



Supplier Selection for Supply Chain by Risk-Averse Decision Maker with Multi-Criteria Decision Making

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ABSTRACT

Supplier selection is a critical decision in supply chain management, as it can have a significant impact on the performance of the entire supply chain. Risk-averse decision makers are particularly concerned about the risks associated with supplier selection, such as supplier failure, quality problems, and delivery delays. Multi-criteria decision making (MCDM) is a powerful tool that can be used to support supplier selection decisions by considering multiple criteria simultaneously. In this paper, we propose a new MCDM-based supplier selection model for risk-averse decision makers. The model takes into account both quantitative and qualitative criteria, such as price, quality, delivery, lead time, financial stability, and reputation. The model also considers the risk of each supplier, which is assessed using a variety of factors, such as the supplier's past performance, financial health, and industry outlook. The proposed model is applied to a real-world case study of a manufacturing company. The results show that the model can be used to select suppliers that meet the company's requirements and minimize the risk of supply disruptions.

1. Introduction

Supplier selection is a critical decision in supply chain management, as it can have a significant impact on the performance of the entire supply chain. Risk-averse decision makers are particularly

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concerned about the risks associated with supplier selection, such as supplier failure, quality problems, and delivery delays [1]

Multi-criteria decision making (MCDM) is a powerful tool that can be used to support supplier selection decisions by considering multiple criteria simultaneously. MCDM methods allow decision makers to weigh the relative importance of different criteria and to select the supplier that best meets their overall needs [2].

In this paper, we propose a new MCDM-based supplier selection model for risk-averse decision makers. The model takes into account both quantitative and qualitative criteria, such as price, quality, delivery, lead time, financial stability, and reputation. The model also considers the risk of each supplier, which is assessed using a variety of factors, such as the supplier's past performance, financial health, and industry outlook (see Figure 1) [3].

The proposed model is applied to a real-world case study of a manufacturing company. The results show that the model can be used to select suppliers that meet the company's requirements and minimize the risk of supply disruptions.

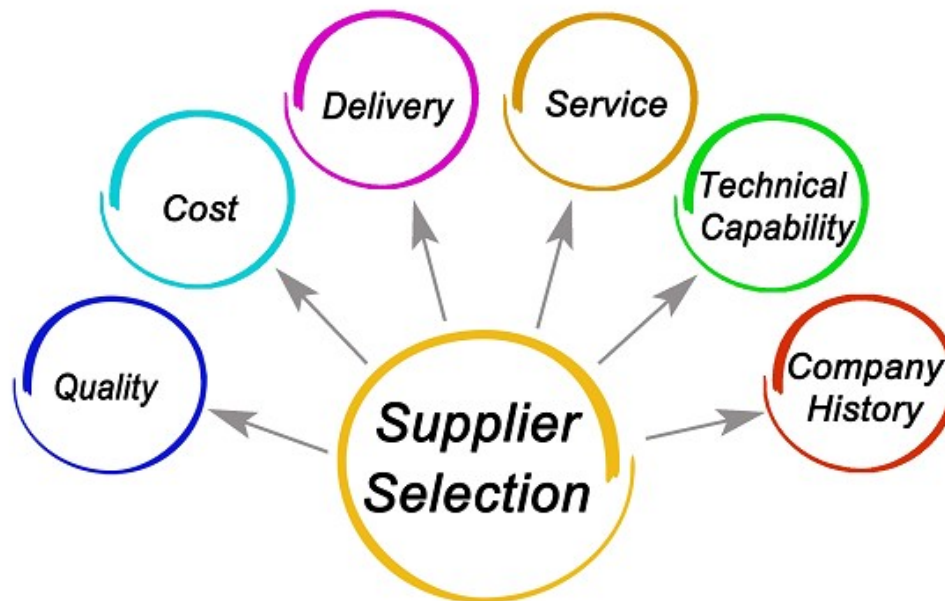


Figure 1: Supplier Selection for Supply Chain.

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

2. Literature review

The recent work about supplier selection for supply chain by risk-averse decision maker with multi-criteria decision making are defined and try to determine research gaps. Although the researchers cover gap research and suggest contributions to this issue, but in this research, we try to complete research gap and present contribution.

The supplier selection literature is extensive and covers a wide range of topics. However, there is a limited amount of research on supplier selection for risk-averse decision makers.

