Assessing Supplier Suitability for Leagile Supply Chains: A Multi-Criteria Decision-Making Approach to Enhance Leanness and Agility

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Abstract

In today's dynamic business environment, effective supply chain management is vital for maintaining competitive advantage. Supplier selection is a crucial aspect of "leagile supply chains", ensuring alignment with lean and agile principles. This paper presents a comprehensive methodology using a recognized MCDM tool, MARCOS, to assess supplier suitability based on multiple criteria derived from existing literature. Moreover, the paper introduces a linguistic methodology by integrating MARCOS with the 2-Tuple Linguistic (2-TL) Model. This linguistic approach enhances decision-making by accommodating subjective assessments and linguistic preferences during the evaluation process. An extensive literature review encompassing lean and agile supply chains and supplier selection enlightens the study. A case study is conducted to validate the proposed methodology. The results and discussions provide practical insights into supplier selection for leagile supply chains. By understanding the fundamental principles of agility and leanness and applying the proposed methodology, organizations can strengthen their responsiveness, improve customer satisfaction, and gain a competitive advantage in the market. The paper offers valuable guidance to organizations aiming to build robust and adaptable supply chain networks in today's dynamic business environment, contributing to the field of agile supply chains.

Keywords
2-Tuple Linguistic Model, Leagile supply chains, MARCOS methodology, Multi-Criteria Decision-Making, Supplier suitability

1. Introduction
In the present dynamic business landscape, supply chains hold immense significance in securing organizations' competitive edge. To navigate rapidly evolving market demands while ensuring operational efficiency, the concept of leagility has emerged as a strategic framework. Leagility combines the principles of agile supply chains, characterized by their ability to swiftly adapt, and respond to changes. It also combines lean supply chains, which prioritize efficiency through waste reduction.

In an agile supply chain, flexibility and responsiveness are key (Nagel et al., 1998). It emphasizes the ability to quickly adjust production and distribution processes in response to shifting customer preferences, market trends, and unforeseen disruptions. Agile supply chains are designed to enable rapid product development, shorter lead times, and efficient collaboration with suppliers, thereby enhancing customer satisfaction and maintaining a competitive edge in volatile markets. Moreover, a lean supply chain aims to streamline operations and eliminate non-value-added activities (Christopher, 2000). It emphasizes the reduction of waste, such as excess inventory, overproduction, unnecessary transportation, and unnecessary movement of goods. By optimizing processes, reducing costs, and improving resource

allocation, lean supply chains strive to achieve operational excellence and maximize efficiency throughout the supply chain network.
Within the context of leagile supply chains, an essential aspect is the selection of suppliers that align with the lean and agile requirements of the organization. These suppliers should be able to adapt to rapid changes, provide timely and reliable deliveries, offer flexibility in production and customization, and exhibit a lean operational mindset. This will eliminate waste and enhance efficiency. By selecting suitable suppliers for leagile supply chains, organizations can strengthen their responsiveness, improve their ability to meet customer demands, and achieve a competitive advantage in the market. Accordingly, organizations can build robust and adaptable supply chain networks that are well equipped to navigate the challenges of the dynamic business environment if they understand the fundamental principles of agile and lean supply chains and apply them to supplier selection processes (Bhamra et al., 2021).

Furthermore, understanding the fundamental principles of agile and lean supply chains is crucial not only for supplier selection but also for the overall success of organizations operating in leagile environments (Mason-Jones et al., 2000). Integrating the 2-Tuple Linguistic (2-TL) model with the multi-criteria decision-making (MCDM) methodology enhances the decision-making process by allowing decision-makers (DMs) to assess and evaluate supplier suitability while dealing with linguistic variables. By incorporating linguistic expressions and preferences into the assessment process, the 2-TL model provides DMs with a more comprehensive understanding of the key concepts of "agile" and "lean" supply chains, as well as their relevance to their respective organizations.

