



# Sustainable Supplier Selection using Neutrosophic Sets and MCDM Framework

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## Abstract

Because of stricter rules from the government and growing awareness among the general public, sustainable supply chain management (SSCM) performs a significant role in the management of firm manufacturing operations. Companies that want to promote sustainable supply chain management (SSCM) must first choose the most suitable sustainable supplier, which is a MCDM dilemma, as highlighted in a number of research studies. In addition, because of their limited expertise, those who make decisions have a propensity to convey their opinions via the use of language phrases. The purpose of this work is to report on a unique MCDM model for the choice of sustainable suppliers. This approach integrates the MCDM MABAC method inside an uncertain language situation. With the assistance of uncertain linguistic sets, the neutrosophic sets used to overcome these uncertainty. When it comes to generating the ranking of possible suppliers, the MABAC is dependable and easy to understand. In conclusion, an iron maker is used as an example to illustrate the practicability and efficacy of the suggested strategy for the selection of sustainable suppliers.

**Keywords:** Sustainable Supplier Selection; Decision Making; Neutrosophic Sets; MCDM; MABAC

## 1. Introduction

In latest days, there has been a global rise in the level of public awareness over issues related to the environment. The administration places a great priority on addressing environmental pollution issues and promoting sustainable development, which has resulted in the establishment of a number of environmental laws and guidelines. When seen in this light, businesses cannot gloss over their sustainability impact if they want to achieve their goal of gaining a competitive edge in the global market. As a direct result of this, sustainable supply chain management (also known as SSCM) plays a vital role and is receiving an increasing amount of attention from both professionals and academia [1], [2]. A new ownership paradigm known as the SSCM has been developed with the goal of improving both the economic profit and corporate environmental of enterprises [3], [4]. There are many different programmes available to businesses in order for them to adopt SSCM [5], [6]. Some examples of these programmes include the use of environmentally friendly components, the creation of environment friendly materials, and the tracking of pollution in production methods. Nevertheless, the environmental performance of a business is dependent not just on the company's own sustainable behaviors but also on the environmental practices of the company's suppliers. As a consequence of this, doing SSCM effectively requires that businesses place a high focus on finding the most suitable environmentally responsible provider in the supply chain [7]–[9].

The choice of sustainable suppliers is a complex task that requires sustainable factors to be included into the choice process in the same way that traditional suppliers are chosen. The technique for making decisions about industrial activity management includes an essential step that is the selection of a sustainable supplier [10], [11]. Producers have the ability to successfully enhance both their sustainability impact and the happiness of their clients via the choice of sustainable suppliers. In addition, a proper supplier choice helps companies connect their supply chains and increase their overall advantages [12]–[14]. This is an important consideration for

businesses. For this reason, it is essential for businesses to select a supplier that is strong on all fronts, including the environment, society, and the economy, and to cultivate a lasting relationship with that supplier in order to preserve their economic benefit [15]–[17]. This study used the MABAC method under the neutrosophic sets to rank and select best supplier.

The process of selecting sustainable suppliers is often referred to as a MCDM issue. In past research, a variety of MCDM approaches were used for the purpose of picking the best possible provider [18]–[21].

The following is a list of goals that this research aims to achieve within this framework: Take into consideration the most important economic, environmental, and social variables when selecting sustainable suppliers and allocating orders. Provide a plan for the creation of a methodology to choose sustainable providers and to determine the optimum number of items to be acquired from each chosen source. To provide different sustainability requirements different relative relevance weights. To provide the theoretical and operational ramifications of the research.

## 2. The MABAC Method

A novel MCDM approach known as the MABAC was proposed. The MABAC approach is a highly useful and reliable instrument for decision making because of its clear computing process and the steady (consistent) of solution. This makes the technique a trustworthy choice. In order to be of assistance to decision makers, a modified version of the MABAC approach is presented here within the context of the single-valued neutrosophic context [22]–[26].

Phase 1: Determine the available options and characteristics, then derive the neutrosophic value.

Phase 2: Aggregate the neutrosophic single-valued decision matrix.

Phase 3: Compute the weights of criteria.

Phase 4: Normalize the decision matrix for positive and negative criteria as:

$$R = \frac{r_{ij} - \min r_i}{\max r_i - \min r_i}, \text{ for positive criteria} \quad (1)$$

$$R = \frac{r_{ij} - \max r_i}{\min r_i - \max r_i}, \text{ for negative criteria} \quad (2)$$

Phase 5: Compute the weighted normalized decision matrix ( $We_{ij}$ )

Phase 6: Compute the border approximation value

$$B_i = \left( \prod_{j=1}^m We_{ij} \right)^{\frac{1}{m}} \quad (3)$$

Where  $i = 1, 2, 3 \dots m; j = 1, 2, 3 \dots n$

Phase 7: Compute the distance between border approximation area and each alternative

$$D = We_{ij} - B_i \quad (4)$$

Phase 8: Compute the total score as:

$$T_i = \sum_{j=1}^n D_{ij} \quad (5)$$

Phase 9: Rank the alternatives

The options are ranked according to the minimum value of total score.

