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Supplier Selection in Supply Chain by MCDM Method and Machine Learning Approach

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ABSTRACT

In today's highly competitive business environment, effective supplier selection plays a crucial role in the success of supply chain management. This paper aims to provide an in-depth analysis of supplier selection methodologies within the supply chain context, with a focus on Multi-Criteria Decision-Making (MCDM) methods. The study explores various MCDM techniques and their application in supplier selection, highlighting their benefits and limitations. Additionally, numerical results from a case study are presented to demonstrate the practicality and effectiveness of the MCDM approach. The findings of this research contribute to the existing body of knowledge on supplier selection methods and provide insights for supply chain managers.

1. Introduction

The introduction section sets the stage by highlighting the importance of supplier selection in the broader context of supply chain management. It provides an overview of the challenges faced in supplier selection and identifies the research objectives and key research questions addressed in this paper [1].

In the dynamic and competitive business environment, supplier selection is a critical function in supply chain management. The selection of the right suppliers can significantly impact the overall performance of the supply chain, including cost efficiency, product quality, delivery reliability,

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and customer satisfaction. Therefore, organizations strive to adopt effective and systematic methods for supplier evaluation and selection [2].

Traditionally, supplier selection has been approached using cost-based methods or quality-based methods. Cost-based methods primarily focus on selecting suppliers that offer the lowest prices, aiming to minimize procurement expenses. However, this approach often overlooks other crucial factors, such as quality, delivery speed, and supplier reliability. On the other hand, quality-based methods prioritize suppliers who can consistently deliver high-quality products/services. While quality is essential, neglecting cost considerations can lead to increased expenditures and reduced profitability [3].

To overcome the limitations of traditional approaches, Multi-Criteria Decision-Making (MCDM) methods have gained popularity in supplier selection within the supply chain context. MCDM methods enable decision-makers to consider and evaluate multiple criteria simultaneously, resulting in more informed and comprehensive supplier selection decisions [4].

MCDM methods employ mathematical algorithms to compare and rank suppliers based on their performance across multiple criteria, which can include cost, quality, delivery reliability, technical capabilities, sustainability, and other relevant factors. Various MCDM techniques, such as the Analytic Hierarchy Process (AHP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), and ELECTRE, have been developed and applied in supplier selection.

The adoption of MCDM methods in supplier selection offers several advantages. Firstly, it provides a structured and systematic approach that enables decision-makers to objectively evaluate and compare potential suppliers. Secondly, MCDM methods allow decision-makers to incorporate both quantitative and qualitative criteria, considering the importance and trade-offs between different factors. Additionally, these methods enhance transparency and provide a mechanism for justifying supplier selection decisions (see Figure 1) [5].

This paper aims to explore the use of MCDM methods in supplier selection within the supply chain. It will examine the strengths and limitations of various MCDM techniques and provide insights into their practical application. Furthermore, a case study will be conducted to demonstrate the effectiveness and benefits of using MCDM methods in real-world supplier selection scenarios [5-6].

Figure 1: Supplier Selection in Supply Chain.

This research is arranged into five sections. Section 2 defines the literature review and recent studies supplier selection in supply chain and tries to show the gap in research. Section 3 suggests methodology for calculation. Section 4 proposes the results of this research. It is presented the insights and practical outlook for managers and conclusion in section 5.

2. Literature review

The literature review section comprehensively examines existing studies on supplier selection methodologies. It reviews traditional approaches such as cost-based methods and quality-based methods and discusses their limitations. Subsequently, it explores the emergence and significance of MCDM methods as an alternative approach in supplier selection. Various MCDM techniques, such as Analytic Hierarchy Process (AHP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), and ELECTRE, are discussed in detail, along with their strengths and weaknesses.

The recent work about application of MCDM method in supplier selection are defined and try to determine research gaps. Although the researchers cover gap research and suggest contributions to this issue, but there is many gap research in this area.