1.1 Objectives

It is essential to consider certain criteria that are highly relevant to both lean and agile supply chains to determine the most appropriate suppliers. The identification of these criteria is of paramount importance because it directly impacts the performance, responsiveness, and flexibility of the entire supply chain network. Therefore, the first objective of this paper is to highlight the key criteria for supplier selection, taking into account the unique requirements of lean and agile supply chains.

Moreover, the paper targets to generate a MCDM model based on MARCOS method integrated with 2-TL model. By combining the 2-TL model with the MARCOS methodology, organizations can go beyond traditional supplier selection approaches, transcending numerical assessments and embracing a more holistic and intuitive evaluation process. The linguistic integration empowers DMs to bridge the gap between abstract concepts of agility and leanness and their practical implications in supplier selection. This deeper understanding enables organizations to make more informed decisions, select suppliers with greater precision, and ultimately build a robust and adaptive leagile supply chain network.

The remainder of this paper is structured as follows. In Section 2, a comprehensive literature review is presented, focusing on the concepts of lean and agile supply chains, as well as the existing body of knowledge on supplier selection. This section provides a solid foundation for understanding the key principles and criteria relevant to leagile supply chains and lays the groundwork for our research. Section 3 outlines the methods employed in this study, including the utilization of the MARCOS methodology, the integration of the 2-TL Model, and the incorporation of group decision making (GDM) techniques. The suggested methodology highlights the systematic and objective approach utilized to evaluate and rank potential suppliers based on multiple criteria. In Section 4, a case study is presented, along with the results and discussions derived from the application of the proposed methodology. The results are thoroughly analyzed and discussed to provide a comprehensive understanding of the supplier suitability assessment process. Finally, in Section 5, the conclusions of this study are presented.

2. Literature Review

This section presents the theoretical foundation of the related domain. Firstly, the literature pertaining to lean and agile supply chains is discussed, followed by an examination of the literature on supplier selection and assessment.

2.1 Agile and Lean Supply Chains

Supply chain performance improvement initiatives aim to align supply and demand while simultaneously reducing costs and enhancing customer satisfaction. This requires minimizing uncertainty within the supply chain to enable more predictable upstream demand. However, certain products, especially highly fashionable ones, inherently possess unpredictable demand, making it impossible to eliminate uncertainty entirely. In such cases, specific supply chains

must accept the presence of uncertainty and develop strategies that enable them to effectively match supply with demand (Mason-Jones et al., 2000).
In the late 90's numerous organizations have embraced the lean thinking paradigm (Womack et al., 1994) as they strive to optimize performance and enhance their competitive position. Also, in the early 2000s, the agile manufacturing paradigm has emerged as a notable alternative to leanness (Richards, 1996). Some viewpoints propose that agility represents the subsequent progression after achieving leanness, implying that once an organization attains leanness, it should aim for agility. Alternatively, it is suggested that agility should be the primary goal, rendering leanness as a secondary objective to be disregarded (Mason-Jones et al., 2000).
From the early 2010s onwards, the increasing prevalence of mass production on a global scale has facilitated greater accessibility for customers to an overabundance of options within a condensed timeframe. Consequently, customers have become accustomed to further personalizing their preferences, thereby seeking out services and products that align more closely with their individual needs (Virmani et al., 2018). Over time, this evolving consumer behavior has significantly influenced and shaped their demands in the present context. Consequently, in response to the evolving customer demands and the need for competitive advantage, supply chains have recognized the significance of integrating both lean and agile properties. In the current business landscape, the success or failure of companies is no longer solely determined by individual companies, but rather by their supply chain arrangements. To thrive in this environment, companies need to align their operations with customer needs (Bhamra et al., 2021). To achieve this, managers must possess the ability to identify and adopt the most suitable strategies.

The combination of lean principles, aimed at minimizing waste and optimizing efficiency, with agile practices, focused on enhancing flexibility and responsiveness, has emerged as a strategic approach. This synergistic integration allows organizations to effectively navigate the dynamic business environment while ensuring operational excellence and meeting the evolving needs and expectations of customers. By harnessing the benefits of both lean and agile methodologies, supply chains can achieve a harmonious balance between efficiency and adaptability, ultimately positioning themselves ahead of the competition (Mason-Jones et al., 2000).

