Choosing Suppliers for Healthcare Supply Chains under Neutrosophic Multi-Criteria Decision-Making Method

Iruma Alfonso Gonzalez[1], Guido Guida Acevedo[2], Flor B. Morocho Quinchuela[3]

[1]Universidad Regional Autónoma de los Andes (UNIANDES Ambato), Ecuador

[2]Universidad Regional Autónoma de los Andes (UNIANDES Santo Domingo), Ecuador

[3]Universidad Regional Autónoma de los Andes (UNIANDES Ambato), Ecuador

Emails: ua.irumaalfonso@uniandes.edu.ec; us.guidoga67@uniandes.edu.ec; ua.flormq29l@uniandes.edu.ec

Abstract

Given the importance of suppliers to the overall viability and effectiveness of a supply chain, the assessment and choice of suppliers is a popular topic of research. Thus, in today's global climate, businesses must develop a methodical approach to evaluating and selecting the most suitable supplier based on their standards. To meet this need, businesses might turn to multi-criteria decision-making (MCDM) techniques, since deciding on a reliable provider is fundamentally an MCDM challenge. Although many examples of using these strategies for supplier assessment and choice can be found in the published literature, not enough research has been conducted on their effectiveness in the healthcare industry. In the healthcare industry, hospitals must also think about supplier-related choices to lessen hazards and threads that impact their efficacy. The VIKOR technique, which is focused on the development of a compromising answer within the context of options and assessment standards, yields excellent outcomes in situations requiring the consideration of numerous factors simultaneously. Numerous studies have shown that neutrosophic numbers actively aid in the process of making decisions. Suppliers in healthcare alternatives selection is a challenge that has been solved by the presented technique.

Keywords: Suppler Selection; Supply Chain; Healthcare; VIKOR; MCDM; Neutrosophic Sets

1. Introduction

Businesses all around the globe are adopting sustainable supply chain practices to lessen their ecological footprint. Manufacturers have a critical role in creating a sustainable supply chain that will help achieve this objective[1], [2]. Assessment and the choice of sustainable suppliers are crucial steps toward achieving sustainability in supply chain management. Sustainable choice of suppliers refers to incorporating social, environmental, and financial considerations into conventional supply chain management. The success of businesses and their supply chains may benefit greatly from a careful choice of sustainable suppliers. The sustainable supply chain as a whole relies heavily on the strategic decision of which sustainable suppliers to work with[3], [4].

Organizational success relies heavily on resolving challenges with sustainable choice of suppliers. Therefore, it is imperative that businesses choose sustainable suppliers. Multiple factors are utilized in making choices, and these requirements sometimes clash with one another, making choosing sustainable suppliers difficult[5], [6]. Decision-

DOI: https://doi.org/10.54216/IJNS.210209
Received: February 02, 2023 Revised: May 01, 2023 Accepted: June 08, 2023

makers engaging in sustainable supplier selection through multi-criteria decision-making (MCDM) must take into account and evaluate both qualitative and quantitative factors[7], [8]. MCDM methodologies are the obvious choice when it comes to weighing economic, social, and environmental considerations in order to choose a sustainable provider. The capacity of MCDM to assess multiple options based on specific criteria makes it a useful tool for analyzing complicated real-world issues[9].

MCDM techniques are used to partition large issues into manageable chunks, which can then be reassembled after analysis to provide the whole overview of the issue at hand. Certain criteria must be defined and met before a choice can be made, and this is particularly true when dealing with complicated issues[10], [11]. The notion of MCDM is well regarded in the scientific community. Standards for making decisions are used by these techniques. A decision maker use MCDM techniques to weight several options in light of predetermined criteria and determine which ones best serve the desired outcome[12]. More and more people are turning to MCDM techniques, and new techniques have been created, to find answers to a wide range of challenges. Outranking techniques, Synthesis techniques, and interactive approaches are the three broad categories under which all MCDM techniques fall. Optimization issues are tackled using an interactive approach, with a non-dominant solution in mind[13], [14]. Decision makers (DMs) may rate options based on their preferences using outranking techniques. When weighing several, perhaps contradictory factors, synthesis techniques allow for informed decision making. In order to find a happy medium between potentially competing factors, the decision-maker might use MCDM techniques to take into account many criteria or goals. Although several MCDM approaches have been published, choosing the optimal approach is quite difficult. Professionals and researchers often choose the approach to be used based on the severity and breadth of the issue at hand[15].