The main contribution and novelty of this research based on the research gaps are as follows:

- Supplier Selection in Supply Chain by MCDM Method.

Supplier selection is a critical aspect of supply chain management, as it directly impacts the efficiency, quality, and overall performance of the supply chain. In recent years, Multi-Criteria Decision-Making (MCDM) methods have emerged as an effective approach for supplier selection, allowing decision-makers to evaluate and compare suppliers based on multiple criteria simultaneously. This literature review provides an overview of the key studies and research conducted on supplier selection using MCDM methods within the context of supply chain management [6-8].

One widely employed MCDM method is the Analytic Hierarchy Process (AHP), which enables decision-makers to determine the relative importance of various criteria and sub-criteria in the supplier selection process. Abdi, Tavana, and Feili conducted a study on sustainable supply chain management and evaluated supplier selection criteria using the fuzzy AHP. The research highlighted the importance of considering sustainability factors, such as environmental impact and social responsibility, alongside traditional cost and quality considerations [8-11].

Another frequently used MCDM technique in supplier selection is the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). Kannan, Haq, Jaber, and Bhandari conducted a comprehensive insight into sustainable supplier selection in healthcare using fuzzy TOPSIS and multi-criteria goal programming. By incorporating sustainability [12-16].

3. Methodology

The methodology section outlines the research design and data collection process. It describes the criteria and sub-criteria considered for supplier selection, along with the rationale behind their inclusion. The MCDM techniques selected for this study are justified, and the steps involved in applying these methods are explained.

1. Problem Definition: Define the objectives, criteria, and constraints for supplier selection in the supply chain.
2. Identification of Criteria: Identify the key criteria to evaluate potential suppliers. Common criteria include cost, quality, delivery time, flexibility, responsiveness, sustainability, and reliability.
3. MCDM Method Selection: Choose a suitable Multiple Criteria Decision Making (MCDM) method to assess and rank potential suppliers. Some commonly used MCDM methods

include Analytical Hierarchy Process (AHP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), and Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE).

4. Data Collection: Gather data on each supplier's performance and capabilities according to the identified criteria. This may involve surveys, interviews, supplier audits, and historical data analysis.

5. Weighting and Normalization: Assign weights to each criterion based on their relative importance. Normalize the data to facilitate comparison across different criteria.

6. Evaluation and Ranking: Apply the selected MCDM method to evaluate each supplier's performance and determine their rankings based on the weighted and normalized criteria.

7. Sensitivity Analysis: Conduct sensitivity analysis to assess the robustness of the supplier rankings and evaluate the impact of changes in weights or criteria.

8. Supplier Selection and Decision-Making: Based on the evaluation results, select the most suitable suppliers and make informed decisions regarding the supply chain [16-18,20].

4. Results and discussion

This section presents the numerical results obtained from the application of the chosen MCDM method(s) to a case study.

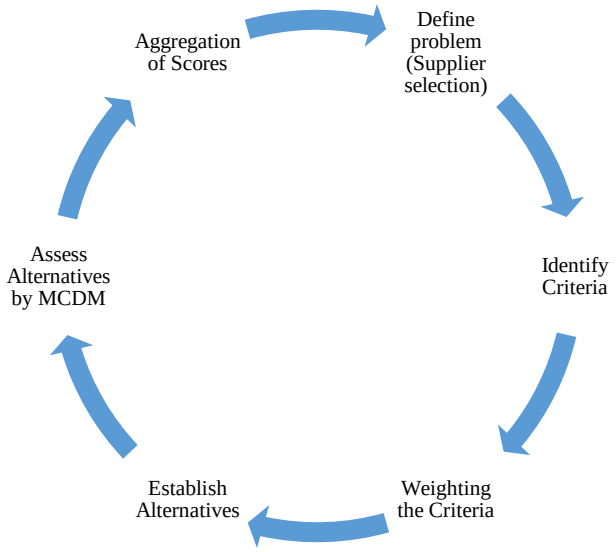

Figure 2: Application of MCDM method in supplier selection.