A recent investigation by Bhamra et al. (2021) examined the relevance of the "leagile" concept in modern contexts. The study revealed the widespread recognition of leagile strategies in diverse industry sectors, particularly in manufacturing, as valuable approaches. This recognition, along with the expanding research in sectors such as healthcare, highlights the significant impact of implementing leagile practices and initiatives on business performance.

2.2 Supplier Assessment and Selection

To address the topic of leagile supply chains, a comprehensive literature search was conducted using the Scopus database. The search was performed using specific keywords (TITLE-ABS-KEY ("supplier selection") AND TITLE-ABS-KEY ("leagile")) resulting in the retrieval of five relevant documents. The details of these documents are presented in the following table.

Table 1. Studies covering leagile supply chain and supplier selection.

Reference	Technique	GDM	Fuzzy Approach	Objective	The most critical assessment criteria
(Li et al., 2020)	DEMATEL	No	No	Leagile supplier selection	Quality, Service level and customer satisfaction
(Galankashi et al., 2021)	AHP-FAHP	Yes	No	Leagile supplier selection of automotive manufacturing companies	Cost, quality, on-time delivery, and production method
(Khorasani et al., 2022)	Multi-objective Model (Genetic algorithm)	No	Yes	Leagile Supplier selection	Ability to respond to demands, Reducing the time delays and costs
(ForouzeshNejad, 2023)	(Rough)Best-Worst Method and (interval-Rough) MABAC	Yes	No	Leagile and sustainable supplier selection for medical devices	Manufacturing flexibility, Cost, Reliability, Smart factory, and Quality

(Rostami et al., 2023)	Goal programming-based fuzzy Best–Worst Method and VIKOR	Yes	Yes	Viable suppler selection for medical devices	Cost, Reliability, Greenhouse gas emission, Market sensitivity, Restorative capacity, and Quality

Drawing from the extensive body of literature on "lean," "agile," and "leagile" supply chains, a comprehensive set of supplier assessment criteria has been formulated. These criteria, which encapsulate the key considerations in evaluating suppliers, are presented in the table below.

Table 2. Leagile supplier assessment criteria (Rostami et al., 2023; ForouzeshNejad, 2023; Khorasani et al., 2022; Galankashi et al., 2021; Li et al., 2020; Bhamra et al., 2021; Matawale et al., 2016; Sonar et al., 2022).

C#	Criteria	Definition
C1	**Efficiency**	The dimension of efficiency in supplier selection corresponds to the strategic objective of waste elimination and process optimization to maximize productivity and resource utilization. It aligns with the emphasis on strategic efficiency in agile organizations, as well as ensuring a continuous flow of materials in leagile supply chains.
C2	**Collaboration and Cooperation**	Cooperation and collaboration are integral aspects of a leagile supply chain, emphasizing active engagement and coordinated efforts among individuals or entities to attain a common objective. Collaboration emphasizes a deeper level of interaction, communication, and joint decision-making, while cooperation signifies a broader concept of working together. In the context of supply chains, both cooperation and collaboration play crucial roles in establishing effective relationships and attaining mutual success
C3	**Cost-effectiveness**	It denotes the supplier's ability to deliver the desired level of quality and performance at an optimal cost, thereby ensuring value for money. Attaining cost-effectiveness is paramount for sustaining competitiveness, optimizing resources, and aligning with the overarching objectives of efficiency and agility. Evaluating the cost-effectiveness of suppliers enables organizations to select partners who can meet the performance requirements while maximizing cost efficiency, thereby contributing to the overall success of the leagile supply chain.
C4	**Lead Time**	Lead time is crucial in meeting delivery requirements and satisfying customer orders promptly. It reflects the supplier's process efficiency, production capabilities, and logistics operations. Shorter lead times contribute to the agility and responsiveness of the leagile supply chain, ensuring timely order fulfillment and customer satisfaction. Assessing lead time allows organizations to evaluate the supplier's ability to expedite processes and deliver products or services promptly, aligning with the need for speed in the leagile supply chain.
C5	**Adaptability**	Supplier adaptability in a leagile supply chain refers to their capacity to effectively respond to unforeseen developments, handle uncertainties, and employ agile scheduling and planning processes. It involves fostering collaboration, communication, and continuous improvement to adjust to changes. Supplier adaptability maintains the balance between agility and efficiency, ensuring the overall success of the leagile supply chain.
C6	**Integration**	Supplier integration in a leagile supply chain involves establishing collaborative relationships, sharing information, coordinating activities, and integrating technology systems. Integrated suppliers contribute to supply chain optimization, ensuring efficient information flow and improved overall performance.

