Intuitionistic Fuzzy Marcos Method for the Green Supplier Selection Problem

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Abstract

MCDM techniques are essential for a variety of decision-making tasks. Approaching the difficulty of determining an appropriate solution is very challenging and complex since many aspects play a significant role. A novel Measurement Alternatives and Ranking (MARCOS) approach for sustainable supplier selection in retail establishments in Morocco is proposed in this study. The developed approach has the following advantages: before the development of an initial matrix, examination of an anti-ideal and ideal solution, more precision about the concept of usefulness, with consideration to both alternative solutions, the development of a new approach to calculate utility functions and the potential of considering a broad range of criteria and alternatives while still keeping the stability of the approach. Supplier selection is very important for organizations. Sustainability in supplier selection is a major problem for all organizations, and supplier selection processes are improperly executed in all areas of activity. And so, this case illustrates how to apply the MARCOS methodology to identify sustainable suppliers in the retail sector, which is done step-by-step, along with detailed explanations and which takes into consideration the criteria derived from the literature.

Keywords
Green Supplier selection, MCDM, Fuzzy MARCOS, Criteria of Supplier selection.

1. Introduction

Nowadays, people are buying from companies who are willing to supply them with cheap cost, high-quality, quick lead time, and, at the same time, maintain a responsible environmental position. In this approach, supplier selection represents an important step in the strategic sourcing process and a decision that has a crucial impact on the overall performance of any company. This decision aims to create and maintain a strong and efficient supplier network necessary for the customer to meet the growing challenges of competition. The sorting of suppliers is done according to several steps, selection and evaluation criteria based on several skills and multi-criteria analysis (price, quality, time, financial health, risk management, etc..) that allow the company to make a sharp choice and respond positively to the needs of consumers. The supplier desired by each company is the one that provides a good quality product, delivered in the minimum time with the lowest cost. The evaluation criteria of a supplier are often in conflict with each other, no supplier excels everywhere and who can combine the triptych QCD (quality, cost, time). The degree of importance in evaluating or choosing a supplier remains a difficult process that depends on each sector of activity and requires a multi-criteria decision.

To identify a sustainable supplier, these factors are used: economic, social, and environmental. Then, rational multi-criteria decision-making approaches should be employed (MCDM). Multi-Criteria Decision Making (MCDM) is a technique that combines several qualitative and quantitative criteria and provides solutions that help decision-makers in many fields of application to choose the option that meets their requirements. The decision-making process necessitates previous identification and compliance of criteria such as when fixing difficult challenges. Multi-criteria decision-making holds a special position in the world of science. These contribute positively aspects that characterize alternative approaches. A decision-maker utilizes MCDM approaches to analyze several possible alternatives to determine whether or not each option meets stated decision-making criteria and, if so, how well each satisfies the established objective of decision-making. This technique allows the decision-maker to use multiple criteria needed to identify at a compromise among all potentially opposing criteria. Even though multitudes of MCDM approaches are published in the literature, the optimal approach can only be identified in a specific sense.

In this article, we will highlight a recent Compromise Solution (MARCOS) methodology for sustainable supplier selection in a practical case, a seven-step procedure has been proposed. This technique is focused on analyzing alternatives and evaluating them by following per under a compromise option. The compromise solution involves calculating utility functions based on the distance between the anti-ideal and ideal solutions, as well as their clusters. The advantage of using this method is the consideration of an ideal and anti-ideal solution, a sharp determination of the degree of utility of the two solutions, and the weight of each to reach a better decision. The paper's key focus is to improve the area of decision-making by introducing a novel way for assisting decision-makers (DMs) in handling multidimensional challenges.

The article is organized as follows; Section 2 discusses the literature review on the green supplier selection problem and MCDM methodologies, Section 3 presents the research methodologies, Section 4 showcases Experimental results and Analysis, Section 5 details Theoretical & managerial implication. Section 6 concludes the paper.

