Research Article

SELECTION OF INVESTMENT COMPANY BASED ON INTERVAL NEUTROSOPHIC VAGUE HERONIAN OPERATOR

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Abstract: *An investment decision is important for a large company to maintain continuous profit. Investment in large-scale projects must consider various factors such as risk index, growth index and the social-political impact index. The investment problem is challenging due to the presence of multiple criteria, decision-makers, and alternatives. The investment decision-making environment is a situation characterised by inconsistency and uncertainty. To deal with these problems, aggregation operator (AO) and set theory play a vital role. Aggregation operators are an important component in decision-making problems involving multiple criteria and multiple decision-makers. Heronian Mean (HM) is an effective AO that can consider the interrelationship among different input arguments. Meanwhile, the interval neutrosophic vague set (INVS) is effective in handling uncertainty and inconsistency information in decision-making problems. Therefore, the combination of HM and INVS namely interval neutrosophic vague Heronian Mean (INVHM) operator is more appropriate when ranking the best company to invest in. The algorithm of decision-making procedure is developed using the proposed INVHM operator to solve the investment decision problems. In addition, the sensitivity analysis is performed with respect to the different parameters of and . The findings show that the ranking order is sensitive to the value of parameters used. Thus, the proposed INVHM operator is a reliable and effective AO in decision-making problems. The comparative analysis is performed with some existing operators to validate the effectiveness of the proposed INVHM operator.*

Keywords: interval neutrosophic vague sets, Heronian mean, aggregation operator.

1. INTRODUCTION

In real decision-making, decision-makers (DMs) usually face difficulties in evaluating the alternatives by real numbers due to the complexity of decision-making problems. Zadeh (1965) first introduced the concept of fuzzy set and conducted in-depth research to address this issue. The fuzzy set (FS) is characterized by a single membership degree in the closed interval. The research to date has attempted to improve the representation of fuzzy set information such as intuitionistic fuzzy set (IFS) (Atanassov, 1986) and interval-valued fuzzy set (Atanassov and Gargov, 1989). However, the fuzzy set cannot handle indeterminate and inconsistent information that arises in real-life problems. Therefore, Smarandache (1998) proposed a neutrosophic set, which is basically a generalization of FS and IFS. The truth membership degree, indeterminacy membership degree and falsity membership degree are three completely independent membership in a neutrosophic set. Thus, it is well adapted for capturing incomplete, indeterminate and inconsistent information. Due to its advantages and efficiency, Hashim et al. (2019) introduced interval neutrosophic vague sets (INVS), which is a generalization of interval neutrosophic sets (INS) and vague sets (VS). INVS is based on interval membership that considers memberships in more detail and eventually can eliminate the information loss during the evaluation process. In contrast to NV and INS, it has a wider range of information to deal with uncertainties information,

Aggregation operators (AOs) are useful tools for fusing multiple arguments into a single comprehensive value and they have received great attention among scholars. To date, a variety of well-known AOs has been created to solve MCDM problems under different environments. Among them, the Heronian mean (HM) operator is one of the most influential AOs discussed in the literature due to its ability to handle interrelationships among input arguments (Beliakov et al, 2007). Since it was introduced in 2007, Sykora (2009) further modified the generalized Heronian mean (GHM) and proved some related properties. However, the existing HM operators do not consider the overall interaction among its attributes properly. To overcome this shortage, Shapley fuzzy measure (SFM) is combined with HM operator to synchronize overall interaction among input arguments.

2. METHODOLOGY

In this section, we apply the INVHM operators in MCDM problems under the INVS environment. The flowchart of the proposed method is presented in Figure 1.