C7	**Trustworthiness**	It encompasses factors such as reputation, management capability, reliability in meeting consumer demand, and ethical business practices. Choosing trustworthy suppliers fosters a reliable and transparent supply chain, aligning with the objectives of leanness and agility.
C8	**Responsiveness**	It pertains to the supplier's agility, prompt communication, quick decision-making, flexibility, adaptability, customer focus, and commitment to continuous improvement. The selection of responsive suppliers enables organizations to effectively address customer requirements, meet dynamic market demands, and enhance the overall efficiency of the leagile supply chain.
C9	**Technological capabilities**	It refers to the adoption, implementation, and proficiency in utilizing appropriate technologies to enhance efficiency, communication, collaboration, and overall performance. Evaluating technological capabilities includes assessing the supplier's infrastructure, data management and analytics capabilities, collaborative technologies, automation and robotics, digital connectivity and visibility, and their inclination towards technology-driven innovation. Selecting suppliers with strong technological capabilities enables organizations to improve the efficiency, agility, responsiveness, and ultimately, the performance and customer satisfaction within the leagile supply chain.
C10	**Culture and mind-set**	It encompasses the organizational culture, mindset, and approach towards collaboration, innovation, continuous improvement, and customer focus. Achieving strategic alignment between organizations and third-party partners is crucial for operational excellence, efficiency, and agility. This entails shared goals, collaborative relationships, integrated processes, mutual understanding, cultural compatibility, and a focus on performance measurement and improvement. By ensuring strategic alignment, organizations and their third-party partners can optimize the advantages of leanness and agility within the supply chain.

3. Methods
This section provides the methodological background for the proposed supplier selection model focusing on leagile properties. In this paper, the 2-Tuple Linguistic (2-TL) model is proposed to determine the weights of assessment criteria, as well as the 2-TL-MARCOS method is suggested for supplier selection.

3.1 2-Tuple Linguistic Model
The 2-TL model is an analytical approach based on linguistic representations, which effectively preserves information without loss during the translation stage. Initially introduced by Herrera et al., (2000), the 2-TL model enables decision-making environments that closely resemble the human cognitive process. It relies on the 2-tuple representation of linguistic sets. To enhance the transfer of knowledge differences between DMs, this paper also applies the *Linguistic Hierarchies* (Martínez et al., 2015) approach. The key translation equation of the 2-TL model is provided as follows:

$$\begin{aligned} &\Delta_s : [0, g] \rightarrow \bar{S} \\ &\Delta_s(\beta) = (S_i, \alpha), \text{with} \begin{cases} i = round(\beta) \\ \alpha = \beta - i \end{cases} \\ &S_i \in S \Rightarrow (S_i, 0) \end{aligned} \tag{1}$$

3.1 MARCOS
The existing literature emphasizes the widespread adoption of Multi-Criteria Decision-Making (MCDM) methodologies for evaluating suppliers. In the field of supply chain management and design, MCDM has been extensively applied to address supplier selection and third-party partner selection (Mohammadkhani et al., 2023;

Jaiswal et al., 2023; Tsai et al., 2023; Paul et al., 2021). These studies have demonstrated the effectiveness of MCDM in establishing decision-making processes that are both flexible and robust.