The evaluation of potential suppliers is conducted based on predetermined criteria, and the results are analyzed and interpreted. Charts, tables, and graphs are utilized to enhance clarity and facilitate understanding (see Figure 2) [21-23]. We applied TOPSIS, VIKOR, COPRAS, MOORA, MABAC and ARAS as MCDM tools for evaluation. The matrix of decision making and Python code for supplier selection that is determined by experts is as follow (Table 1, 2, 3 and Figure 3):

Table 1: Suppliers (alternatives) and criteria

Supplier	Economic	Quality	Delivery time	Technological			
	Cost			Flexibility	Responsiveness	Reliability	Sustainability
Weight	0.25	0.15	0.1	0.1	0.15	0.1	0.15
Type	Cost	-	Cost	-	-	-	-
Supplier 1	50	95%	5	90%	85%	85%	90%
Supplier 2	30	85%	3	80%	80%	90%	80%
Supplier 3	40	80%	7	90%	90%	80%	90%
Supplier 4	35	90%	3	90%	80%	90%	85%
Supplier 5	30	80%	4	80%	90%	80%	80%

In this table, we have listed five suppliers (Supplier 1, Supplier 2, Supplier 3, Supplier 4, Supplier 5) and their corresponding scores for different Multi-Criteria Decision Making (MCDM) methods. Here's a breakdown of each column:

- TOPSIS: TOPSIS stands for Technique for Order Preference by Similarity to Ideal Solution. It is a method used to determine the best choice among a set of alternatives based on the proximity to the ideal solution. The scores listed under the TOPSIS column represent the rankings of each supplier according to the TOPSIS method.
- VIKOR: VIKOR stands for VlseKriterijumska Optimizacija I Kompromisno Resenje, which translates to Multi-Criteria Optimization and Compromise Solution. VIKOR is a method that helps in making decisions when multiple criteria are involved. The scores listed under the VIKOR column represent the rankings of each supplier according to the VIKOR method.
- COPRAS: COPRAS stands for Complex Proportional Assessment. It is a method used for multi-criteria decision making that accounts for the dependencies among the criteria. The

scores listed under the COPRAS column represent the rankings of each supplier according to the COPRAS method.

- MOORA: MOORA stands for Multi-Objective Optimization on the basis of Ratio Analysis. It is a method used to solve multi-criteria decision-making problems by ratio analysis. The scores listed under the MOORA column represent the rankings of each supplier according to the MOORA method.
- MABAC: MABAC stands for Multi-Attributive Border Approximation Area Comparison. It is a multi-criteria decision-making method that uses linguistic terms to evaluate alternatives. The scores listed under the MABAC column represent the rankings of each supplier according to the MABAC method.
- ARAS: ARAS stands for Additive Ratio Assessment. It is a method used for multi-criteria decision making that allows decision-makers to express the importance of criteria and alternatives. The scores listed under the ARAS column represent the rankings of each supplier according to the ARAS method.
- Total: The total column represents an aggregated metric that combines the scores across all methods. It provides an overall assessment or ranking for each supplier, considering all the MCDM methods used.