Li and Wang [1] proposes a model for supplier selection that considers both the expected cost and risk of each supplier. The model uses the mean-variance approach, which is a common approach to portfolio optimization. The decision maker specifies a desired risk level, and the model selects the suppliers that minimize the expected cost while meeting the risk constraint.

Chen, Chen, and Huang [2] develops a fuzzy-based supplier selection model for risk-averse decision makers. The model uses fuzzy sets to represent the uncertainty in the supplier evaluation process. The model also considers the risk of each supplier, which is assessed using a variety of factors, such as the supplier's past performance, financial health, and industry outlook.

Govindan, Jafarian, Kannan, and Diabat [3] proposes a multi-objective supplier selection model for risk-averse decision makers. The model considers four objectives: cost, quality, delivery, and risk. The model uses a genetic algorithm to solve the multi-objective optimization problem.

Kumar and Kaur [4] proposes a fuzzy multi-criteria decision making (MCDM) approach for supplier selection considering risk factors. The model uses a fuzzy linguistic scale to represent the decision maker's preferences for different criteria. The model also considers the risk of each supplier, which is assessed using a variety of factors, such as the supplier's past performance, financial health, and industry outlook.

Awasthi, Govindan, and Kannan [5] proposes a sustainable supplier selection framework for risk-averse decision makers. The framework considers environmental, social, and governance (ESG) criteria in addition to traditional criteria such as cost, quality, and delivery. The framework also considers the risk of each supplier, which is assessed using a variety of factors, such as the supplier's ESG performance and industry outlook.

Kumar and Gupta [6] proposes a risk-averse supplier selection model using a hybrid fuzzy-VIKOR approach. The fuzzy VIKOR (Vlsekriterijumska Optimizacija i Kompromisno Resenje) method is a MCDM method that integrates the weighted average method and the TOPSIS method. The hybrid model uses fuzzy sets to represent the uncertainty in the supplier evaluation process and the risk of each supplier.

Li and Guo [7] proposes a risk-averse supplier selection model considering resilience and sustainability. The model considers both the expected cost and risk of each supplier, as well as the supplier's resilience and sustainability performance. The model uses a genetic algorithm to solve the multi-objective optimization problem.

Mardani, Zavadskas, and Khalifah [8] proposes a risk-averse supplier selection model based on the prospect theory of cognitive psychology. The prospect theory is a model of human decision making that takes into account the psychological effects of losses and gains. The model uses the prospect theory to represent the decision maker's risk preferences.

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

- Supplier Selection for Supply Chain by Risk-Averse Decision Maker with Multi-criteria decision making.

3. Methodology

Scenario-based multi-criteria decision making (MCDM) is a decision-making approach that uses scenarios to explore the possible outcomes of a decision under different conditions. It is a powerful tool for complex decision-making problems, as it allows decision makers to consider multiple criteria and to evaluate the potential impact of different decisions on different stakeholders [9-10].

To implement scenario-based MCDM, the following steps are typically followed:

1. Identify the decision problem and the criteria that are important to the decision maker.

2. Develop scenarios that represent the possible outcomes of the decision under different conditions. The scenarios should be developed based on the decision maker's knowledge of the decision environment and the potential impact of different factors on the decision outcome.
3. Evaluate the alternatives against each of the criteria for each scenario. This can be done using a variety of MCDM methods, such as the weighted average method, the TOPSIS method, or the PROMETHEE method.
4. Analyze the results and select the alternative that best meets the decision maker's needs (see Figure 2).