In this paper, the integrated approach of 2-TL and MARCOS is employed for supplier selection (Kaya, 2023; Wang et al., 2022). The MARCOS method combines three key elements to ensure robust decision-making (Stević et al., 2020): 1) establishment of reference points including ideal and anti-ideal values, 2) determination of the relationship between alternatives and the ideal/anti-ideal values, and 3) definition of the utility degree of alternatives relative to the ideal and anti-ideal solution. By integrating these benefits of the MARCOS approach, such as the judgment of ideal and anti-ideal solutions, closer utility degree measurements, novel utility function establishment, and aggregation, with the advantages of 2-TL, a decision-making process aligned with human cognitive processes is achieved.
The MARCOS method yields more reasonable results by fusing the outcomes of the ratio approach and reference point sorting approach. The basic steps of the MARCOS method can be summarized as follows (Stević et al., 2020): formation of an initial decision-making matrix, formation of an extended initial matrix, normalization of the extended initial matrix to obtain the normalized matrix, derivation of the weighted matrix, calculation of the utility degree of alternatives, determination of the utility function of alternatives, and ranking of the alternatives. Refer to Figure 3 below for an overview of the general steps involved in this methodology.

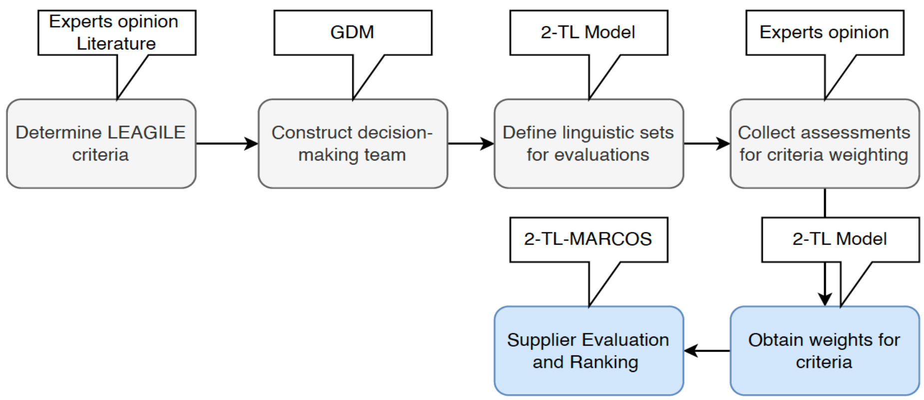


Figure 3. Suggested framework for supplier selection.

3.1 Group Decision Making

MCDM aims to identify the most suitable alternative by considering multiple criteria simultaneously. GDM can be a suitable approach to achieve an objective solution in this process, particularly when there are diverse DMs with different backgrounds and perspectives. GDM involves the collaboration of DMs with a shared awareness of working together to reach a collective decision, even in situations with ambiguity and uncertainty. However, achieving consensus among DMs with differing opinions becomes more challenging. While conventional approaches like the majority rule, minority rule, or total agreement are commonly used in GDM, they may not always guarantee a satisfactory solution for all DMs (Büyüközkan et al., 2015).

In this paper, evaluation process is employed using the Delphi approach, which serves as an effective communication tool for GDM. The Delphi process is particularly useful for addressing complex problems as a group, leveraging the expertise and knowledge of the participants (Büyüközkan, 2004). The method relies on input from knowledgeable and experienced contributors within the group. Given the subjective nature of DMs' assessments and the inherent uncertainty in their judgments, linguistic variables are employed instead of crisp numbers to represent the uncertain and subjective nature of the data. This allows DMs to express their assessments in a more flexible and nuanced manner, accounting for the subjective aspects of their decision-making process. Furthermore 2-TL model enables to aggregate different opinions from DMs.