2. Literature Review

In recent studies, the focus of GSCM has shifted away from green buying and toward green logistics, sustainable supply chains, and even reverse logistics. However, the majority of publications (Table 1) imply that businesses charged with sustainable development seek a win-win situation when it comes to supply chains and sustainable development.

The primary goal of GSCM is to reduce environmental emissions associated with the procurement, production, delivery, and production of goods, while also educating suppliers about the importance of environmental solutions. Hervani et al. (2005) describe it as the "integration of green procurement, sustainable manufacturing/materials management, environmentally-friendly distribution/marketing, and reverse logistics".

In the literature, several researchers have addressed the topic of green supplier selection to show the strategic and environmental importance of this issue. The selection of green suppliers is a delicate subject that requires a lot of rigor and attention. Several papers have been examined; bibliographical studies between 2010 & 2021 have also been realized and will be presented in this paper shortly.

Table 1. Literature review of GSSP

Year	Author	Methods	Investigations
2010	Wen and Chi	AHP, ANP, DEA	They developed a carbon footprint model via integrated methods of AHP (Analytic-hierarchy process) & ANP (Analytic network process) which are well known and widely used in the supplier selection process. In addition, a profound analysis of the useless and useful selection criteria has been done by the DEA method (Data envelopment analysis)
2010	Kuo et al.	ANN-MADA	They have referred to both DEA and ANP combining an artificial neural network (ANN) methodology with two multi-attribute decision analyzing methodologies (MADA). This is a hybrid method that combines ANN-MADA
2011	Yeh and Chuang	MOGA_1 MOGA_2	They have indicated that in traditional supplier selection management environmental factors are not considered and that GSS management will improve the competitive advantage in the marketplace
2012	Büyüközkan and çifçi	Fuzzy AHP Fuzzy axiomatic Design	They proposed a model that combined and allows the supplier to be evaluated with the combination of Fuzzy AHP and Fuzzy Axiomatic design methods. This method is used to calculate the weight of criteria and the supplier's ranking respectively
2013	Shen et Al.	Fuzzy TOPSIS	They suggested a fuzzy multi-criteria approach. They used a fuzzy TOPSIS method in the industry automotive sector to find the best result
2014	Kannan et Al.	Fuzzy TOPSIS	They used the fuzzy topsis method for choosing a Brazilian company. Three forms are used in this research
2015	Kannan et Al.	FAD	They found a new method in the Fuzzy axiomatic Design approach to select a green supplier of a plastic manufacturer in Singapore
2016	Yu and Hou	MMAHP	They applied a modified multiaplicative analytic hierarchy (MMAHP) process. The operation is composed of three stages 1 -Determine criteria and alternative suppliers 2-Calculate the weight of each criterion 3-Evaluate the criteria
2017	Mousakhani et al.	IT2FSs	They used type 2 fuzzy sets based on the MCDM approach for green suppliers. A sensitivity analysis was carried out to determine the impact of the various weight of DM on ranking performance
2018	Huai-Wei Lo James J.H. Liou Her-Shing Wang Yi-Song Tsai	TOPSIS Fuzzy multi-objective linear programming (FMLOP)	This work presents a method for solving fuzzy multi-objective structural equation (FMOLP) problems in which all coefficients are fuzzy triangular numbers and all constraints are fuzzy equality or inequality.
2019	Shubham Guptaa Umang Sonia Girish Kumarb	AHP WASPAS	They proposed a framework based on multi-criteria decision making (MCDM) which used to evaluate green suppliers by using analytical process AHP with another technique: MABAC (Multi-attribute border approximation area comparison), WASPAS(Weighted aggregated sum-product assessment), and TOPSIS (Technique for order preference by similarity to Ideal Solution)
2020	Huseyin Selcuk Kilic Ahmet Selcuk Yalcin	IF-TOPSIS	This study aims to improve its approach to a multi-point/multi-supplier / multi-period setting by proposing the integrated methodology including the IF-TOPSIS and a modified two-phase fuzzy goal programming model
2021	Seyed Amin SeyedHaeria JafarRezaeib	Best-worst method	The results of this study confirmed the proposed comprehensive model, which incorporates interconnections between criteria as well as specialist judgment ambiguities, to be highly capable of handling the green supplier selection problem.