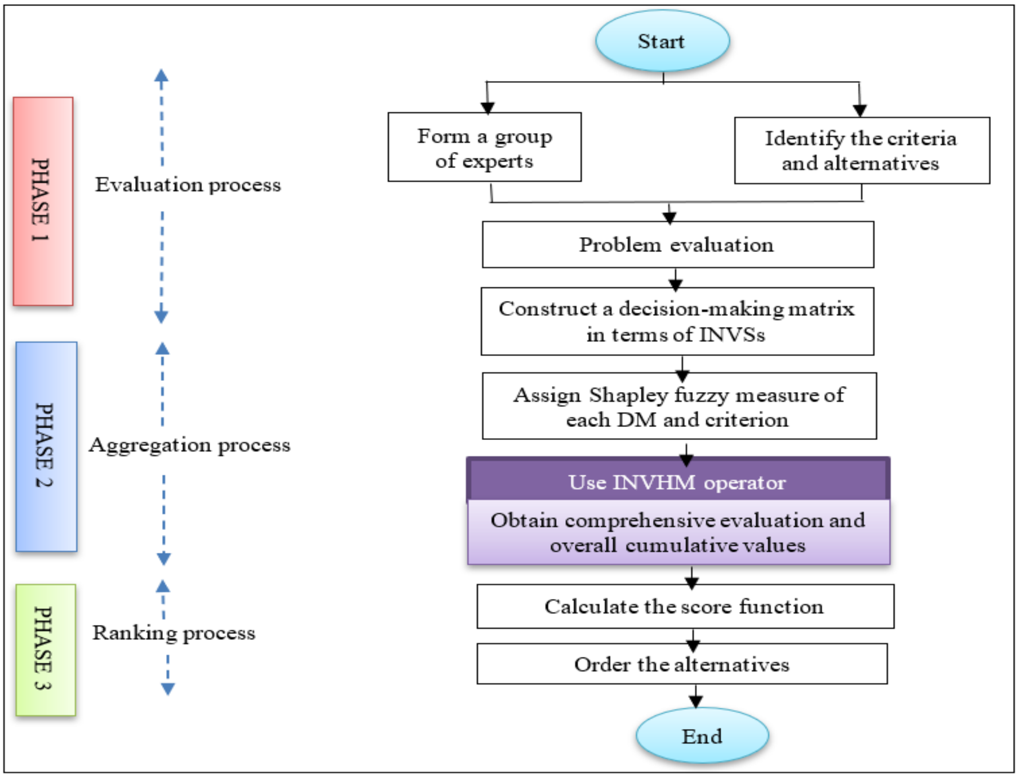

Figure 1: Flowchart of the proposed method

3. FINDINGS

Step 1: Determine the Shapley fuzzy measure of decision makers (DMs) and criteria. The Shapley fuzzy weight for DMs: $\varpi_1(\mu,M)=0.31$ $\varpi_2(\mu,M)=0.38$, $\varpi_3(\mu,M)=0.31$ and the Shapley fuzzy weight for each criterion: $\varpi_1(\mu,C)=0.4$ $\varpi_2(\mu,C)=0.2$, $\varpi_3(\mu,C)=0.4$.

Step 2: Compute the comprehensive evaluation values using INVHM where $p=q=1$

$b_1^1=[0.161,0.460],[0.243,0.560],[0.165,0.640],[0.339,0.600],[0.540,0.839],[0.440,0.757]$,
$b_2^1=[0.524,0.786],[0.161,0.591],[0.374,0.611],[0.244,0.459],[0.214,0.476],[0.409,0.839]$,
$b_3^1=[0.392,0.756],[0.324,0.786],[0.409,0.576],[0.339,0.600],[0.244,0.608],[0.214,0.676]$,
$b_4^1=[0.371,0.646],[0.440,0.623],[0.256,0.688],[0.291,0.575],[0.354,0.629],[0.377,0.560]$,
$b_1^2=[0.341,0.506],[0.268,0.833],[0.409,0.576],[0.426,0.639],[0.494,0.659],[0.167,0.732]$,
$b_2^2=[0.256,0.406],[0.207,0.694],[0.323,0.594],[0.230,0.459],[0.540,0.744],[0.306,0.793]$,
$b_3^2=[0.392,0.716],[0.200,0.389],[0.409,0.640],[0.339,0.600],[0.284,0.608],[0.611,0.800]$,
$b_4^2=[0.412,0.822],[0.480,0.725],[0.372,0.775],[0.381,0.640],[0.178,0.588],[0.275,0.520]$,
$b_1^3=[0.274,0.483],[0.181,0.588],[0.256,0.573],[0.213,0.459],[0.517,0.726],[0.412,0.819]$,
$b_2^3=[0.543,0.787],[0.351,0.762],[0.393,0.641],[0.509,0.727],[0.213,0.457],[0.238,0.649]$,
$b_3^3=[0.202,0.506],[0.312,0.833],[0.409,0.576],[0.291,0.538],[0.494,0.798],[0.167,0.688]$,
$b_4^3=[0.335,0.766],[0.243,0.646],[0.201,0.739],[0.307,0.600],[0.234,0.665],[0.354,0.757]$

Step 3: Compute the overall cumulative values where $p=q=1$.