5. Case Study

The present study employs a case study approach to assess the proposed methodology for leagile supplier selection. The selected case company, ABC, operates in the Fast-Moving Consumer Goods (FMCG) sector in Türkiye. A decision-making group consisting of managers from the marketing, IT, and supply chain departments is assembled to participate in the study. Specifically, two DMs are selected from the supply chain department. Each DM possesses distinct backgrounds and expertise, necessitating the provision of different linguistic sets tailored to their specific evaluation requirements. The linguistic sets are calibrated to offer varying levels of granularity, with the most experienced and knowledgeable DM employing a set with higher granularity, while the less experienced DM employs a set with lower granularity. The linguistic sets are provided in the following Table 3 and 4.

Table 3. Nine scaled linguistic set.

Linguistic Terms for CN Assessment	**Abr.**	**2-TL**
Absolutely Low Important	ALI	S_0^9
Very Low Important	VLI	S_1^9
Low Important	LI	S_2^9
Medium Low Important	MLI	S_3^9
Medium Important	MI	S_4^9
Medium High Important	MHI	S_5^9
High Important	HI	S_6^9
Very High Important	VHI	S_7^9
Absolutely High Important	AHI	S_8^9

Table 4. Five scaled linguistic set

Linguistic Terms for CN Assessment	**Abr.**	**2-TL**
Very Low Important	VLI	S_0^5
Low Important	LI	S_1^5
Medium Important	MI	S_2^5
High Important	HI	S_3^5
Absolutely High Important	AHI	S_4^5

In the case study, the aforementioned steps are followed. The decision-making group actively participates in the validation of the selection criteria list, assigning appropriate importance weights to each criterion, and conducting evaluations of the supplier alternatives. A comprehensive set of nine supplier alternatives is generated from ABC Company's network, and each alternative is systematically evaluated by the decision-making group based on the identified multiple criteria. The subsequent sections of this study will present the results of the criteria weighting process, followed by a detailed analysis of the alternative assessments.

5.1 Results and Discussion

The criteria weights are provided in the following table. Afterwards, the aggregated matrix for MARCOS assessment is provided with crisp numbers. The linguistic matrix will be given during the presentation for detailed discussion.

Table 5. Criteria weights.

C#	**DM1**	**DM2**	**DM3**	**Aggregated**
C1	MHI,0	MHI,0	HI,0	(MHI,0.20)
C2	AHI,0	MHI,0	AHI,0	(VHI,0.10)

C3	VHI,0	AHI,0	HI,0	(VHI,0.10)
C4	AHI,0	AHI,0	AHI,0	(AHI,0)
C5	HI,0	VHI,0	HI,0	(VHI, -0.20)
C6	VHI,0	AHI,0	MI,0	(VHI, -0.30)
C7	AHI,0	AHI,0	AHI,0	(AHI,0)
C8	VHI,0	AHI,0	HI,0	(VHI,0.10)
C9	MHI,0	MHI,0	HI,0	(MHI,0.20)
C10	AHI,0	MHI,0	AHI,0	(VHI,0.10)

Table 6. Aggregated assessment matrix for MARCOs with ideal and ant ideal values.

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**
S1	1,02	1,83	2,65	2,80	1,83	0,45	1,83	1,52	1,90	1,68
S2	1,25	2,10	2,37	2,37	1,40	0,45	2,10	1,52	1,75	1,30
S3	2,65	2,48	0,85	1,95	2,10	1,05	2,48	1,38	1,45	1,13
S4	1,95	1,95	2,80	2,48	1,95	0,75	1,95	1,90	1,75	1,68
S5	1,63	1,40	2,10	1,13	0,58	0,60	1,40	1,37	0,92	1,00
S6	0,58	1,95	0,55	2,53	1,40	0,30	1,95	0,38	1,75	0,83
S7	0,67	1,83	2,10	2,10	2,80	0,15	1,83	1,13	1,60	1,90
S8	2,80	2,80	0,55	2,65	2,65	1,20	2,80	1,08	1,98	1,28
S9	2,38	2,65	0,70	2,10	1,95	0,90	2,65	1,23	1,83	0,98
AI	**2,80**	**2,80**	**2,80**	**2,80**	**2,80**	**1,20**	**2,80**	**1,90**	**1,98**	**1,90**
AAI	**0,58**	**1,40**	**0,55**	**1,13**	**0,58**	**0,15**	**1,40**	**0,38**	**0,92**	**0,83**

Furthermore, the subsequent figure presents the ranking of the supplier alternatives. The supplier that obtained the highest weight (2-TL-MARCOS) is positioned as the top-ranked alternative. However, to assess the robustness and sensitivity of the methodology to changes in criteria weights, a detailed sensitivity analysis is conducted in the subsequent subsection. This analysis aims to examine the impact of varying criteria weights on the ranking outcomes, providing valuable insights into the stability and reliability of the decision-making process.