## 3. Application

In this part of the article, an iron manufacturing firm is used as a case study to demonstrate the relevance and utility of the model that has been provided for the purpose of choosing sustainable suppliers. The manufacturing industry is a major contributor to environmental degradation as well as global warming since it is one of the most resource-intensive and polluting sectors. As a result of the significant ecological pressure exerted by consumers and the government, manufacturing companies are being forced to lessen the adverse effects that their production operations have on the surrounding environment. The purpose of this application is to provide assistance to a case company so that they may choose the most suitable sustainable supplier for the purpose of adopting SSCM.

Considerations include prices, quality of products, technological prowess, and delivery dependability, environmental protection systems, waste treatment, manufacturing of pollution, security, rights, health of employees, professional growth of staff, and public publication of information as shown in Figure 1.

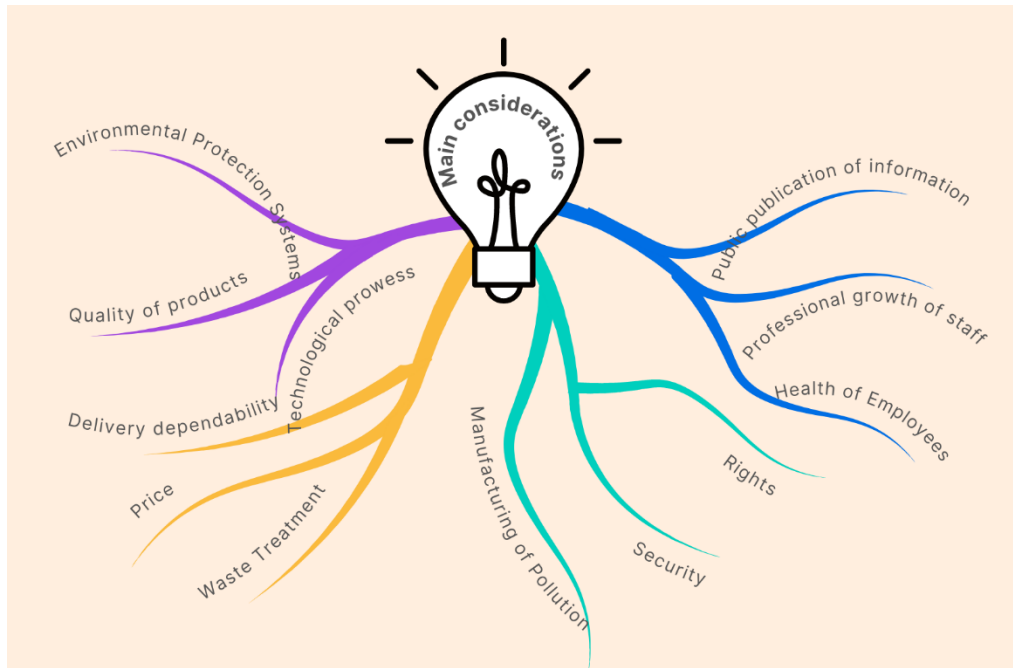


Figure 1: The selected criteria.

There are five alternatives. First compute the weights of the previous criteria. Evaluate the previous criteria by the decision makers. Then compute the weights of criteria by the average method. Figure 2 shows the weights of criteria.