Partner selection began in the late 1960s with Dickson (1966) and a lot of other work. Since 1985, the rising interest in the personal discipline has been reiterated by different articles (Table 1 & Table 3). It is remarkable to see how the selection criteria (Table 2) for suppliers fluctuate between companies.
Mostly, companies are interested. in criteria related to cost, quality and delivery time.

Table 2 The criteria for choosing suppliers most evoked by the researchers

Criteria	Wen and Chi (2010)	Ku and al (2010)	Yeh and Chung (2011)	Buyuk Ozkan and cift (2012)	Shen and Al (2013)	Kannane and Al (2014)	Kannane and Al (2015)	Xu and Hou (2016)	Mousakhani and Al (2017)	Huai Weïlo (2018)	Shubhan Gupta (2019)	Huseyin selcuk (2020)	Seyed Amin SeyedHaeria
Quality	√	√	√	√			√	√	√	√	√	√	√
Cost	√	√	√				√	√	√	√	√	√	√
Service & delivery	√	√	√				√	√	√	√	√	√	√
Technology	√			√	√				√			√	√
Eco-design													
Green image	√				√			√	√	√	√	√	
Cooperation								√	√				
Environmental Management System	√	√	√		√	√	√	√	√	√	√	√	
Supplier Risk										√		√	√

Below is a summary of all works used in this research with authors, year of research, name of journal and article.

Table 3. Litterature review summary

Year	Authors	Journal name	Article name
2010	Wen and Chi	Proceedings-2010 IEEE 17th International Conference on Industrial Engineering and Engineering Management	Developing green supplier selection procedure: A DEA approach
2010	Kuo and Al	Journal of cleaner production	Integration of artificial neural network and MADA methods for green supplier selection
2011	Yeh and Chuang	Expert systems with applications	Using multi-objective genetic algorithm for partner selection in green supply chain problems
2012	Büyüközkan and çifçi	Expert systems with applications	A novel hybrid MCDM approach based on fuzzy DEMATEL, fuzzy ANP, and fuzzy TOPSIS to evaluate green suppliers
2013	Shen and Al	Resources, conservation, and recycling	A fuzzy multi-criteria approach for evaluating green supplier's performance in the green supply chain with linguistic preferences
2014	Kannan et al	European Journal of Operational Research	Selection green suppliers based on GSCM practices: using Fuzzy TOPSIS applied to Brazilian Electronics Company
2015	Kannan et al	Journal of cleaner production	A fuzzy axiomatic design approach based green supplier selection: A case study from Singapore
2016	Yu and Hou	Kybernetes	An approach for green supplier selection in the automobile manufacturing industry
2017	Mousakhani and Al	Journal of cleaner production	A novel interval type-2 fuzzy evaluation model based group decision analysis from green supplier selection problems, a case study of the battery industry
2018	Huai-Wei Lo James J.H. Liou Her-Shing Wang Yi-Song Tsai	Journal of cleaner production	An integrated model for solving problems in green supplier selection and order allocation
2019	Shubham Guptaa Umang Sonia Girish Kumarb	Computer and Industrial Engineering	Green supplier selection using multi-criteria decision making under fuzzy environment: A case study : automotive industry
2020	Huseyin Selcuk Kilic Ahmet Selcuk Yalcin	Applied soft computing journal	Modifier two-phase fuzzy goal programs integrated with IF-TOPSIS for green supplier selection
2021	Seyed Amin Seyed Haeria Jafar Rezaeib	Journal of Cleaner Production	A grey-based green supplier selection model for uncertain environments

3. Methodology

The selection of green suppliers is considered to be an issue of decision making with several requirements, alternatives, and decision-makers (DMs) due to the existence of many criteria (Table 2). The GSS's steps are illustrated in Figure 1.