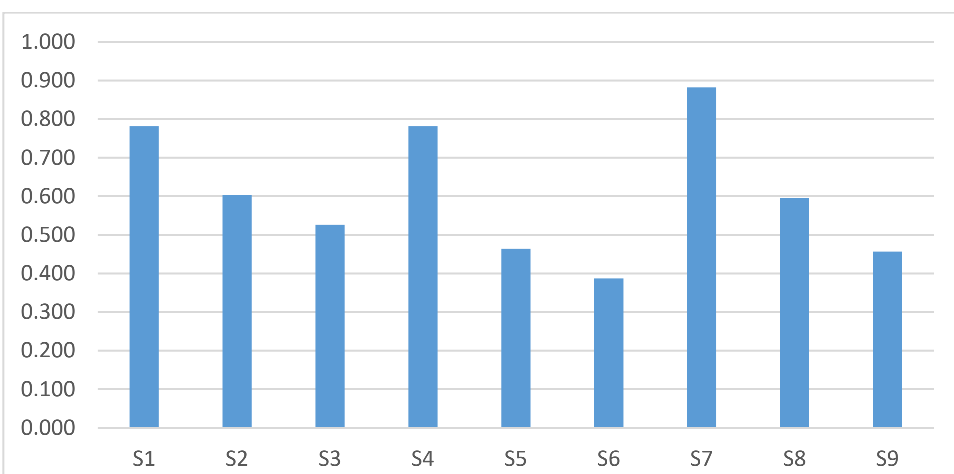
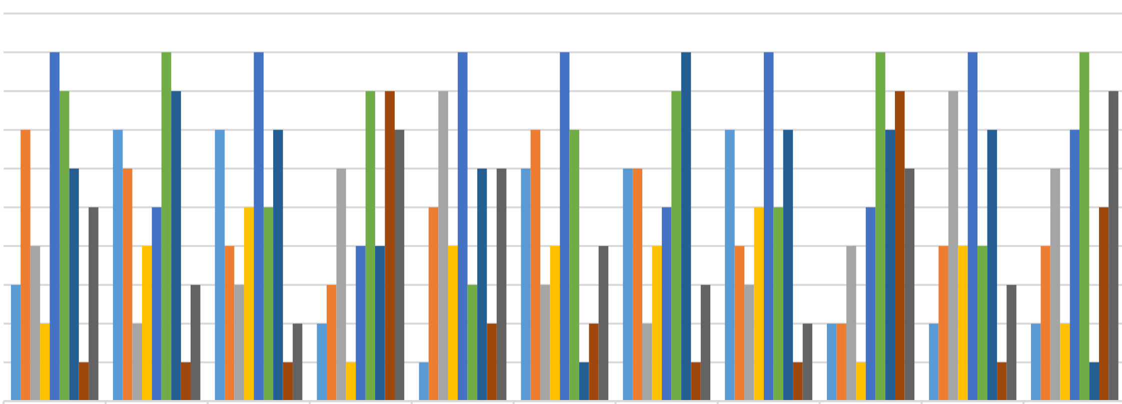


Figure 4. Criteria impotence.

5.2 Validation

Sensitivity analysis holds great significance in decision-making processes. By conducting sensitivity analysis under changing criteria weights, we can assess the impact of each criterion on the performance ranking of alternative suppliers. This allows us to determine which suppliers excel in specific criteria and helps identify their strengths and weaknesses.