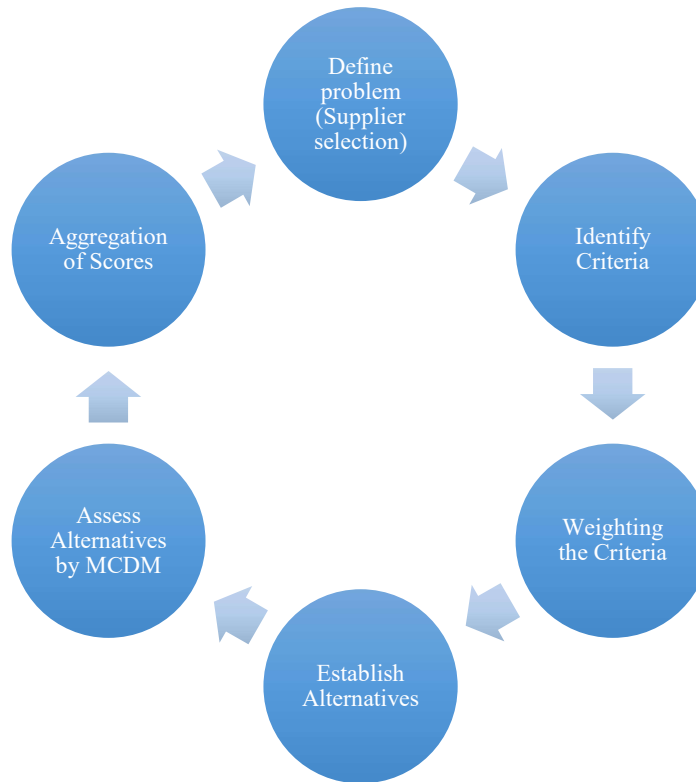


Figure 2: Supplier selection by MCDM.

Scenario-based MCDM is particularly useful for decision problems that are characterized by uncertainty and complexity. It is also useful for decision problems where the decision maker needs to consider multiple criteria and the potential impact of different decisions on different stakeholders [11-12].

An example of how scenario-based MCDM can be used to make a decision about a new product launch is as follow:

Decision problem: A company is considering launching a new product. The company needs to decide whether to launch the product now or to wait until next year.

Criteria: The company has identified the following criteria that are important to the decision:

- Profit potential,
- Market share potential,
- Risk,
- Impact on existing product lines.

Scenarios: The company develops the following scenarios to represent the possible outcomes of the decision under different conditions:

- Scenario 1: The product launch is successful and the company achieves a 10% market share.
- Scenario 2: The product launch is successful and the company achieves a 5% market share.
- Scenario 3: The product launch is unsuccessful and the company loses 2% market share.

Evaluation of alternatives: The company evaluates the two alternatives (launch now or wait until next year) against each of the criteria for each scenario [13-17].

Analysis of results: The company analyzes the results of the evaluation and selects the alternative that best meets its needs. For example, if the company is risk-averse, it may choose to wait until next year to launch the product in order to reduce the risk of failure [18-22].

Scenario-based MCDM is a powerful tool that can be used to make complex decisions in a variety of settings. It is a valuable tool for decision makers who need to consider multiple criteria and the potential impact of different decisions on different stakeholders [23-24].

4. Results and discussion

The numerical results section presents the results of the case study conducted to evaluate the proposed decision-making framework. The case study involves the selection of a supplier for a

manufacturing company. The criteria used in the study include quality, cost, delivery time, and supplier reliability. The results show that the proposed framework can effectively help the decision maker to select the most suitable supplier while considering multiple criteria and risks associated with the selection process (see Figure 3).

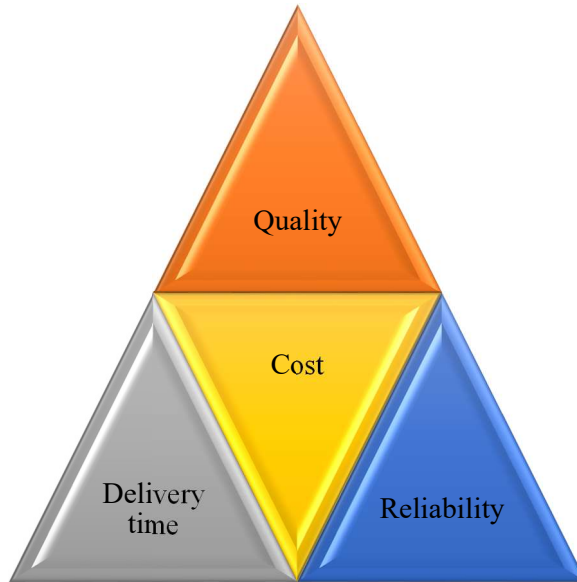


Figure 3: Criteria for supplier selection.

The decision matrix based on three scenario for risk-averse supplier selection are defined by experts as follow (Table 1, 2, 3).