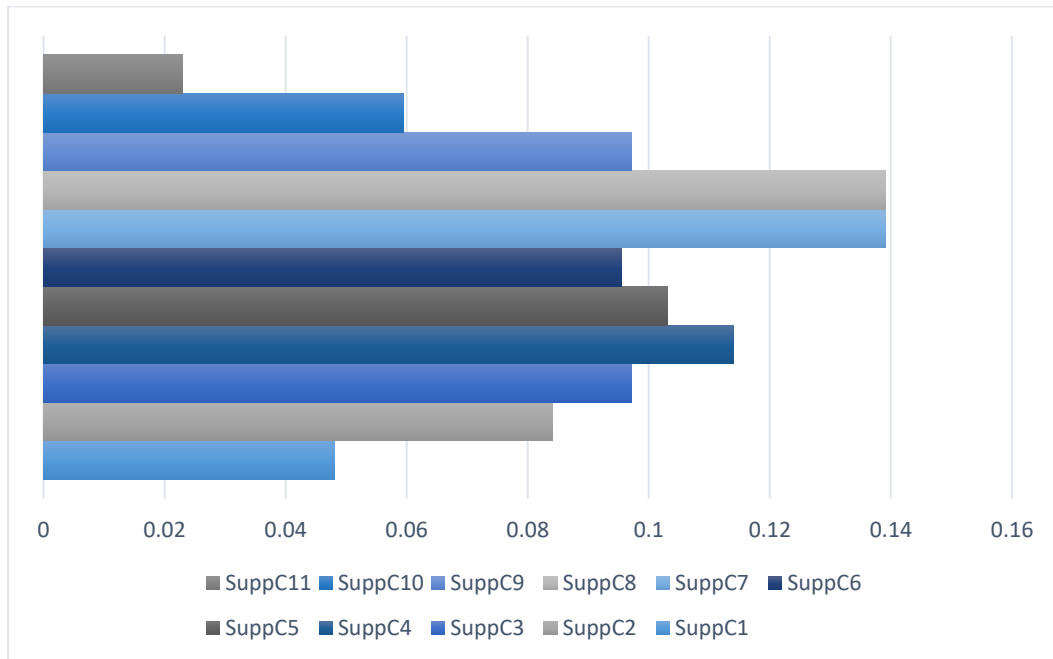


Figure 2: The weights of 11 criteria.

Let experts to evaluate the criteria and alternative to build the decision matrix as shown in Tables 1-3. Then aggregate these matrices into one matrix.

Table 1: The first decision matrix.

	Supp C <sub>1</sub>	Supp C <sub>2</sub>	Supp C <sub>3</sub>	Supp C <sub>4</sub>	Supp C <sub>5</sub>	Supp C <sub>6</sub>	Supp C <sub>7</sub>	Supp C <sub>8</sub>	Supp C <sub>9</sub>	SuppC <sub>10</sub>	SuppC <sub>11</sub>
SuppA <sub>1</sub>	0.33	0.22	0.66	0.88	0.9	0.77	0.88	0.77	0.9	0.66	0.22
SuppA <sub>2</sub>	0.33	0.66	0.9	0.88	0.77	0.88	0.77	0.9	0.22	0.1	0.1

SuppA <sub>3</sub>	0.22	0.66	0.22	0.33	0.22	0.1	0.9	0.88	0.66	0.33	0.1
SuppA <sub>4</sub>	0.33	0.77	0.77	0.88	0.9	0.22	0.33	0.22	0.66	0.33	0.22
SuppA <sub>5</sub>	0.22	0.66	0.77	0.88	0.9	0.66	0.66	0.66	0.22	0.33	0.33

Table 2: The second decision matrix.

	Supp C <sub>1</sub>	Supp C <sub>2</sub>	Supp C <sub>3</sub>	Supp C <sub>4</sub>	Supp C <sub>5</sub>	Supp C <sub>6</sub>	Supp C <sub>7</sub>	Supp C <sub>8</sub>	Supp C <sub>9</sub>	SuppC <sub>10</sub>	SuppC <sub>11</sub>
SuppA <sub>1</sub>	0.9	0.22	0.66	0.88	0.9	0.77	0.9	0.77	0.9	0.66	0.22
SuppA <sub>2</sub>	0.33	0.66	0.9	0.88	0.77	0.88	0.77	0.9	0.77	0.1	0.66
SuppA <sub>3</sub>	0.88	0.66	0.22	0.33	0.22	0.1	0.9	0.88	0.66	0.33	0.9
SuppA <sub>4</sub>	0.1	0.77	0.77	0.88	0.9	0.66	0.77	0.22	0.66	0.33	0.22
SuppA <sub>5</sub>	0.66	0.66	0.66	0.88	0.66	0.66	0.66	0.1	0.22	0.33	0.88

Table 3: The third decision matrix

	Supp C <sub>1</sub>	Supp C <sub>2</sub>	Supp C <sub>3</sub>	Supp C <sub>4</sub>	Supp C <sub>5</sub>	Supp C <sub>6</sub>	Supp C <sub>7</sub>	Supp C <sub>8</sub>	Supp C <sub>9</sub>	SuppC <sub>10</sub>	SuppC <sub>11</sub>
SuppA <sub>1</sub>	0.88	0.22	0.1	0.33	0.22	0.77	0.33	0.77	0.9	0.77	0.77
SuppA <sub>2</sub>	0.77	0.66	0.9	0.22	0.77	0.88	0.77	0.9	0.22	0.1	0.66
SuppA <sub>3</sub>	0.66	0.66	0.22	0.1	0.1	0.1	0.9	0.1	0.1	0.33	0.77
SuppA <sub>4</sub>	0.1	0.77	0.77	0.88	0.9	0.22	0.33	0.22	0.66	0.33	0.66
SuppA <sub>5</sub>	0.33	0.33	0.1	0.33	0.1	0.33	0.1	0.66	0.1	0.33	0.9

Table 4: Total decision matrix.

