nxn} in terms of influences and directions between criteria, where c_{ij} denotes the degree to which the criterion i affects the criterion j and can be represented as follows:

$$C_{nxn} = \begin{bmatrix} (\mu_{11}, v_{11}) & \cdots & (\mu_{1j}, v_{1j}) \\ \vdots & \ddots & \vdots \\ (\mu_{i1}, v_{i1}) & \cdots & (\mu_{ij}, v_{ij}) \end{bmatrix}. \quad (10)$$

Step 2 (Aggregating the opinions of decision makers). Decision makers' opinions obtained in terms of PFNs are aggregated via *Eq. (8)* as a Pythagorean fuzzy aggregated weighted averaging approach. The defuzzification process is applied by using *Eq. (9)*.

Step 3 (Acquiring a normalized direct relation matrix). The normalized direct relation matrix is computed by using *Eq. (11)*:

$$X = \frac{1}{\max \sum_{j=1}^{n} c_{ij}} x C_{nxn}, \ 1 \le i \le n. \quad (11)$$

Step 4 (Obtaining the total-relation matrix). Once the normalized direct-relation matrix X has been obtained, the total-relation matrix T can be acquired by using *Eq. (12)*, where I is represented as the identity matrix.

$$T = X(I - X)^{-1}. \quad (12)$$

Step 5 (Producing a causal diagram and analyzing results). The sum of columns and the sum of rows are used to derive vector F and vector E within the total relation matrix T via *Eqs. (13)-(15)* respectively. Then, the horizontal axis vector (E+F), called "Prominence", is formed by adding E to F, which indicates the level of importance of the criterion. Similarly, the vertical axis (E-F), called "Relation", is formed by subtracting E from F, which may divide criteria into a cause group and an effect group. If (E-F) >0, the criterion belongs to the cause group; otherwise, it belongs to the effect group. Therefore, the causal diagram can be derived by mapping the dataset of (E+F, E-F), which provides valuable insights for making decisions.

$$T = \left|t_{ij}\right|_{nxn}.. \quad (13)$$

$$E = \left[\sum_{i=1}^{n} t_{ij}\right]_{nx1} = \left|t_{i.}\right|_{nx1}. \quad (14)$$

$$F = \left[\sum_{j=1}^{n} t_{ij}\right]_{1xn} = \left|t_{.j}\right|_{1xn}. \quad (15)$$

Step 6 (Acquiring the importance value of criteria). The importance value of each criterion can be computed as *Eq.(16)* and *Eq. (17)* by taking (E+F) and (E-F) values into account [50], [51].

$$w_i = \sqrt{(E_i + F_i)^2 + (E_i - F_i)^2}. \quad (16)$$

The final weight of each criterion is calculated by applying the normalization process as follows:

$$fw_i = \frac{w_i}{\sum_{i=1}^{n} w_i}, i = 1,2, \dots, n. \quad (17)$$

4 | Analysis

Elements that are considered for prioritizing in terms of efficient logistics strategies can be stated as reduced logistics costs, higher customer service satisfaction level, forming time utility, fulfilling the logistics needs that rise with production/quantity elasticity, efficient usage of technological developments in logistics processes, and constructing place utility, and can be coded as *Table 2*.

Table 2. Elements for efficient logistics strategies.

Elements	Coding Value
C1	Reducing logistics costs
C2	Higher customer service satisfaction level
C3	Forming time utility
C4	Providing high-quality logistics service
C5	Fulfilling the logistics needs that rise with production/quantity elasticity
C6	Efficient usage of technological developments in logistics processes
C7	Constructing place utility

A survey was prepared to find the importance level of elements for efficient logistic strategies based on a seven-point Pythagorean fuzzy linguistic scale, converting the DEMATEL comparison scale to PFNs. As a result, surveys were filled out by 12 decision makers in manufacturing firms having more than 50 employees in Eskişehir. Equal weights are assigned to each decision maker, and the risk preference coefficient (ξ) is considered as 0.5 according to the results of expert discussions. Then, a direct relationship matrix consisting of PFNs is created by using the Pythagorean fuzzy aggregated weighted averaging approach, as shown in *Table 3*.

Table 3. Direct relationship matrix consisting of PFNs ($\xi = 0.5$).