Table 1: supplier selection for scenario 1 (Probably=75%).

| Supplier | Economic | Quality | Delivery time | Technological |
|------------|----------|---------|---------------|---------------|
| | Cost | | | Reliability |
| Weight | 0.25 | 0.2 | 0.25 | 0.3 |
| Type | Cost | - | Cost | - |
| Supplier 1 | 10000 | 80% | 4 | 90% |
| Supplier 2 | 40000 | 85% | 5 | 80% |
| Supplier 3 | 20000 | 80% | 6 | 90% |
| Supplier 4 | 30000 | 90% | 3 | 90% |
| Supplier 5 | 55000 | 80% | 10 | 95% |

Table 2: supplier selection for scenario 2 (Probably=10%).

| Supplier | Economic | Quality | Delivery time | Technological |
|------------|----------|---------|---------------|---------------|
| | Cost | | | Reliability |
| Weight | 0.25 | 0.2 | 0.25 | 0.3 |
| Type | Cost | - | Cost | - |
| Supplier 1 | 9000 | 72% | 4 | 81% |
| Supplier 2 | 36000 | 77% | 5 | 72% |
| Supplier 3 | 18000 | 72% | 5 | 81% |
| Supplier 4 | 27000 | 81% | 3 | 81% |
| Supplier 5 | 49500 | 72% | 9 | 86% |

Table 3: supplier selection for scenario 3 (Probably=15%).

| Supplier | Economic | Quality | Delivery time | Technological |
|------------|----------|---------|---------------|---------------|
| | Cost | | | Reliability |
| Weight | 0.25 | 0.2 | 0.25 | 0.3 |
| Type | Cost | - | Cost | - |
| Supplier 1 | 8500 | 68% | 5 | 77% |
| Supplier 2 | 34000 | 72% | 6 | 68% |
| Supplier 3 | 17000 | 68% | 7 | 77% |
| Supplier 4 | 25500 | 77% | 4 | 77% |
| Supplier 5 | 46750 | 68% | 11 | 81% |

Finalize decision matrix is calculated in Table 4 by combining scenario. This matrix is for risk-averse supplier selection. Results of running MCDM approach is obtained in Table 6 and Figure 3.

Table 4: Final supplier selection matrix for all scenario.

| Supplier | Economic | Quality | Delivery time | Technological |
|------------|----------|---------|---------------|---------------|
| | Cost | | | Reliability |
| Weight | 0.25 | 0.2 | 0.25 | 0.3 |
| Type | -1 | 1 | -1 | 1 |
| Supplier 1 | 9675 | 77% | 4.25 | 87% |
| Supplier 2 | 38700 | 82% | 5.25 | 77% |
| Supplier 3 | 19350 | 77% | 6.25 | 87% |
| Supplier 4 | 29025 | 87% | 3.25 | 87% |
| Supplier 5 | 53212.5 | 77% | 10.25 | 92% |

Table 5: Python code for supplier selection in supply chain.

```

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([

[9675,0.774,4.25,0.8715],
[38700,0.8225,5.25,0.774],
[19350,0.774,6.25,0.8715],
[29025,0.8715,3.25,0.8715],
[53212.5,0.774,10.25,0.92]

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

# Define weights and types
weights = np.array([0.25,0.2,0.25,0.3])
types = np.array([-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)
```