3.1 Fuzzy set theory

Bullman and Zadeh (1970) suggested a fuzzy- MCDM approach based on manipulated fuzzy sets due to solving the challenges of unreliable weight allocation and ranking alternatives against measuring criteria. People relied on logical instruments that are generally the product of bivalent logic (True/false, Yes/no)

Although the challenges that humans face in their daily lives and approaches and thoughts that humans use to solve those problems are not fundamentally opposed Tong and Bonissone (1980).

Similar to how bivalent logic is based on classic sets, fuzzy logic is based on fuzzy sets. A fuzzy set is a collection of objects in which no predefined or clear-cut boundary exists between the objects that are or are not members of the set. A membership function characterizes a fuzzy set by assigning a grade of membership to each element within the interval [0, 1], where '0' indicates the minimum membership function and '1' indicates the maximum membership, and the rest value between 1 and 0 indicates 'partial' degree of membership.

Fuzzy Set Theory has been used extensively by decision-makers (DMs) to address complex decision-making problems that include multiple alternatives and parameters in a constructive, reliable, and systematic manner Wang and Chang, (2007). Due to the ambiguity of the information associated with the parameter in selecting suppliers, FST was regarded as one of the most important tools for modeling ambiguous preferences in a mathematically precise manner.
It deals with imprecise details and confusion to find the overall best-ranking supplier. Amid, Ghodsypour and O'Brien (2006) create a multi-objective linear model to deal with ambiguous data. Chen and He (1997) presented a model to solve the MCDM problem by combining the MCDM TOPSIS approach with FST.

3.2 Intuitionistic Fuzzy MARCOS Model

The Marcos method is a multi-criteria data analysis (MCDM) method that initially starts by considering the ideal and anti-ideal alternatives. It assigns a particular function, weight, or priority value relatively with the ideal and anti-ideal alternatives. The ideal solution represents the closest and the most distant are the anti-ideal solutions
From the definition of several criteria, we can start the calculation through a decision matrix that presents the criteria vs. weight using a weight determination technique.

According to the literature, the ideal solution is presented by a max value for the allocation criteria and a min value for the cost elements and conversely for the anti-ideal solution which is presented by a max value for the cost criteria and a min value for the benefit elements. This matrix is used to measure the degree of advantage of each alternative that could be intelligently ranked later.

The selection of suppliers is usually done in several phases. Initially, the company must start by defining a working group that can break down all the elements and detail the decision-making problem, and determines the important criteria for supplier selection to model the problem.

In this section, we present an Intuitionistic Fuzzy MARCOS model for the evaluation of the alternatives MARCOS Method has the following steps:
Step 1: MARCOS begins with a basic decision-making matrix. This matrix represents the decision-evaluation makers of m possibilities against n criteria. In most situations, this matrix is the result of an expert group's aggregation of evaluation matrices. By P, designate this initial matrix.

$$P_1 = (p_{ij}) = \begin{pmatrix} p_{11} & \cdots & p_{1n} \\ \vdots & \ddots & \vdots \\ p_{m1} & \cdots & p_{mn} \end{pmatrix}$$

Step 2: After considering the ideal and anti-ideal solution noted id_j and aid_j, the initial choice matrix of step 1 is extended by adding two rows that contain the terms ideal and anti-ideal for each column.

Since the criteria may be classified into two categories: benefit criteria (enablers) and cost criteria (barriers), the ideal and anti-ideal solutions for each option are calculated as follows:
The weight of criteria is calculated as:

$$id_j = max_i\ (p_{ij}) \text{ if j is an enabler and } id_j = min_i\ (p_{ij}) \text{ if j is a barrier}$$

$$aid_j = min_i\ (p_{ij}) \text{ if j is an enabler and } aid_j = max_i\ (p_{ij}) \text{ if j is a barrier}$$