Scientific investigations use sensitivity assessments to determine whether the judgements made are appropriate in the face of a predetermined change in the hypothesis, thereby avoiding these uncertainty-related pitfalls[16], [17]. Tools like Bayesian networks, fuzzy logic, and neutrosophic logic may help with this. The fuzzy sets (FSs) theory, proposed by Zadeh, who established the membership grade/truth (T) specified in the interval [0,1], is widely utilized in MCDM. Unlike classical logic, it only allows for "true" and "not true" (or false) propositions. Similar to how human cognition is not dependent on a binary classical logic, fuzzy logic allows for the mathematical modelling of nebulous or inaccurate notions. Atanassov defined intuitionistic fuzzy sets (IFSs), which permit more complicated mental constructs and semantic doubts, and therefore included the degree of non-membership/falsehood (F). Nonetheless, FSs and IFSs are unable to evaluate metaphors or social occurrences that may be seen in two ways according to the observer[18], [19].

As a generalization of FSs and notably IFSs, Neutrosophic Sets (NSs) allow for novel breakthroughs in the management of ambiguity. The element of indeterminacy was first presented by Smarandache. Truth, falsehood, and indeterminacy are the 3 distinguishing features of NSs elements. In contrast to the fuzzy and intuitionistic designs, neutrosophic systems allow for a more than one sum of the three attributes (T, F, I), up to a maximum of three. In this approach, ambiguity and other semantic errors, including paradoxes, may be modelled. Single value neutrosophic sets (SVNSs) and interval neutral sets (INSs) were suggested since NSs are more challenging when it comes to technological or academic decision making. To more effectively interpret the ambiguity produced by the imprecision, inconsistency, and insufficient data that characterizes the real world, linguistic factors and conceptual aggregation operators were introduced to better define its characteristics[20], [21].

While the NSs may be traced back to the last years of the twentieth century, the theory behind them is relatively new. Hospital efficiency evaluation, employee selection, and typhoon disaster assessment are just some of the recent examples of where MCDM has been put to use. According to Navarro et al.'s analysis of the literature, no instances of the neutrosophic method being used in MCDM for assessing infrastructures have been discovered since 1995. As far as we are aware, NSs have not yet been used to assess the long-term viability of structural engineering or the construction of private homes. It initially showed up in the area of civil engineering in 2020, specifically in the context of building bridges. This is why the researchers have chosen to employ neutrosophic reasoning to assess the longevity of a residence designed for a single family[22], [23].

DOI: https://doi.org/10.54216/IJNS.210209
Received: February 02, 2023 Revised: May 01, 2023 Accepted: June 08, 2023

2. Materials and Methods

In 2004, the VIKOR technique made its debut in the academic literature. The method's foundational idea is focused on weighing competing criteria to determine which option is best. The approach's goal is to arrive at a mutually agreeable resolution during the vetting phase. Figure 1 shows the steps of the VIKOR method.