	Sup pC <sub>1</sub>	Supp C <sub>2</sub>	Supp C <sub>3</sub>	Supp C <sub>4</sub>	Supp C <sub>5</sub>	Supp C <sub>6</sub>	Supp C <sub>7</sub>	SuppC <sub>8</sub>	SuppC <sub>9</sub>	SuppC <sub>10</sub>	Supp C <sub>11</sub>
SuppA <sub>1</sub>	0.70	0.22	0.47	0.69	0.67	0.77	0.70	0.77	0.9	0.69	0.40
SuppA <sub>2</sub>	0.47	0.66	0.9	0.66	0.77	0.88	0.77	0.9	0.40	0.10	0.47
SuppA <sub>3</sub>	0.58	0.66	0.22	0.25	0.18	0.1	0.9	0.62	0.47	0.33	0.59
SuppA <sub>4</sub>	0.17	0.77	0.77	0.88	0.9	0.36	0.47	0.22	0.66	0.33	0.36
SuppA <sub>5</sub>	0.40	0.55	0.51	0.69	0.55	0.55	0.47	0.47	0.18	0.33	0.70

Then normalize the decision matrix as shown in Table 5. Then compute the weighted decision matrix. Then compute the border approximation area. Then compute the distance between alternatives and border approximation area. Then compute the total score. Then rank the alternatives according to the lowest value of total score as shown in Figure 2. From Figure 2 the supplier 5 is the best supplier and supplier 2 is the worst supplier.

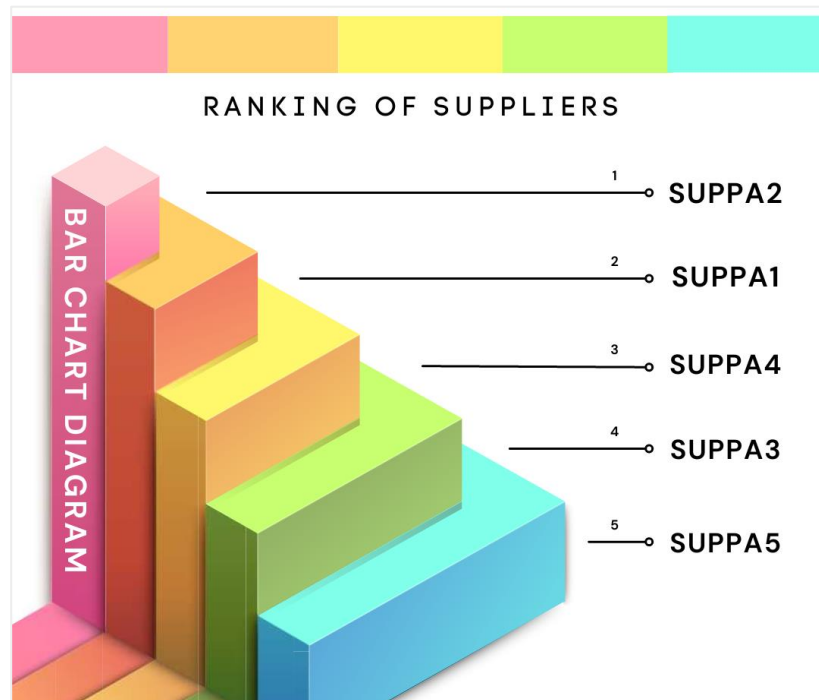


Figure 3: The ordering of suppliers.

#### 4. Conclusions

Lately, sustainable supply chain management has been gaining a growing attention among businesses all over the world, and supervisors are coming under rising stress to take into account sustainable practices in their supply chain operations. Moreover, this trend has gained traction in all regions of the world. An improvement in an organization's SSS and Order Allocation (SSS/OA) approach might result in a rise in that organization's level of competitiveness. An examination of the relevant literature reveals that the SSS and OA techniques need significant revision in order to take social performance into account. Currently, the methodologies place more of an emphasis on economic and ecological factors. The purpose of this study is to discuss the creation of a hybrid MCDM MABAC with the neutrosophic sets. The MABAC method used to rank and select best supplier from five supplier based on 11 criteria. The case study created on Iron Company. The results show that the supplier 5 is the best supplier and supplier 2 is the worst supplier.

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