The ideal solution is the finest possible option, while the anti-ideal solution is the worst possible option. The extended matrix so formed is denoted by

$$P_2 = (e_{ij)})$$

Step 3: After the steps of scaling and normalizing, the following two equations are used to normalize the extended matrix:

$$\begin{cases} n_{ij} = \dfrac{e_{ij}}{id_j}, & \text{if } j \text{ is an enabler} \\ n_{ij} = \dfrac{id_j}{e_{ij}}, & \text{if } j \text{ is a barrier} \end{cases}$$

The selection of suppliers is usually done in several phases (Figure 1). Initially, the company must start by defining a working group that can break down all the elements and detail the decision-making problem, and determines the important criteria for supplier selection to model the problem.
The diagram below represents all the steps required for the selection of a supplier.

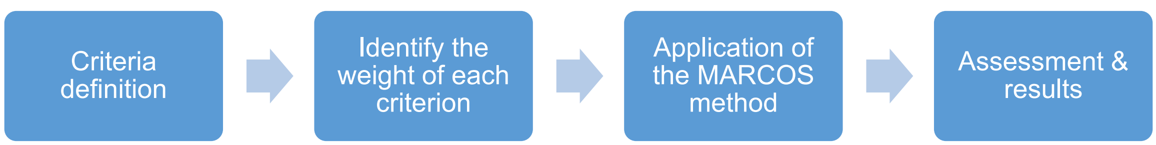

Figure 1. Steps of GSSP

Step 4: To calculate the weighted matrix L, use the formula: L=l ij. To create the later matrix, the equation below must be applied:

$$l_{ij} = n_{ij} \times w_j$$

Where w_j is the weight coefficient of criterion j.

Step 5: This equation may be used to calculate the utility degree of each choice:

$$U_i^- = \frac{S_i}{S_{aii}},$$

$$U_i^+ = \frac{S_i}{S_{ai}},$$

Where $\boldsymbol{S_i = \sum_{i=1}^{n} l_{ij}}$

Step 6: To calculate the overall utility of any choice, it is necessary to compute the following two terms:

$$\begin{cases} O_i^- = \dfrac{U_i^+}{U_i^+ + U_i^-}, \\ O_i^+ = \dfrac{U_i^-}{U_i^+ + U_i^-}, \end{cases}$$

The final utility of each alternative i is given by:

$$F_i = \frac{U_i^+ + U_i^-}{1 + \dfrac{1 - O_i^+}{O_i^+} + \dfrac{1 - O_i^-}{O_i^-}}$$

Step 7: the last phase is determining which option is the best based on its ultimate usefulness. A good alternative will have the most value and conversely, a bad alternative will have the lowest value.

4. Case study

This section features the most environmentally friendly products available for a Moroccan company operating in the retail sector. As shown in Figure 2, the analysis was performed using 9 criteria, with 3 decision-makers selecting the best of four supplier firms. The following criteria apply:

- Quality (C1): This criterion covers issues such as product output that complies with quality requirements, quality rejection rate, and contribution the quality, and quality systems
- Cost (C2): The supplier's entire cost. This value comprises product, acquisition, and procurement costs.
- Delivery (C3): This criterion indicates the supplier's service quality, delivery capability, on-time delivery, and adaptability to changing situations.
- Technology (C4): Suppliers' adaptability to present and emerging technology.
- Eco-design (C5): This criterion enables the determination of whether the product's design complies with the ecological guidelines for selecting a green supplier.
- Green-image (C6): The frequency of green consumers, green supplier evaluations in comparison to other firms, environmental social obligations, and sustainable purchase capacity
- Cooperation (C7): This criterion reflects harmony, a high level of trust, and adaptability in the workplace.
- Environmental Management System (C8): Environmental management objectives, policies, and plans are complemented by a system that includes certified environmental management systems
- Risk management (C9): based on continuous risk assessment to minimize vulnerability and ensure continuity of the supply chain