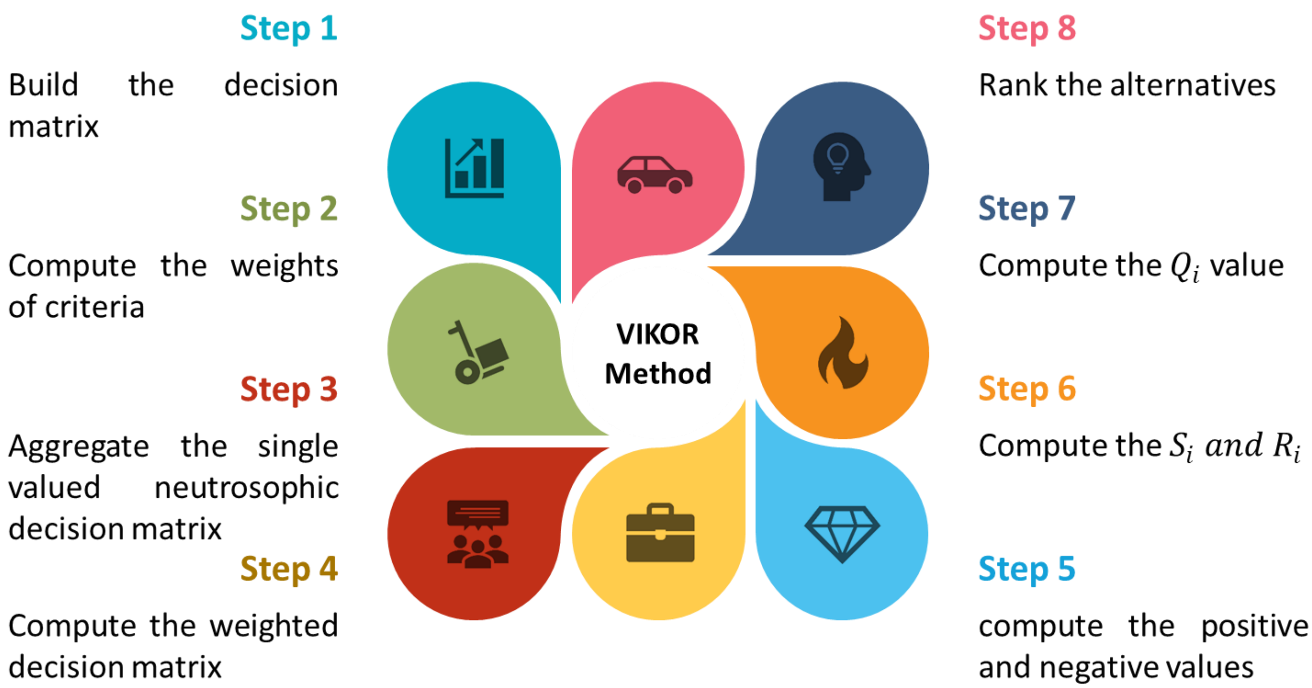

Figure 1: The steps of the VIJOR method.

Step 1: Build the decision matrix

Step 2: Compute the weights of criteria

Step 3: Aggregate the single valued neutrosophic decision matrix

$$D = (d_{ij})_{m \times n} \quad (1)$$

$$d_{ij} = \left(d_{ij}^{(1)}, d_{ij}^{(2)}, d_{ij}^{(3)} \ldots \ldots d_{ij}^{(u)}\right) = w_1 d_{ij}^{(1)} \oplus w_2 d_{ij}^{(2)} \oplus w_3 d_{ij}^{(3)} \ldots \ldots \oplus w_u d_{ij}^{(u)} \quad (2)$$

$$d_{ij} = \left(1 - \prod_{t=1}^{u}\left(1 - T_{ij}^{(t)}\right)^{w_t}, \prod_{t=1}^{u}\left(I_{ij}^{(t)}\right)^{w_t}, \prod_{t=1}^{u}\left(F_{ij}^{(t)}\right)^{w_t}\right) \quad (3)$$

Where w refers to the weights of criteria $w = (w_1, w_2, w_3, \ldots \ldots w_k)^T$, T,I,F refers to the truth, indeterminacy and falsify membership degree.