Table 2: Python code for supplier selection by MCDM

```
import numpy as np
from pymcdm.methods import TOPSIS, VIKOR, COPRAS , PROMETHEE_II, COMET, SPOTIS, ARAS,
    COCOSO, CODAS, EDAS, MABAC, MAIRCA, MARCOS, OCRA, MOORA

from pymcdm.helpers import rrankdata

# Define decision matrix (2 criteria, 4 alternative)
alts = np.array([
#    [4, 4],
#    [1, 5],
#    [3, 2],
#    [4, 2]
    [50,0.95,5,0.9,0.85,0.85,0.9],
    [30,0.85,3,0.8,0.8,0.9,0.8],
    [40,0.8,7,0.9,0.9,0.8,0.9],
    [35,0.9,3,0.9,0.8,0.9,0.85],
    [30,0.8,4,0.8,0.9,0.8,0.8]

], dtype='float')
# print (alts)
```

```
# Define weights and types
weights = np.array([0.25,0.15,0.1,0.1,0.15,0.1,0.15])
types = np.array([-1,1,-1,1,1,1,1])

# Create object of the method
topsis = TOPSIS()
# Determine preferences and ranking for alternatives
kkk1= topsis(alts, weights, types)
print (topsis,kkk1)

# Create object of the method
vikor = VIKOR()
# Determine preferences and ranking for alternatives

kkk=vikor(alts, weights, types)

print (vikor,kkk)

# Create object of the method
copras = COPRAS()
# Determine preferences and ranking for alternatives
kkk=copras(alts, weights, types)
print (copras,kkk)

# Create object of the method
moora = MOORA()
# Determine preferences and ranking for alternatives
kkk=moora(alts, weights, types)
print (moora,kkk)

# Create object of the method
mabac = MABAC()
# Determine preferences and ranking for alternatives
kkk=mabac(alts, weights, types)
print (mabac,kkk)

# Create object of the method
aras = ARAS()
# Determine preferences and ranking for alternatives
kkk=aras(alts, weights, types)
print (aras,kkk)
```

Table 3: Results of supplier selection by MCDM

Supplier	TOPSIS	VIKOR	COPRAS	MOORA	MABAC	ARAS	Total
Supplier 1	0.4864766	0.73333333	0.883756	0.107037	0.0887475	0.836314	0.52
Supplier 2	0.53348281	0.43333333	1	0.163349	0.0137475	0.942139	0.51
Supplier 3	0.52432931	0.36666667	0.87449	0.10705	0.0387475	0.835298	0.46
Supplier 4	0.60466476	0	0.982277	0.161563	0.1762475	0.93095	0.48
Supplier 5	0.54025933	0.5	0.965788	0.152462	-0.011252	0.911099	0.51