The alternatives are as follows:
Green Supplier 1 (GS1) is located in the Casablanca region. It has 100-400 employees, who export to 5 continents.
Green Supplier 2 (GS2) is located in the Nador region. It has 100-400 employees, who export to 3 continents.
Green Supplier 3 (GS3) is located in the Dakhla region. It has 100-400 employees, who export to 2 continents.
Green Supplier 4 (GS4) is located in the north of Morocco, more precisely in Tangier, which exports to several countries, especially Spain, due to its geographical proximity
The value of decision-makers is first determined as linguistic terms. The relevance of DM1 is "very significant," the relevance of DM2 is "significant," and the relevance of DM3 is "less significant." Then, using the formula described in Step 1 on methodology, these language phrases are translated to numerical values, and the decision-maker's significance weights are computed.
In the illustration below, we have implemented a hierarchy (Figure 2) based on the findings from the Delphi technique, which uses the criterion to integrate the supplier assessment process.

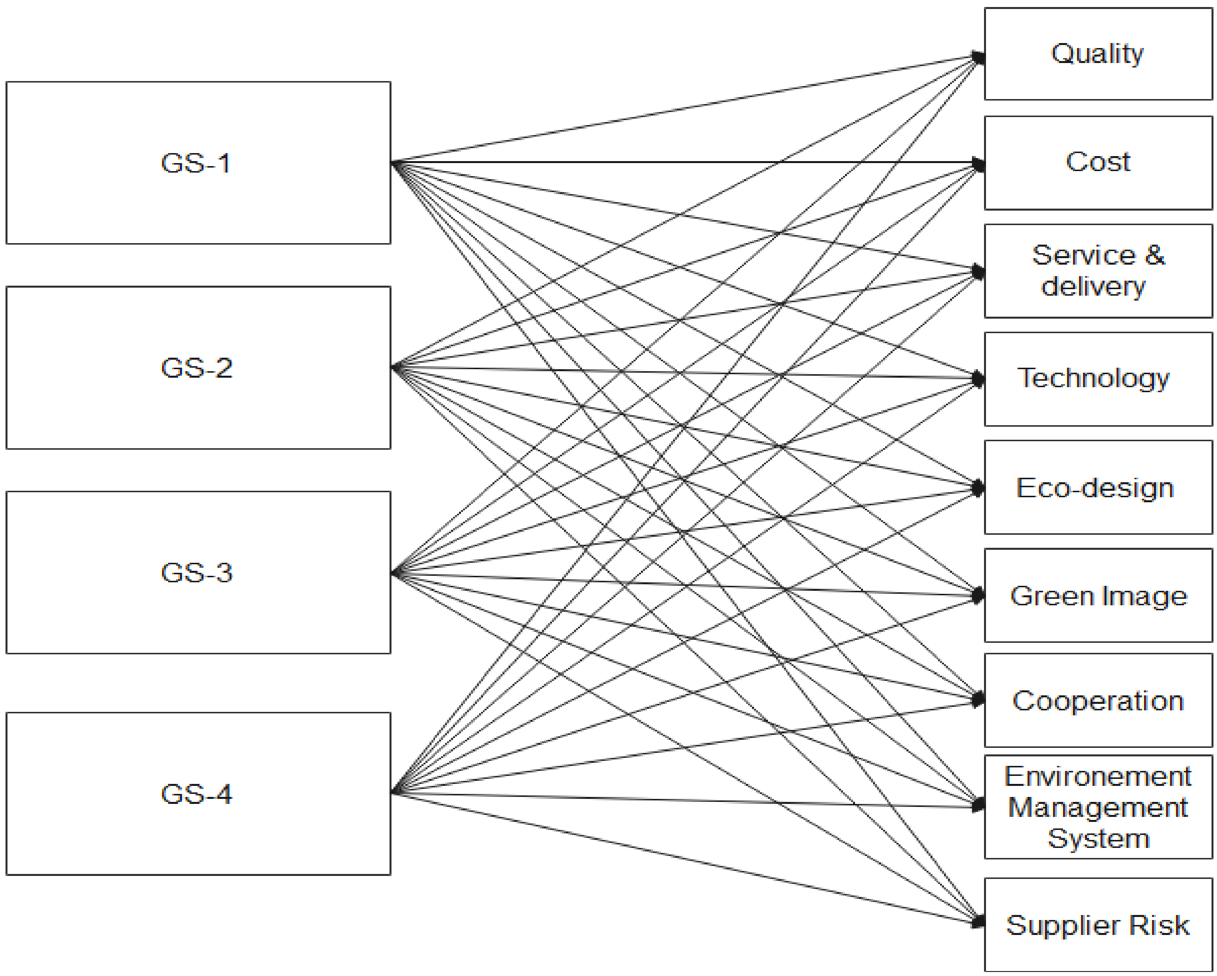

Figure 2. Hierarchy of GSSP based on Criteria

Table 4. Applied weights of criterion

Very significant (VS)	[0.80, 0.20, 0.00]
Significant (S)	[0.70, 0.30, 0.00]
Less significant (LS)	[0.60, 0.35, 0.05]
Unsignificant (U)	[0.25, 0.65, 0.10]
Very unsignificant (VU)	[0.20, 0.80, 0.00]

Table 5. The technical terminology for evaluating the alternative

Very Interesting (VI)	[0.90, 0.1, 0.00]
Interesting (I)	[0.85, 0.15, 0.00]
Reasonable (R)	[0.75, 0.15, 0.10]
Acceptable (A)	[0.50, 0.50, 0.00]
Moderately low (ML)	[0.45, 0.45, 0.10]
Low (L)	[0.20, 0.65, 0.15]

Table 6. Weights of criterion depending on DMs' opinions

	DM1	DM2	DM3
C1	VS	S	S
C2	S	LS	S