Step 4: Compute the weighted decision matrix

DOI: https://doi.org/10.54216/IJNS.210209
Received: February 02, 2023 Revised: May 01, 2023 Accepted: June 08, 2023

$$U^* = U \otimes W \quad (4)$$

$$U^*_{ij} = w_j \otimes u_{ij} = \left(T^w_{ij}, I^w_{ij}, F^w_{ij}\right) \quad (5)$$

Step 5: compute the positive and negative values

$$T_j^{w+} = \left(\max_i T_j^w | j \in B\right), \left(\min_i T_j^w | j \in N\right) \quad (6)$$

$$I_j^{w+} = \left(\max_i I_j^w | j \in B\right), \left(\max_i I_j^w | j \in N\right) \quad (7)$$

$$F_j^{w+} = \left(\max_i F_j^w | j \in B\right), \left(\max_i F_j^w | j \in N\right) \quad (8)$$

$$T_j^{w-} = \left(\max_i T_j^w | j \in B\right), \left(\max_i T_j^w | j \in N\right) \quad (9)$$

$$I_j^{w-} = \left(\max_i I_j^w | j \in B\right), \left(\max_i I_j^w | j \in N\right) \quad (10)$$

$$F_j^{w-} = \left(\max_i F_j^w | j \in B\right), \left(\max_i F_j^w | j \in N\right) \quad (11)$$

Where B refers to beneficial criteria and N refers to non-beneficial.

$$w_j^+ = \left(T_j^{w+}, I_j^{w+}, F_j^{w+}\right), w_j^- = \left(T_j^{w-}, I_j^{w-}, F_j^{w-}\right) \quad (12)$$

Step 6: Compute the S_i and R_i

$$S_i = \sum_{j=1}^n w_j \frac{\| w_j^+ - w_{ij} \|}{\| w_j^+ - w_j^- \|} \quad (13)$$

$$R_i = \max_j w_j \frac{\| w_j^+ - w_{ij} \|}{\| w_j^+ - w_j^- \|} \quad (14)$$

Step 7: Compute the Q_i value

$$Q_i = \varphi \left[\frac{S_i - S^+}{S^- - S^+}\right] + (1 - \varphi) \left[\frac{R_i - R^+}{R^- - R^+}\right] \quad (15)$$

Step 8: Rank the alternatives

3. **Results**

A public hospital served as the setting for this investigation. By analysing the available literature, we were able to establish both the primary and secondary criteria for making our supplier choice.

Three buying specialists from the hospital under review were questioned to assign relative importance to the various selection criteria. Professionals were asked to rate the vendors. Let experts to evaluate the criteria to compute the weights of criteria as shown in Table 1.

Table 1: The importance of criteria in healthcare.

Criteria	Weights
$HealtC_1$	0.105715
$HealtC_2$	0.154286

DOI: https://doi.org/10.54216/IJNS.210209
Received: February 02, 2023 Revised: May 01, 2023 Accepted: June 08, 2023

$HealtC_3$	0.134285
$HealtC_4$	0.017143
$HealtC_5$	0.051429
$HealtC_6$	0.154286
$HealtC_7$	0.105715
$HealtC_8$	0.154286
$HealtC_9$	0.105715
$HealtC_{10}$	0.017143

Then let experts to evaluate the criteria and alternatives to build the decision matrix by using the single valued neutrosophic numbers as shown in Table 2.

Table 2: The neutrosophic number by the decision maker.