Criteria	C1	C2	C3	C4	C5	C6	C7
C1	0	(0.757,0.247)	(0.741,0.276)	(0.504,0.539)	(0.583,0.441)	(0.416,0.647)	(0.733,0.279)
C2	(0.631,0.38)	0	(0.676,0.331)	(0.605,0.422)	(0.501,0.534)	(0.432,0.608)	(0.658,0.368)
C3	(0.488,0.538)	(0.449,0.581)	0	(0.505,0.534)	(0.419,0.623)	(0.203,0.805)	(0.522,0.544)
C4	(0.533,0.501)	(0.521,0.509)	(0.443,0.577)	0	(0.579,0.464)	(0.498,0.536)	(0.683,0.335)
C5	(0.465,0.582)	(0.496,0.547)	(0.463,0.577)	(0.47,0.564)	0	(0.533,0.506)	(0.762,0.239)
C6	(0.635,0.394)	(0.417,0.617)	(0.415,0.618)	(0.585,0.44)	(0.62,0.406)	0	(0.793,0.207)
C7	(0.38,0.668)	(0.424,0.621)	(0.721,0.305)	(0.541,0.504)	(0.38,0.668)	(0.237,0.771)	0

After that, the defuzzification process is applied via *Eq. (9)*, and a new direct relationship matrix consisting of crisp values is created and seen in *Table 4*.

Table 4. Direct relationship matrix consisting of crisp values ($\xi = 0.5$).

Criteria	C1	C2	C3	C4	C5	C6	C7
C1	0	0.754899	0.732732	0.482545	0.570701	0.384736	0.727308
C2	0.625577	0	0.672462	0.591222	0.483509	0.412292	0.645332
C3	0.475238	0.433802	0	0.485481	0.397975	0.198833	0.4889
C4	0.515648	0.505834	0.43308	0	0.557412	0.481188	0.673699
C5	0.441582	0.474407	0.442899	0.453047	0	0.513357	0.761613
C6	0.62076	0.400304	0.398836	0.572635	0.606807	0	0.792835
C7	0.356007	0.401133	0.70781	0.518408	0.356007	0.233078	0

A normalized direct relation matrix is created via *Eq. (11),* and then the total relation matrix T is acquired by using *Eq. (12)* and seen in *Table 5*.

Table 5. Total relation matrix ($\xi = 0.5$).

Criteria	C1	C2	C3	C4	C5	C6	C7
C1	0.728096	0.899928	1.004461	0.871443	0.846957	0.643176	1.114387
C2	0.838141	0.691227	0.948895	0.855834	0.794594	0.622285	1.051219
C3	0.635015	0.627245	0.597482	0.656248	0.608302	0.447351	0.795999
C4	0.771156	0.76766	0.847644	0.671259	0.767825	0.606018	1.002447
C5	0.736123	0.740722	0.828441	0.762539	0.615898	0.597277	0.995471
C6	0.832095	0.786052	0.886544	0.847963	0.817801	0.520153	1.080022
C7	0.617772	0.626247	0.769229	0.671667	0.606296	0.458906	0.686471

Prominence (horizontal) and relation (vertical) axes represented by (E+F) and (E-F) are calculated for creating a causal diagram. Computations for these axes can be shown in *Table 6*.

Table 6. Prominence and relation axes computations for a causal diagram ($\xi = 0.5$).

Criteria	E+F	E-F
C1	11.26685	-0.95005
C2	10.94128	-0.66311
C3	10.25034	1.515053
C4	10.77096	-0.09706
C5	10.33414	-0.2188
C6	9.665797	-1.87546
C7	11.1626	2.289428

According to *Table 6*, criterion 7, named constructing place utility, was found to be the most considered cause criterion, with a prominence value of 11.1626. On the other hand, criterion 6, named efficient usage of technological developments in logistics processes, was acquired as the most considered effect criterion, having the relation value of -1.87546.

Decision makers need to pay more attention to the cause criteria group because of its impact on the whole system and goal. Also, they achieve a high level of performance via controlling and focusing on cause group criteria. Constructing place utility (C7) is identified with the highest E-F score, with '2.289428', meaning that C7 has a greater level of impact on the whole system than it does when receiving from other criteria. The degree of importance (E+F) score for criterion C7 is 11.1626, which ranks second among all cause criteria. Therefore, C7 has been defined as having a remarkable impact on other criteria, and an anticipated improvement of C7 will lead to the recovery of the whole system.

The criterion with the second-highest E-F score is identified as C3, namely forming time utility with a score of 1.515053. The degree of importance (E+F) score for criterion C3 is 10.250, which ranks sixth among all criteria. Degree of influential impact (E) of C3 is 5.882695 and is ranked in second place among all criteria. The degree of influence (F) of C3 is 4.367642, which means that the smaller impact it receives from other values examined ultimately leads to a small value for the degree of importance (E+F). So C3 needs to be considered as a notable impact on other criteria, and improvement of C3 will lead to the recovery of the whole system.