C3	LS	LS	U
C4	S	VS	S
C5	LS	U	VS
C6	S	S	VS
C7	LS	S	U
C8	U	U	LS
C9	S	VS	LS

Table 6. Weights Of criteria

C1	[0.89, 0.08, 0.03]
C2	[0.70, 0.24, 0.06]
C3	[0.50, 0.43, 0.07]
C4	[0.90, 0.1, 0.00]
C5	[0.60, 0.39, 0.01]
C6	[0.70, 0.25, 0.05]
C7	[0.82, 0.14, 0.04]
C8	[0.50, 0.50, 0.00]
C9	[0.70, 0.28, 0.02]

5. Results

The language evaluation of the nine criteria is performed by the decision makers (DMs) using the rating scales included in Table 4, which use the five insurance options considered to form a judgment on each of the nine criteria regarding those insurance options.

In Table 5, the technical terminology for evaluating the alternative.

In Table 6, the weight is determined depending on DM's opinion.

The results of the examination of the criteria's weights are presented in Table 7.

The importance of each alternatives based on criteria is found in Table 8 a score matrix each criterion is presented in Table 9. Following the results of table 9, it proposes an ideal solution, an anti-ideal solution in the extended matrix of Table 10 Standardized values are calculated in the normalized matrix of Table 11. These results allowed us to calculate the weight of each criterion in Table 12.

Finally, the most useful alternatives are ranked in descending order according to their utility functions. The most important utility function is the best alternative as presented in Table 13 and 14.

Table 8: Importance of alternatives based on criteria

DM1	C1	C2	C3	C4	C5	C6	C7	C8	C9
GS1	I	I	R	R	A	R	I	I	R
GS2	I	VI	I	I	I	I	I	VI	I
GS3	R	R	R	A	ML	L	R	R	R
GS4	VI	R	R	VI	I	VI	VI	R	R
DM2									
GS1	R	I	I	A	ML	A	R	I	I
GS2	VI	I	I	VI	I	I	VI	I	I
GS3	I	R	A	L	ML	A	I	R	A
GS4	VI	VI	R	VI	VI	I	VI	VI	R
DM3									
GS1	R	I	I	R	R	A	R	I	I
GS2	I	VI	I	I	VI	I	I	VI	I
GS3	R	R	ML	A	L	ML	R	R	ML
GS4	VI	VI	R	I	VI	I	VI	VI	R