	$HealtC_1$	$HealtC_2$	$HealtC_3$	$HealtC_4$	$HealtC_5$	$HealtC_6$	$HealtC_7$	$HealtC_8$	$HealtC_9$	$HealtC_{10}$
Healt A_1	(0.60, 0.35, 0.40)	(0.90, 0.10,0.10)	(0.80, 0.25, 0.20)	(0.10, 0.90,0.90)	(0.30, 0.70, 0.70)	(0.90, 0.10,0.10)	(0.60, 0.35, 0.40)	(0.90, 0.10,0.10)	(0.60, 0.35, 0.40)	(0.10, 0.90,0.90)
Healt A_2	(0.90, 0.10,0.10)	(0.80, 0.25, 0.20)	(0.10, 0.90,0.90)	(0.20, 0.75, 0.80)	(0.80, 0.25, 0.20)	(0.10, 0.90,0.90)	(0.10, 0.90,0.90)	(0.80, 0.25, 0.20)	(0.10, 0.90,0.90)	(0.90, 0.10,0.10)
Healt A_3	(0.10, 0.90,0.90)	(0.30, 0.70, 0.70)	(0.80, 0.25, 0.20)	(0.30, 0.70, 0.70)	(0.80, 0.25, 0.20)	(0.60, 0.35, 0.40)	(0.20, 0.75, 0.80)	(0.20, 0.75, 0.80)	(0.60, 0.35, 0.40)	(0.10, 0.90,0.90)
Healt A_4	(0.90, 0.10,0.10)	(0.80, 0.25, 0.20)	(0.10, 0.90,0.90)	(0.20, 0.75, 0.80)	(0.30, 0.70, 0.70)	(0.10, 0.90,0.90)	(0.10, 0.90,0.90)	(0.10, 0.90,0.90)	(0.30, 0.70, 0.70)	(0.80, 0.25, 0.20)
Healt A_5	(0.30, 0.70, 0.70)	(0.60, 0.35, 0.40)	(0.20, 0.75, 0.80)	(0.60, 0.35, 0.40)	(0.20, 0.75, 0.80)	(0.60, 0.35, 0.40)	(0.60, 0.35, 0.40)	(0.30, 0.70, 0.70)	(0.20, 0.75, 0.80)	(0.80, 0.25, 0.20)
Healt A_6	(0.20, 0.75, 0.80)	(0.10, 0.90,0.90)	(0.10, 0.90,0.90)	(0.70, 0.30, 0.30)	(0.10, 0.90,0.90)	(0.30, 0.70, 0.70)	(0.10, 0.90,0.90)	(0.30, 0.70, 0.70)	(0.10, 0.90,0.90)	(0.30, 0.70, 0.70)
Healt A_7	(0.90, 0.10,0.10)	(0.60, 0.35, 0.40)	(0.30, 0.70, 0.70)	(0.60, 0.35, 0.40)	(0.70, 0.30, 0.30)	(0.20, 0.75, 0.80)	(0.60, 0.35, 0.40)	(0.80, 0.25, 0.20)	(0.20, 0.75, 0.80)	(0.80, 0.25, 0.20)
Healt A_8	(0.80, 0.25, 0.20)	(0.10, 0.90,0.90)	(0.20, 0.75, 0.80)	(0.10, 0.90,0.90)	(0.70, 0.30, 0.30)	(0.80, 0.25, 0.20)	(0.10, 0.90,0.90)	(0.10, 0.90,0.90)	(0.20, 0.75, 0.80)	(0.10, 0.90,0.90)
Healt A_9	(0.30, 0.70, 0.70)	(0.20, 0.75, 0.80)	(0.20, 0.75, 0.80)	(0.30, 0.70, 0.70)	(0.30, 0.70, 0.70)	(0.80, 0.25, 0.20)	(0.20, 0.75, 0.80)	(0.20, 0.75, 0.80)	(0.20, 0.75, 0.80)	(0.10, 0.90,0.90)
Healt A_{10}	(0.90, 0.10,0.10)	(0.10, 0.90,0.90)	(0.90, 0.10,0.10)	(0.30, 0.70, 0.70)	(0.10, 0.90,0.90)	(0.90, 0.10,0.10)	(0.10, 0.90,0.90)	(0.90, 0.10,0.10)	(0.30, 0.70, 0.70)	(0.90, 0.10,0.10)

Then apply the previous steps in previous section to rank the alternatives. First determine the positive and negative criteria. The cost criterion is negative and all criteria are positive criteria. In this study, we used ten criteria and ten suppliers. The ten criteria are list as: Ecological, Social, Flexibility, Dependability, Quality, Shipping, Reputation, Administration and Planning, Safety and health on the job, Learning. Compute the weighted matrix as shown in Table 3.

