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A MAGDM ALGORITHM FOR DECISION-MAKING PROBLEMS ON FUZZY SOFT SETS USING A COEFFICIENT CORRELATION AND AN ENTROPY MEASURE FOR DETERMINING THE WEIGHT OF PARAMETERS

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ABSTRACT

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In statistics, the correlation coefficient concept aims to show how strong the linear relationship between two variables is. Sometimes the data collected relates to everyday life problems whose value is uncertain. Therefore, the concept of correlation coefficient must be developed on the fuzzy sets and the fuzzy soft sets environment. In this study, a decision-making algorithm was designed on fuzzy sets using the concept of the correlation coefficient. The method used is MAGDM, where the parameter weights are determined using entropy measures. Using this method, the algorithm of our decision-making problem is more realistic and general. The final section gives an example of a decision-making problem and a numerical illustration using the designed algorithm.

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1. INTRODUCTION

In 1965, Zadeh [1] introduced the concept of fuzzy sets to measure the capacity of human judgment on some of the objects being studied. Then Molodtsov [2] introduced the idea of soft sets in 1999. A soft set is a set of pair parameters with a collection of several related objects expressed with a value of 1 or 0. In 2007, Roy and Maji [3] introduced a generalization of soft sets, namely fuzzy soft sets, a combination of soft sets and fuzzy sets. In fuzzy soft set theory, each object associated with a certain parameter is given a value expressed in the interval [0,1].

The study of fuzzy sets include its generalization as Intuitionistic fuzzy sets, hesitant fuzzy sets, Dual Hesitant Fuzzy Sets, Dual Interval-Valued Hesitant Fuzzy Sets, picture fuzzy sets, Pythagorean fuzzy sets and Spherical Fuzzy Sets was also developed in the context of the correlation coefficient inspired by the statistics concept, as in [4]–[19] . The correlation coefficient aims to show whether or not the linear relationship between the two variables is strong. Sometimes the data collected relates to problems in everyday life whose value is uncertain, so various researchers developed the concept of correlation into fuzzy correlation as in [20]–[22] .

In 2019, Sharma and Singh [23]constructed a generalized correlation coefficient formula for fuzzy sets and fuzzy soft sets and utilized normalized correlation coefficients and correlation efficiency in the Multiple Attribute Group Decision Making (MAGDM) problems. MAGDM is a decision-making method for a problem that exists in real life, which is done to choose the best object among existing objects by considering several attributes. For example, a bank investor needs to know the health condition of the bank where he/she wants to invest. For that, he/she asks some decision-makers as experts to assess banks by considering several attributes. However, the algorithm proposed by Sharma and Singh did not consider entropy measure to determine the weight of attributes. An entropy measure is essential to determine how vague a decision-makers judgment is so that it is more realistic for determining the weight of the attributes/parameters.

This article will construct an algorithm for the decision-making problem in the fuzzy soft set environment by involving multiple decision-makers using the MAGDM method. In addition, determining the parameter weights in this method will use the entropy measurement concept. In the last section, using the designed algorithm, we present a numerical illustration for the decision-making problem of determining the best bank.

2. RESEARCH METHODS

This section recalls some definitions related to our topic, namely fuzzy set, soft set, fuzzy soft set, generalized correlations value of fuzzy soft set, generalized correlations coefficient of fuzzy soft set, generalized correlations efficient of fuzzy soft set, generalization of normalized correlations efficient of fuzzy soft set and entropy measure. In this section, suppose that $Z = \{x_1, x_2, \dots, x_n\}$ is a set of objects, E is a set of parameters and $P(Z)$ is a power set of Z

Definition 2.1 (Fuzzy Set) [1] A fuzzy set (FS) A over Z is defined as

$$A = \{(x_i , \mu_A(x_i))\} \}| x_i \epsilon Z\},$$

where $\mu_A : Z \to [0,1]$ *is a function called membership function of the fuzzy set A. The value* $\mu_A(x_i)$ *is called a membership value of* $x_i \epsilon Z$ *in the fuzzy set A.*