Table 9: Score matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9
GS1	0,492	0,391	0,893	0,710	0,056	0,405	0,494	0,240	0,890
GS2	0,240	0,314	0,208	0,197	0,315	0,567	0,320	0,496	0,205
GS3	0,466	0,184	0,998	0,087	0,156	0,388	0,584	0,121	0,296
GS4	0,300	0,271	0,865	0,011	0,495	0,066	0,596	0,930	0,899

Table 10: Extended matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9
IDEAL	0,492	0,391	0,998	0,710	0,495	0,567	0,596	0,930	0,899
GS1	0,492	0,391	0,893	0,710	0,056	0,405	0,494	0,240	0,890
GS2	0,240	0,314	0,208	0,197	0,315	0,567	0,320	0,496	0,205
GS3	0,466	0,184	0,998	0,087	0,156	0,388	0,584	0,121	0,296
GS4	0,300	0,271	0,865	0,011	0,495	0,066	0,596	0,930	0,899
ANTIDEAL	0,240	0,184	0,208	0,011	0,056	0,066	0,320	0,121	0,205

Table 71: Normalized matrix

Normalized Matrix (nij=eij/idj)									
	C1	C2	C3	C4	C5	C6	C7	C8	C9
IDEAL	2,05	2,13	4,79	66,55	8,83	8,61	1,86	7,66	4,38
GS1	1,00	1,00	1,12	1,00	8,83	1,40	1,21	3,88	1,01
GS2	2,05	1,24	4,79	3,61	1,57	1,00	1,86	1,88	4,38

GS3	1,06	2,13	1,00	8,20	3,17	1,46	1,02	7,66	3,03
GS4	1,64	1,44	1,15	66,55	1,00	8,61	1,00	1,00	1,00
ANTIDEAL	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00

Table 82. Weighted matrix

Weighted Matrix (lij=nij*wj)									
	C1	C2	C3	C4	C5	C6	C7	C8	C9
Ideal	0,1641	0,0138	0,0338	0,1404	0,0852	0,0495	0,0107	0,0440	0,0252
GS1	0,0800	0,0065	0,0079	0,0021	0,0852	0,0081	0,0069	0,0223	0,0058
GS2	0,1641	0,0081	0,0338	0,0076	0,0152	0,0058	0,0107	0,0108	0,0252
GS3	0,0845	0,0138	0,0071	0,0173	0,0306	0,0084	0,0059	0,0440	0,0174
GS4	0,1314	0,0093	0,0081	0,1404	0,0097	0,0495	0,0058	0,0058	0,0058
Antideal	0,0800	0,0065	0,0071	0,0021	0,0097	0,0058	0,0058	0,0058	0,0058

Utility degrees

Table 93: Utility degrees

	U-	U+	Si
IDEAL			**0,567**
S1	1,479	0,335	0,190
S2	1,828	0,414	0,235
S3	1,260	0,285	0,162
S4	2,716	0,615	0,348
Antideal			**0,128**

Aggregated Utility

Table 14: Aggregated Utility

	O-	O+	Final utility	Final ranking
S1	0,185	0,815	0,321	3
S2	0,185	0,815	0,397	2
S3	0,185	0,815	0,274	4
S4	0,185	0,815	0,590	1

6. Conclusion

Green/sustainable development is attracting more and more consideration in the industry. A company must take environmental sustainability and green production in the position of being an important aspect of its corporate social responsibility to improve the product life cycle and achieve business perpetuity. It's important to implement a good green supplier selection strategy in a dynamic competitive and regulatory environment since it helps mitigate environmental and legal concerns while also improving efficiency and productivity.

This paper suggests a strategy to choose the criteria for determining green suppliers and to measure operational efficiency. It presented a new approach to how to choose & evaluate the criteria of the supplier by using the newly-introduced MARCOS method.

In the future, this model and approach should be implemented, since they are relatively easy and can be adapted to other decision-making issues as well

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