DOI: https://doi.org/10.54216/IJNS.210209
Received: February 02, 2023 Revised: May 01, 2023 Accepted: June 08, 2023

Table 3: The weighted decision matrix

	$HealtC_1$	$HealtC_2$	$HealtC_3$	$HealtC_4$	$HealtC_5$	$HealtC_6$	$HealtC_7$	$HealtC_8$	$HealtC_9$	$HealtC_{10}$
$HealtA_1$	0.03744	0	0.019584	0.017143	0.036376	0.154286	0	0	0	0
$HealtA_2$	0	0.022501	0.134285	0.013809	0	0	0.105715	0.022501	0.105715	0.017143
$HealtA_3$	0.105715	0.115714	0.019584	0.011429	0	0.099643	0.081844	0.131785	0	0
$HealtA_4$	0	0.022501	0.134285	0.013809	0.036376	0	0.105715	0.154286	0.064793	0.014643
$HealtA_5$	0.079286	0.054642	0.114702	0.002381	0.042648	0.099643	0	0.115714	0.081844	0.014643
$HealtA_6$	0.090298	0.154286	0.134285	0	0.051429	0.038571	0.105715	0.115714	0.105715	0.004286
$HealtA_7$	0	0.054642	0.100714	0.002381	0.006272	0.0225	0	0.022501	0.081844	0.014643
$HealtA_8$	0.015417	0.154286	0.114702	0.017143	0.006272	0.131785	0.105715	0.154286	0.081844	0
$HealtA_9$	0.079286	0.131785	0.114702	0.011429	0.036376	0.131785	0.081844	0.131785	0.081844	0
$HealtA_{10}$	0	0.154286	0	0.011429	0.051429	0.154286	0.105715	0	0.064793	0.017143

Using Eqs. (6-11) to compute the positive and negative values. Then compute the S_i and R_i using Eqs. (13-14). Then compute Q_i by using Eq. (15). Finally rank the alternatives based on the smallest value of Q_i. The values of Q_i are shown in Figure 2. From Figure 2, the suppliers 7 is the best supplier and supplier 6 is the worst supplier.

DOI: https://doi.org/10.54216/IJNS.210209
Received: February 02, 2023 Revised: May 01, 2023 Accepted: June 08, 2023

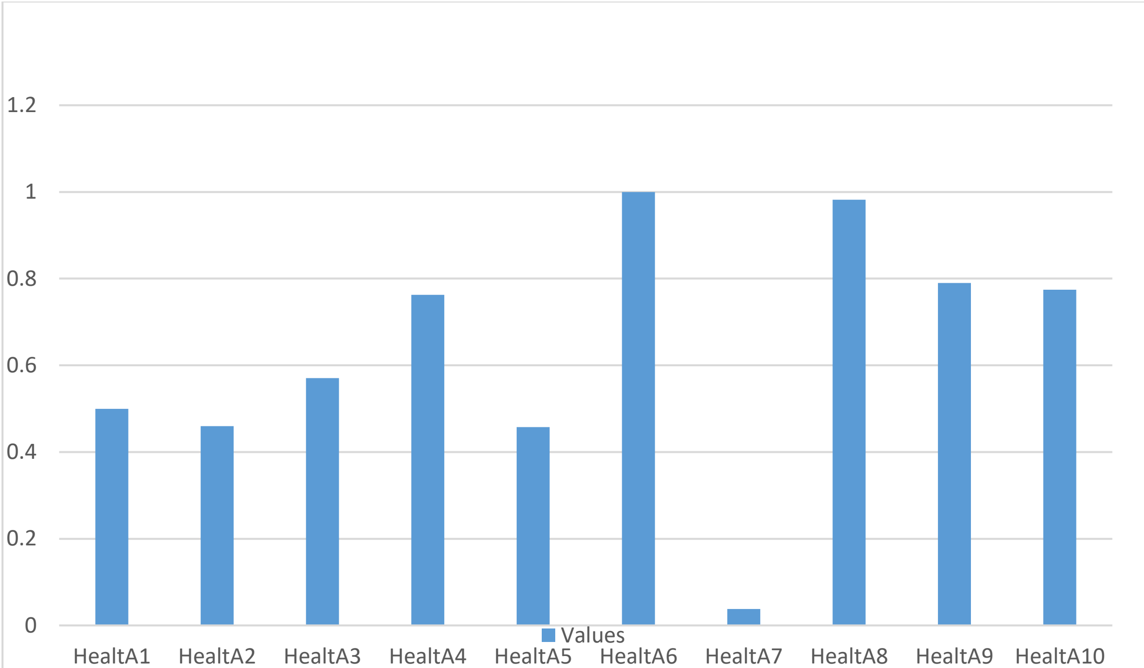

Figure 2: The values of Q_i.