$b_1=[0.269,0.485],[0.235,0.694],[0.276,0.594],[0.327,0.569],[0.515,0.731],[0.306,0.765]$,
$b_2=[0.436,0.682],[0.241,0.688],[0.359,0.613],[0.305,0.532],[0.318,0.564],[0.312,0.759]$,
$b_3=[0.339,0.674],[0.274,0.684],[0.409,0.600],[0.324,0.581],[0.326,0.661],[0.316,0.726]$,
$b_3=[0.377,0.758],[0.402,0.672],[0.279,0.737],[0.330,0.607],[0.242,0.623],[0.328,0.598]$.

Step 4: Calculate the score function.

$S(b_1)=0.467$, $S(b_2)=0.524$, $S(b_3)=0.502$ and $S(b_4)=0.539$.

Step 5: Order all of the alternatives

$A_4 \succ A_2 \succ A_3 \succ A_1$.

Hence, the best alternative is A_4, which represents a car company.

4. DISCUSSION

A sensitivity analysis is implemented to verify proposed method 's sensitivity in the final ranking. The effects of parameters on the ranking is examine using proposed method. Sensitivity analysis is performed using different values of $p,q\in(0,10]$, where the results are shown in Figure 2.

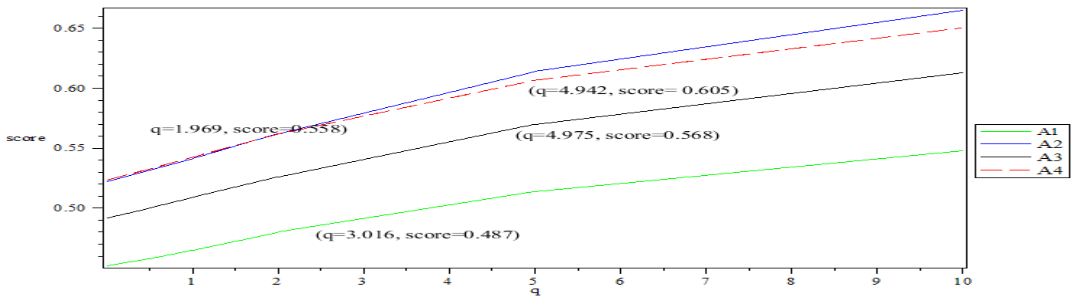

Figure 2: The score value with $p = 0$ and $q \in (0,10]$ using INVHM operator.

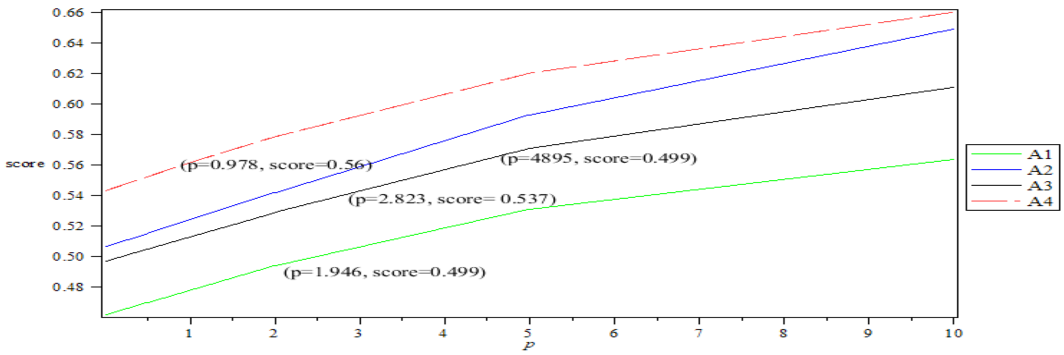

Figure 3: The score value with $q = 0$ and $p \in (0,10]$ using INVHM operator.

Based on sensitivity analysis, the finding shows that the ranking order is sensitive to the changes in the parameters p and q. Thus, it is a reliable aggregation operator in decision-making.

5. CONCLUSION

This paper combines HM operator with SFM under INVS and develops methods to deal with the MCDM problems. The proposed aggregation operator extends the improved generalized weighted Heronian mean (IGWHM) under an interval neutrosophic vague environment. The study begins by proposing the INVHM operator. Then, a decision-making approach is developed for MCDM problems under INVS information. A case study of investment decision is presented to validate the proposed method's applicability and effectiveness. Next, the sensitivity analysis is conducted to comprehensively investigate the effect of ranking alternatives on the changing of the two existing parameters. Finally, a comparative analysis is performed in two ways: to validate the proposed method and to illustrate its advantages.

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