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Intuitionistic fuzzy sets on Performance Evaluation of the supply chain using Supply chain operations reference (SCOR)

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1. ABSTRACT

Reference assessment of supply chain in supply chain management is vital. The aim of this study is to identify the criteria and sub-criteria for evaluating and measuring the supply chain in the National Iranian Oil Products Distribution Company. In this research, the supply chain operations are considered as the reference, and the corresponding sub-criteria are extracted from the features of reliability, responsiveness, quality, cost, and asset management indeed. The objective of this study was to rank ten key decision-making units in the headquarters process and supply chain cycle of this company using the DEMATEL method. Relationships between 24 sub-criteria based on these features are defined in an intuitionistic fuzzy environment and then weighted using the Analytic Network Process (ANP) method with three types of data: deterministic, fuzzy type I, and intuitionistic fuzzy weighted type. Weighting using all three methods was compared, with intuitionistic fuzzy data yielding significantly more accurate results. And as a result, its first and eighth units got the the best the worst ranking respectively.

Keywords: Supply Chain, SCOR, Intuitionistic Fuzzy, ANP, DEMATEL.

2. INTRODUCTION

This study presents an insightful exploration into the utilization of the Supply Chain Operations Reference (SCOR) model and diverse analytical methodologies to enhance supply chain performance [1]. Initially, it underscores the SCOR model's significance as a robust reference framework widely adopted in research and industry, detailing its components such as standardized definitions of key business processes and the classification of key performance indicators (KPIs). Moreover, it elucidates how supply chain management leverages information technology to optimize supply chain flow, thereby improving market responsiveness, inventory management, cost efficiency, and ultimately, customer satisfaction. This study further delves into the realm of supply chain evaluation, highlighting the prominence of hierarchical activity-based costing and the SCOR model in providing metrics for managing output across various dimensions. Additionally, it touches upon the adoption of modern multi-criteria decision-making (MCDM) techniques like Analytic Hierarchy Process (AHP) and fuzzy set theory to address uncertainties in performance measurement. Transitioning to a practical context this study sheds light on the case study of the National Iranian Oil Products Distribution Company, emphasizing the criticality of supply chain performance that monitors business success within the petroleum industry. This section underscores the organization's complex operational landscape, encompassing domestic demand fluctuations, international trade dynamics, and the necessity of product diversification. The structured organization of the article is outlined, delineating sections dedicated to literature review, the introduction of analytical methodologies including the DEMATEL-ANP method and intuitionistic fuzzy set theory [2], alongside a detailed case study to exemplify the application of proposed approaches. Finally, this study alludes to the results analysis and sensitivity assessment, culminating in conclusive insights presented in the article's final section.

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3. MATERIALS AND METHODS

3.1. Combining Intuitionistic Fuzzy DEMATEL with Analytic Network Process (ANP)

The Intuitionistic Fuzzy Decision-Making Trial and Evaluation Laboratory (IF DEMATEL) method is an extension of the traditional DEMATEL technique, which addresses uncertainty in decision-making by incorporating intuitionistic fuzzy sets. It allows decision-makers to express their opinions with linguistic terms and quantify both positive and negative relationships between factors. By combining DEMATEL with intuitionistic fuzzy sets, IF DEMATEL enhances the ability to model complex systems where precise numerical data may be lacking or uncertain.

When combined with Analytic Network Process (ANP), IF DEMATEL offers a powerful approach for decision-making in complex systems. ANP is a multi-criteria decision-making method that allows for the consideration of interdependencies and feedback loops between criteria. By integrating ANP with IF DEMATEL, decision-makers can analyze complex relationships within a system while also considering the uncertainty and inherent vagueness in real-world decision environments. This combined approach enables a more comprehensive and robust analysis, facilitating better-informed decision-making processes. The proposed methodology involves several steps for decision-making using IF DEMATEL and ANP. Firstly, linguistic variables are designed based on respondents' linguistic expressions to determine the importance of each decision maker. Then, a fuzzy intuitionistic decision-making matrix is created incorporating the opinions of decision-makers. In this matrix, each decision maker's weight is calculated using Equation 3. Subsequently, a fused intuitionistic fuzzy decision-making matrix (AIFDM) is generated by combining the individual decision-making matrices using the IFWA operator, considering the weights of decision makers. Next, direct relationships among the criteria are established through expert opinions using a five-degree linguistic ranking scale, leading to the creation of a direct relationship matrix [3].

In the following steps, linguistic information is substituted for intuitionistic fuzzy numbers, and then, certainty values are calculated to utilize DEMATEL as an expected deterministic value. Then The direct impact matrices of membership, non-membership, and hesitancy values are determined. These values are utilized to calculate the overall relationship matrix (T), which is then normalized to create a weighted supermatrix. Finally, the final weights for the options are determined by prioritizing the columns of the normalized matrix, providing a comprehensive decision-making framework that accounts for the opinions and preferences of decision-makers in a complex system.