Moreover, the sensitivity analysis aids in testing the robustness and reliability of the suggested model by evaluating its performance under different criteria weight scenarios. The analysis provides valuable insights for DMs, enabling them to make informed choices and enhance the overall effectiveness of the supplier selection process.



	Cae Study	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10
S1	3	7	7	2	1	6	6	7	2	2	2
S2	7	6	4	3	5	7	6	4	2	4	4
S3	4	2	3	6	8	3	2	3	4	8	6
S4	2	4	5	1	4	4	4	5	1	4	2
S5	9	5	9	4	9	9	5	9	5	9	7
S6	8	9	5	8	3	7	8	5	9	4	9
S7	6	8	7	4	6	1	9	7	7	7	1
S8	1	1	1	8	2	2	1	1	8	1	5
S9	5	3	2	7	6	4	3	2	6	3	8

Figure 5. Sensitivity analysis.

Although the eighth supplier does not consistently obtain the top rank across all cases, it frequently outperforms other alternatives in most scenarios. Therefore, selecting Supplier 8 as a leagile supplier or partner is likely to yield favorable outcomes within the leagile environment. Additionally, the sensitivity assessment allows for the incorporation of changes in ABC Company's strategies by assigning different weights to the criteria. This enables the consideration of various future scenarios and facilitates informed decision-making regarding supplier selection in the leagile supply chain context.

6. Conclusion

In conclusion, the supplier selection process for leagile supply chains is inherently a MCDM problem. The complexity arises from the need to consider multiple criteria such as efficiency, adaptability, responsiveness, and collaboration, among others. The integration of lean and agile principles further adds to the challenge of identifying suppliers who can meet the diverse requirements of leagile supply chains.

In addressing this complex decision-making process, the present study highlights the importance of linguistic decision-making. By utilizing linguistic variables, DMs can effectively evaluate and compare different suppliers based on their performance across various criteria. Linguistic decision-making allows for a more nuanced and flexible approach, capturing the subjective and imprecise nature of the decision-making process in supplier selection. The suggested

integrated methodology, 2-TL-MARCOS, has demonstrated its effectiveness in facilitating the supplier selection process for leagile supply chains.
However, it is important to acknowledge the limitations of this study. The decision-making group consisted of three individuals from specific departments, namely marketing, IT, and supply chain. While their expertise and insights were valuable, the small sample size limits the generalizability of the findings. Future research should involve a larger and more diverse group of DMs to validate and extend the suggested integrated methodology for leagile supplier selection. Additionally, it is worth noting that the criteria suggested for this methodology are intended to be generic and applicable to leagile supplier selection in various industries and contexts. However, the results obtained from the application of the methodology in this case study are specific to the particular context of the ABC company in the FMCG sector. Therefore, caution should be exercised when generalizing these findings to other companies or industries. Furthermore, it is worth mentioning that the sensitivity analysis conducted by varying the criteria weights revealed consistent top-three rankings for the suppliers, indicating a certain level of robustness in the suggested model. This consistency suggests that the proposed methodology can maintain its performance and reliability even under changing criteria weights. However, it is important to note that these results are case-specific and may vary in different scenarios. Further research is needed to explore the robustness and generalizability of the model across diverse industries and supply chain contexts.

To sum up, the combination of MCDM principles, linguistic decision-making, and the 2-TL-MARCOS methodology presents a promising approach for addressing the complexities of supplier selection in leagile supply chains. The suggested methodology offers DMs a structured framework to evaluate and prioritize potential suppliers based on multiple criteria. Further research should focus on validating and refining this methodology, particularly in larger-scale applications, to enhance its applicability and broaden its impact within the field of leagile supply chain management.

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Biography

Gülçin Büyüközkan is the Dean of the Engineering Faculty, Galatasaray University, Türkiye. She also works as a professor in the Industrial Engineering Department of the same university. Her current studies mainly focus on smart systems, smart technologies, digital transformation, sustainability, supply chain management, multi-criteria decision making, and the application of intelligent techniques on these areas. Prof. Büyüközkan is the author of numerous journal and conference papers.

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