4. Conclusion

Every industry is rapidly becoming more globalized in today's highly competitive market. Therefore, there are more providers from whom to choose and more parameters to consider while making that decision. Businesses in the manufacturing or service industries are under pressure to establish reliable alliances and choose the most reliable vendors to ensure their continued success. The assessment and choice of a supplier allow a business to get high-quality goods and services at a reasonable cost and promptly. Depending on the nature of the goods or services being purchased, this procedure may include a wide range of variables and complex interdependencies. Improving quality and flexibility in addition to lead time is a critical role of a company's buying department. Given the significance to a business, there has to be a methodical approach to choosing the best vendor. The steps involved in this procedure include identifying the need for a new supplier, determining and defining the decision criteria, conducting an initial qualification process, selecting a final provider, and keeping tabs on the chosen vendor. In this article, we show how a private healthcare organization might use MCDM techniques to identify a supplier that will be there for the long haul. To solve the issue of making decisions based on several factors, the authors of this work propose a new technique they name VIKOR. The VIKOR method is used to rank the alternatives. The VIKOR method is a hybrid with neutrosophic sets to solve vague and uncertain information. From applying the neutrosophic VIKOR method, supplier 7 is the best, and supplier 7 is the worst.

References

[1] D. Sumrit, "Supplier selection for vendor-managed inventory in healthcare using fuzzy multi-criteria decision-making approach," *Decis. Sci. Lett.*, vol. 9, no. 2, pp. 233–256, 2020.

[2] D. Pamucar, A. E. Torkayesh, and S. Biswas, "Supplier selection in healthcare supply chain management during the COVID-19 pandemic: a novel fuzzy rough decision-making approach," *Ann. Oper. Res.*, pp. 1–43, 2022.

[3] Ž. Stević, D. Pamučar, A. Puška, and P. Chatterjee, "Sustainable supplier selection in healthcare industries using a new MCDM method: Measurement of alternatives and ranking according to COmpromise solution

DOI: https://doi.org/10.54216/IJNS.210209
Received: February 02, 2023 Revised: May 01, 2023 Accepted: June 08, 2023

(MARCOS)," *Comput. Ind. Eng.*, vol. 140, p. 106231, 2020.

[4] A. Beşkese and C. Evecen, "Supplier selection in healthcare sector," *J. Trends Dev. Mach. Assoc. Technol.*, vol. 16, no. 1, pp. 91–94, 2012.

[5] S. G. Fashoto, B. Akinnuwesi, O. Owolabi, and D. Adelekan, "Decision support model for supplier selection in healthcare service delivery using analytical hierarchy process and artificial neural network," *African J. Bus. Manag.*, vol. 10, no. 9, pp. 209–232, 2016.

[6] K. K. Göncü and O. Çetin, "A Decision Model for Supplier Selection Criteria in Healthcare Enterprises with Dematel ANP Method," *Sustainability*, vol. 14, no. 21, p. 13912, 2022.

[7] S. Akcan and M. Güldeş, "Integrated multicriteria decision-making methods to solve supplier selection problem: A case study in a hospital," *J. Healthc. Eng.*, vol. 2019, 2019.

[8] B. Debnath, A. B. M. M. Bari, M. M. Haq, D. A. de Jesus Pacheco, and M. A. Khan, "An integrated stepwise weight assessment ratio analysis and weighted aggregated sum product assessment framework for sustainable supplier selection in the healthcare supply chains," *Supply Chain Anal.*, vol. 1, p. 100001, 2023.

[9] I. E. Ahmed Sleem, "An Interval Valued Neutrosophic Sets Integrated with the AHP MCDM Methodology to Assess the Station of 5G Network," *Neutrosophic Inf. Fusion*, vol. 1, no. 1, pp. 34–40, 2023, doi: 10.54216/NIF.010104.