4. RESULTS AND DISCUSSION

This research aims to evaluate the performance of the supply chain of the National Iranian Oil Products Distribution Company using effective indicators. The study adopts an applied objective and a descriptive-survey method for data collection. Information is gathered through the opinions of 10 managers and experts familiar with the supply chain in different management areas of the company, utilizing separate approaches. Data collection methods include library studies, field studies via interviews, and questionnaires. To ensure questionnaire validity, initial questions are designed with respect to structure and comprehensibility considerations. Feedback from advisors, consultants, and experts is incorporated to enhance validity after the initial questionnaire design.

4.1. Using the IF-DEMATEL-ANP model SCOR in a case study

In the formation of the super matrix and calculation of the final weight, a normalized matrix T is employed to assess the inter-relationships among the key criteria and sub-criteria. This matrix is adjusted according to the local weights derived from paired comparisons between the main criteria, sub-criteria, and alternatives. After normalization, the matrix T becomes normalized based on the sum of the column values. Finally, to determine the final weights, the super matrix is raised to the power of $2k+1$, where k is an arbitrary number chosen to ensure convergence. (table 1-4)

Table 1. One experts linguistic among main criteria

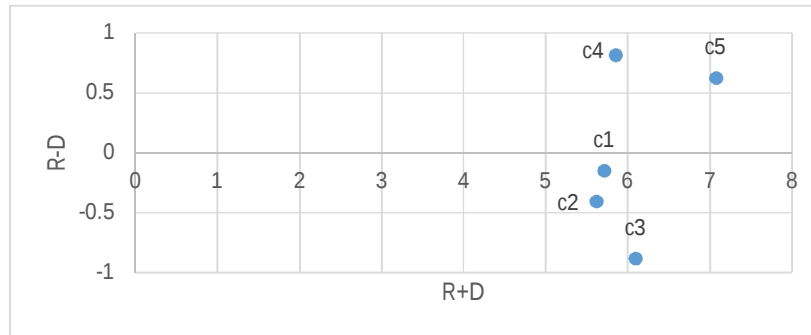
criteria	c_1	c_2	c_3	c_4	c_5
c_1	N	H	M	L	M
c_2	L	N	H	L	M
c_3	M	M	N	L	VH
c_4	M	M	H	N	VH
c_5	H	H	VH	VH	N

Table 2. Direct influence matrix ($\tilde{T}_z^{(k)} = X(I-X)^{-1}$) for main criteria after normalization

criteria	c_1	c_2	c_3	c_4	c_5
c_1	0.4266	0.6193	0.6220	0.4899	0.6243
c_2	0.5403	0.4082	0.6767	0.4337	0.5478
c_3	0.5339	0.5447	0.4761	0.4276	0.6235
c_4	0.6580	0.6571	0.7965	0.4432	0.7779
c_5	0.7754	0.7825	0.9185	0.7240	0.6504

**Table 3.** The sum of influential matrices T_D and T_C for the dimension and criteria

Dimension	R_i	D_i	$R_i + D_i$	$R_i - D_i$	criteria	R_i	D_i	$R_i + D_i$	$R_i - D_i$
c_1	2/7821	2/9341	5/7162	-0/1520	c_{11}	3/8426	3/7291	7/5717	0/1135
					c_{12}	3/3789	3/6522	7/0310	-0/2733
					c_{13}	3/8221	3/6373	7/4594	0/1848
					c_{14}	3/6328	3/6579	7/2907	-0/0251

**Figure 1.** the causal diagram**Table 4.** Super matrix formation and calculation of the final weight:

C1	C2	C3	C4	C5	C11	C12	C13	C14	C21	C22	C23	C24	C25	C31
0.081	0.069	0.058	0.065	0.078	0.028	0.026	0.026	0.022	0.022	0.022	0.023	0.020	0.028	0.022
3	7	3	8	4	8	8	4	6	4	5	8	6	7	6

C32	C33	C34	C35	C41	C42	C43	C44	C51	C52	C53	C54	C55	C56
0.019	0.018	0.021	0.032	0.017	0.018	0.019	0.018	0.015	0.015	0.016	0.022	0.018	0.026
4	7	1	2	7	9	6	0	3	5	8	7	9	0

5. CONCLUSION

The assessment of supply chain performance has become crucial for enhancing existing supply chains. This study evaluates the supply chain performance of the National Iranian Oil Products Distribution Company using relevant criteria and features. A proposed method employs a scoring model for selecting criteria and sub-criteria, utilizing the fuzzy intuitionistic Analytic Network Process (ANP) for decision-making. Additionally, the fuzzy intuitionistic DEMATEL method determines the weights of criteria and sub-criteria, evaluating their influential and causal relationships based on performance.

Result and sensitivity analysis show that fuzzy intuitionistic data outperforms classical and deterministic data in terms of accuracy so that led to more realistic results. Ten decision units were ranked, and its first and eighth ones achieved the highest and lowest ranking respectively.

6. REFERENCES

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