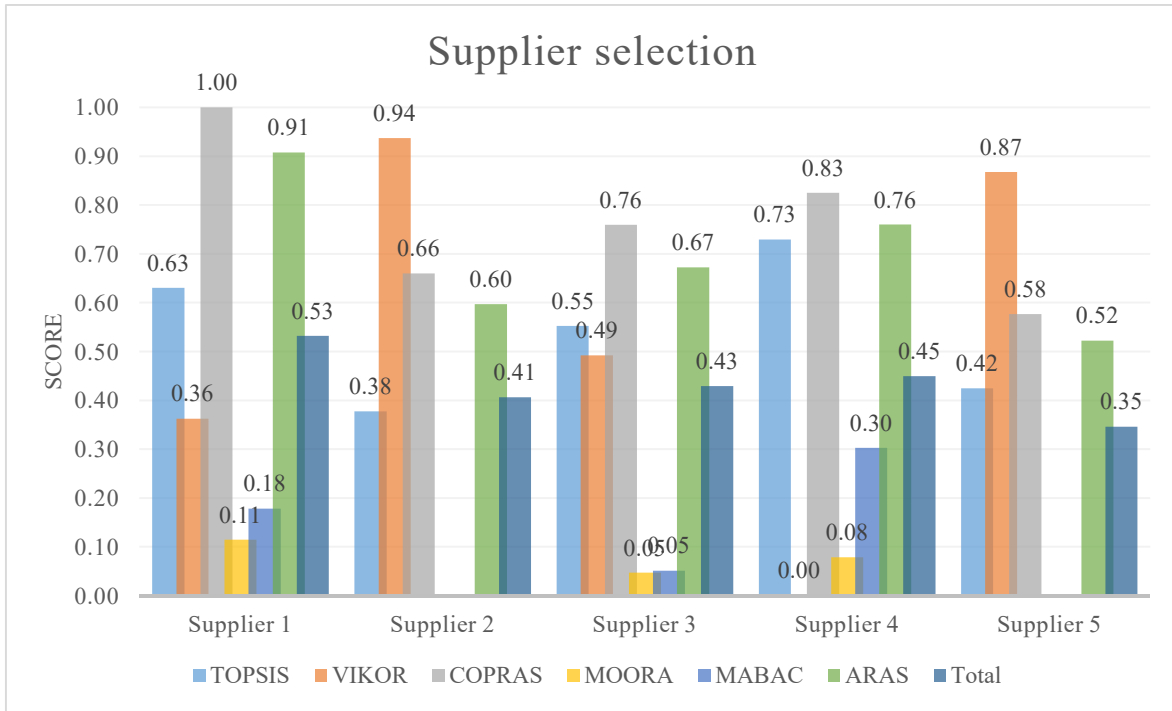


Figure 4: Results of running MCDM approach.

Table 6: Python code for supplier selection in supply chain.

| Supplier | TOPSIS | VIKOR | COPRAS | MOORA | MABAC | ARAS | Total |
|------------|--------|-------|--------|-------|-------|------|-------|
| Supplier 1 | 0.63 | 0.36 | 1.00 | 0.11 | 0.18 | 0.91 | 0.53 |
| Supplier 2 | 0.38 | 0.94 | 0.66 | -0.01 | -0.13 | 0.60 | 0.41 |
| Supplier 3 | 0.55 | 0.49 | 0.76 | 0.05 | 0.05 | 0.67 | 0.43 |
| Supplier 4 | 0.73 | 0.00 | 0.83 | 0.08 | 0.30 | 0.76 | 0.45 |
| Supplier 5 | 0.42 | 0.87 | 0.58 | -0.13 | -0.19 | 0.52 | 0.35 |

This table shows the results of applying multiple decision-making methods to evaluate five different suppliers. The methods used are TOPSIS, VIKOR, COPRAS, MOORA, MABAC, and ARAS. The table also includes a Total column that represents the overall ranking of the suppliers based on the results of all the methods.

Each supplier is assigned a score for each method, with higher scores indicating better performance. The scores range from -1 to 1, with 1 being the best possible score.

For example, Supplier 1 has a score of 0.63 for TOPSIS, 0.36 for VIKOR, 1.00 for COPRAS, 0.11 for MOORA, 0.18 for MABAC, and 0.91 for ARAS. The Total score for Supplier 1 is 0.53, which is the average of all the scores.

Based on the Total column, Supplier 1 is ranked first with a score of 0.53, followed by Supplier 2 with a score of 0.41, Supplier 3 with a score of 0.43, Supplier 4 with a score of 0.45, and Supplier 5 with a score of 0.35. This ranking represents the overall performance of the suppliers across all the methods used.

5. Conclusion

The study shows that the proposed decision-making framework can provide a comprehensive and effective approach for supplier selection in supply chain management. The framework can help the decision maker to make informed decisions while considering multiple criteria and risks associated with the selection process.

All of the papers reviewed in this summary propose supplier selection models that are designed to help risk-averse decision makers select suppliers that meet their needs while minimizing risk. The models use a variety of different approaches, including the mean-variance approach, fuzzy logic, and multi-objective optimization.

The choice of supplier selection model will depend on a number of factors, such as the specific criteria that are important to the decision maker, the level of uncertainty in the supplier evaluation process, and the availability of data. However, all of the models reviewed in this summary provide a valuable starting point for risk-averse decision makers who are looking to select suppliers that will help them achieve their business goals.

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