[10] M. Yazdani, A. E. Torkayesh, and P. Chatterjee, "An integrated decision-making model for supplier evaluation in public healthcare system: the case study of a Spanish hospital," *J. Enterp. Inf. Manag.*, vol. 33, no. 5, pp. 965–989, 2020.

[11] M. Abbaspour Onari and M. Jahangoshai Rezaee, "Implementing bargaining game-based fuzzy cognitive map and mixed-motive games for group decisions in the healthcare supplier selection," *Artif. Intell. Rev.*, pp. 1–34, 2023.

[12] A. Gamal and N. N. Mostafa, "Sustainable Supplier Selection using Neutrosophic Sets and MCDM Framework," *Neutrosophic Inf. Fusion*, vol. 1, no. 1, pp. 27–33, 2023, doi: 10.54216/nif.010103.

[13] M. Goh, S. Zhong, and R. De Souza, "Operational framework for healthcare supplier selection under a fuzzy multi-criteria environment," 2020.

[14] H. Eroğlu and R. Şahin, "A neutrosophic VIKOR method-based decision-making with an improved distance measure and score function: case study of selection for renewable energy alternatives," *Cognit. Comput.*, vol. 12, no. 6, pp. 1338–1355, 2020.

[15] H. K. M. Ahmed Abdelhafeez, "Enhance the Performance of Bus Rapid Transit (BRT) through the Evaluation of Alternatives under an Integrated MCDM Neutrosophic Environment," *Neutrosophic Inf. Fusion*, vol. 1, no. 2, pp. 08–15, 2023, doi: 10.54216/NIF.010201.

[16] J. Nsikan, E. A. Affiah, I. Briggs, and N. Koko, "Sustainable supplier selection factors and supply chain performance in the Nigerian healthcare industry," *J. Transp. Supply Chain Manag.*, vol. 16, p. 633, 2022.

[17] E. Boz, S. Çizmecioğlu, and A. Çalık, "A Novel MDCM Approach for Sustainable Supplier Selection in Healthcare System in the Era of Logistics 4.0," *Sustainability*, vol. 14, no. 21, p. 13839, 2022.

[18] H. Paronyan, R. M. Carballido, and M. A. Matos, *Neutrosophic VIKOR for Proposal of Reform to Article 189 of the Integral Criminal Code in Ecuador*, vol. 37. Infinite Study, 2020.

[19] J. Wang, G. Wei, and M. Lu, "An extended VIKOR method for multiple criteria group decision making with triangular fuzzy neutrosophic numbers," *Symmetry (Basel).*, vol. 10, no. 10, p. 497, 2018.

[20] N. L. A. M. Kamal, L. Abdullah, F. M. Yee, I. Abdullah, and N. Vafaei, "Single Valued Neutrosophic VIKOR and Its Application to Wastewater Treatment Selection.," *Neutrosophic Sets Syst.*, vol. 47, 2021.

[21] J. Hu, L. Pan, and X. Chen, "An interval neutrosophic projection-based VIKOR method for selecting

DOI: https://doi.org/10.54216/IJNS.210209
Received: February 02, 2023 Revised: May 01, 2023 Accepted: June 08, 2023

doctors," *Cognit. Comput.*, vol. 9, pp. 801–816, 2017.

[22] H. Pouresmaeil, E. Shivanian, E. Khorram, and H. S. Fathabadi, "An extended method using TOPSIS and VIKOR for multiple attribute decision making with multiple decision makers and single valued neutrosophic numbers," *Adv. Appl. Stat*, vol. 50, pp. 261–292, 2017.

[23] R. Bausys and E.-K. Zavadskas, *Multicriteria decision making approach by VIKOR under interval neutrosophic set environment*. Infinite Study, 2015.

DOI: https://doi.org/10.54216/IJNS.210209
Received: February 02, 2023 Revised: May 01, 2023 Accepted: June 08, 2023