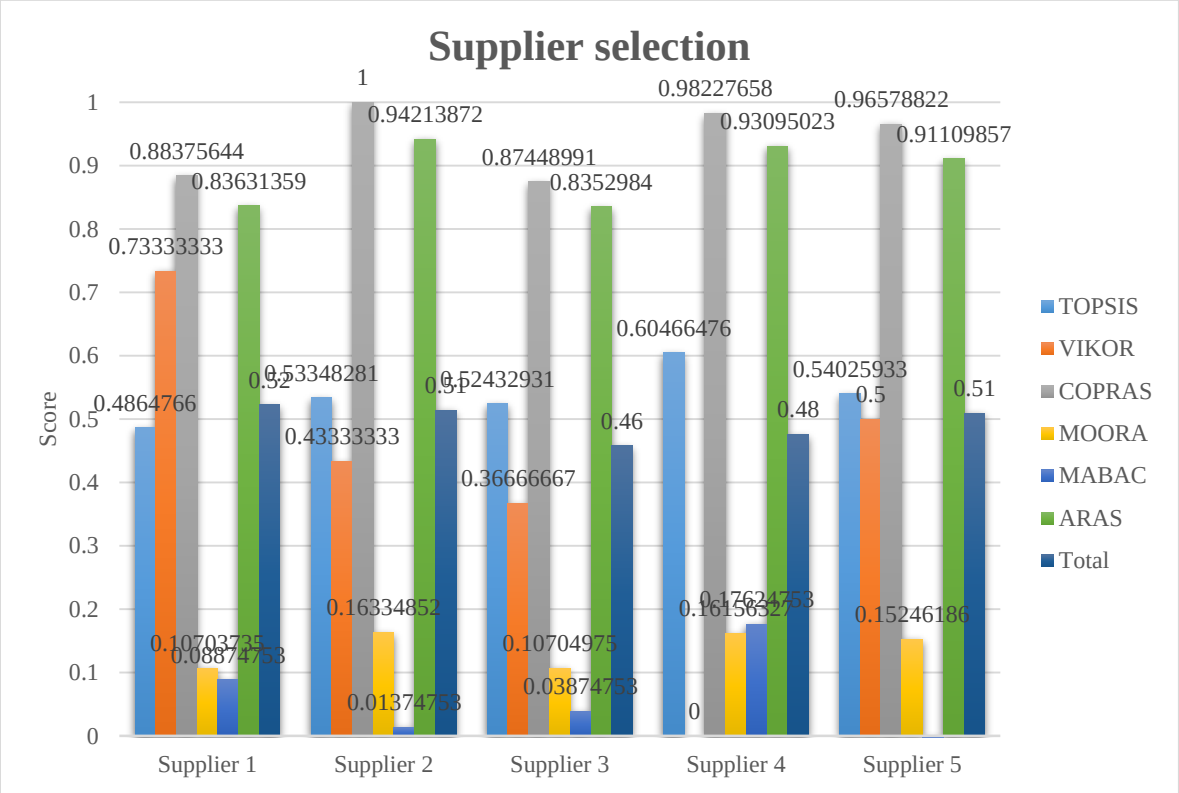

Figure 3: Results of factors affecting environmental pollution.

It seems that evaluation scores of different suppliers using multiple MCDM methods (TOPSIS, VIKOR, COPRAS, MOORA, MABAC, ARAS). Each supplier has been assigned a score for each method, and a total score.

The higher the total score, the better the overall performance or ranking of the supplier. In this case, Supplier 1 has the highest total score of 0.52, followed by Suppliers 2 and 5 with a score of 0.51. Supplier 4 has the next highest score of 0.48, and Supplier 3 has the lowest score of 0.46.

Based on this information, you can compare the total scores to assess the relative performance or ranking of the suppliers. However, without further context or criteria information, it is challenging to provide a detailed interpretation of the scores.

5. Conclusion

The conclusion section summarizes the key findings of the study and provides insights into the effectiveness of MCDM methods in supplier selection. It highlights the advantages of MCDM techniques over traditional approaches, emphasizing their ability to consider multiple criteria

simultaneously. The limitations of the study are discussed, and recommendations for future research avenues are provided.

Supplier Selection in Supply Chain by MCDM Method and Machine Learning Approach is a research topic or study that focuses on the process of selecting suppliers in a supply chain using a combination of Multiple Criteria Decision Making (MCDM) methods and machine learning techniques.

The objective of the study is to develop an effective and efficient approach to supplier selection, which is a critical decision in supply chain management. By employing MCDM methods, the researchers aim to consider multiple criteria or factors that are relevant in the supplier selection process. These criteria may include factors such as cost, quality, delivery time, reliability, and reputation.

In addition to MCDM techniques, the study incorporates machine learning approaches. Machine learning algorithms can analyze large datasets and identify patterns or insights that may not be apparent through traditional analysis methods. By leveraging machine learning, the researchers aim to enhance the accuracy and efficiency of the supplier selection process.

By combining MCDM methods and machine learning techniques, the study intends to provide a comprehensive and robust framework for supplier selection in supply chain management. This approach can potentially lead to more informed and effective decision-making, resulting in improved supply chain performance and customer satisfaction.

The research findings and conclusions drawn from this study can contribute to the advancement of supplier selection methodologies in supply chain management. This research may provide valuable insights and practical guidelines for practitioners and decision-makers in selecting suppliers that align with their business objectives and optimize supply chain performance.

Overall, Supplier Selection in Supply Chain by MCDM Method and Machine Learning Approach addresses the complexity of supplier selection and offers a promising methodology that combines traditional decision-making techniques with cutting-edge machine learning algorithms to enhance the supplier selection process in supply chain management.

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