The features for each affected criterion need to be examined closely to identify which factor would prove vital in the efficient logistics strategies, despite being easily impacted by other criteria. From among all criteria within the effect group, efficient usage of technological developments in logistics processes (C6), which has the lowest E-F score with -1.87546, can be identified as the most affected by other criteria. But with a lower degree of influence and the degree of influenced impact values, this leads to a lower degree of importance (E+F) value of 9.665797. However, this criterion can be improved upon by adjusting other examined criteria, so it is not recognized as an essential factor for efficient logistics strategies.

The criterion with the second lowest E-F score is defined as C1, namely reducing logistics costs, with a score of -0.95005. On the contrary, the degree of importance (E+F) score for C1 is 11.26685, which ranks in first place among all criteria due to having the highest degree of influence (F) value as 6.108448, meaning that it receives the largest impact from other values examined. Therefore, C1 needs to be considered as a vital impact apart from the cause criteria groups.

Criteria are divided into cause (C3 and C7) and effect (C1, C2, C4, C5, and C6) criteria groups by relationship values (E-F). Criteria affecting efficient logistics strategies can be stated as C3 and C7. On the contrary, the criteria that were affected by the efficient logistics strategies are defined as C1, C2, C4, C5, and C6.

Additionally, the importance values of criteria for efficient logistics strategies are computed via *Eq. (16)* and *Eq. (17)*, and shown in *Table 7*.

Table 7. Final weights for criteria related to efficient logistics strategies ($\xi = 0.5$).

Criteria	fw_i	Rank
C1	0.1508	2
C2	0.146193	3
C3	0.138195	5
C4	0.143659	4
C5	0.137858	6
C6	0.131318	7
C7	0.151976	1

According to the results of final weights, while constructing place utility (C7) is identified as the most vital criterion, having the importance value of 0.151976, efficient usage of technological developments in logistics processes (C6) is identified as the least vital one, having the importance value of 0.131318, showing similarity with the cause-and-effect model. Final weights for criteria related to efficient logistics strategies can be ranked as C7>C1>C2>C4>C3>C5>C6. The obtained results verify the importance and impact of the cause-and-effect model on the whole system.

5 | Conclusion

Nowadays, firms focus on practical and sustainable business models in the process of change and transformation at strategic and operational levels due to globally intense competition. The concepts of logistics strategy and its formation have gained importance via new generation supply chain and logistics solutions because the creation and implementation of logistics strategy is vital for both continuity of the enterprises and their future-based policies. Firms that do not form or implement a logistics strategy in a dynamic and agile environment can lose their competitive power and level. Thus, they gain superiority against competitors and also improve the level of internal and external customer satisfaction via determined and implemented logistics strategies. Long-term permanence, efficiency, and sustainability can be achieved by preparing and implementing efficient logistics strategies.

In this direction, elements effective in constructing efficient logistics strategies for manufacturing firms having more than 50 employees are prioritized from the PFS-based DEMATEL method. Elements are analyzed by dividing into cause-and-effect groups according to their relationship values (E-F). Constructing place utility (C7) was found to be the most vital cause criterion by having a greater level of impact on the whole system than it does when receiving from other criteria. On the other hand, efficient usage of technological developments in logistics processes (C6) was handled as the most remarkable effect criterion, as it is easily affected by other criteria in terms of efficient logistics strategies. The criteria are weighted and ranked by taking (E+F) and (E-F) values into account. As generally stated, elements of forming time and place utility, reducing logistics costs, and providing a higher customer satisfaction level are given higher importance by decision makers in the logistics strategies process. According to the authors' knowledge, it is the first study from the viewpoint of examining critical elements for efficient logistics strategies in uncertainty via PFS-based DEMATEL. Decision makers can express their views more flexibly by this method. Elements for efficient logistics strategies can be expanded and analyzed by using other hybrid techniques in future studies.

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Author Contribution

Conceptualization, S.K.; Methodology, Ş.B.B. and Ç.K.; Software, Ş.B.B. and Ç.K.; formal analysis, Ç.K.; resources, S.K., Ş.B.B. and Ç.K.; writing-creating the initial design, S.K., Ş.B.B. and Ç.K.; writing-reviewing and editing, S.K., Ş.B.B. and Ç.K.; visualization, Ş.B.B. and Ç.K.; project management, Ş.B.B. and Ç.K. All authors have read and agreed to the published version of the manuscript.

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Data Availability

The dataset generated and/or analyzed during the current study is available without restriction within the manuscript.

Conflicts of Interest

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