Definition 2.2 (Soft Set) [2] A pair $(\boldsymbol{F}, \boldsymbol{E})$ is called a soft set (SS) over $\boldsymbol{Z}$ if and only if $\boldsymbol{F}$ is a function $\boldsymbol{F} : \boldsymbol{E} \to \boldsymbol{P}(\boldsymbol{Z})$ *such that*

$$(F, E) = \{(e, F(e)) \mid e \epsilon E, F(e) \epsilon P(Z)\}.$$

Definition 2.3 (Fuzzy Soft Set) [3] Suppose that FS(Z) is a collection of all fuzzy sets over $\boldsymbol{Z}$. A pair $(\boldsymbol{G}, \boldsymbol{E})$ is called a fuzzy soft set (FSS) over $\boldsymbol{Z}$ if and only if $\boldsymbol{G}$ is a function $\boldsymbol{G} : \boldsymbol{E} \to \boldsymbol{FS}(\boldsymbol{Z})$ such that

$$(G, E) = \{(e, G(e)) \mid e \epsilon E, G(e) \epsilon FS(Z)\}.$$

Here, $G(e) = \{\mu_e(x_i) | x_i \epsilon Z\} = \{(x_i, \mu_e(x_i)) | x_i \epsilon Z\}$ *with* $\mu_e(x_i)$ *is the membership value of* x_i *related to the parameter* e.

Definition 2.4 (Generalized correlation value on fuzzy soft sets) [23] A generalized correlation value between fuzzy soft sets $\boldsymbol{U}$ and $\boldsymbol{V}$ over $\boldsymbol{Z}$ is defined as

$$C^{\alpha}{}_{FSS}(U,V) = \sum_{j=1}^{m}\left(\sum_{i=1}^{n} \mu_{Uj}^{\frac{\alpha}{2}}(x_i)\mu_{Vj}^{\frac{\alpha}{2}}(x_i)\right),$$

where $\alpha \in R$. Here Uj and Vj are related to the j_th parameter for each FSS U and V, respectively.

Definition 2.5 (Generalized correlation coefficient on fuzzy soft sets) [23] *Given two FSSs* $\boldsymbol{U}$ *and* $\boldsymbol{V}$ *over* $\boldsymbol{Z}$. *The function*

$$\rho^{\alpha}_{FSS}(U,V) = \frac{\sum_{j=1}^{m}\left(\sum_{i=1}^{n} \mu_{Uj}^{\frac{\alpha}{2}}(x_i)\mu_{Vj}^{\frac{\alpha}{2}}(x_i)\right)}{\left[\sum_{j=1}^{m}\sum_{i=1}^{n}\mu_{Uj}^{\alpha}(x_i)\right]^{\frac{1}{2}}\left[\sum_{j=1}^{m}\sum_{i=1}^{n}\mu_{Vj}^{\alpha}(x_i)\right]^{\frac{1}{2}}},$$

is called a generalized correlation coefficient between two FSSs U and V over Z.

Definition 2.6 (Generalized correlation efficiency on fuzzy soft sets) [23] Suppose that $\boldsymbol{FSS(Z)} = \{\boldsymbol{Z_1}, \boldsymbol{Z_2}, \dots, \boldsymbol{Z_t}\}$ is the collections of fuzzy soft sets $\boldsymbol{Z_k}=(\boldsymbol{F_k}, \boldsymbol{E})$ over $\boldsymbol{Z}$. A generalized correlation efficiency for each fuzzy soft set $(\boldsymbol{F_k}, \boldsymbol{E}), \boldsymbol{k} = \boldsymbol{1}, \boldsymbol{2}, \dots, \boldsymbol{t}$ is defined as

$$\gamma^{\alpha}{}_{FSS}(F_k, E) = \frac{\sum_{l=1}^{t}\rho^{\alpha}{}_{FSS}\{(F_k,E),(F_l,E)\}}{t-1} \quad , \textit{for } k \neq l, \alpha \in R.$$

Definition 2.7 (Generalization of normalized correlations efficient of fuzzy soft) [23] A generalization of normalized correlations efficient $\boldsymbol{N\gamma^{\alpha}{}_{FSS}(F_k, E)}$ of the FSS $(\boldsymbol{F_k}, \boldsymbol{E})$ is defined as

$$N\gamma^{\alpha}{}_{FSS}(F_k, E) = \frac{\gamma^{\alpha}{}_{FSS}(F_k,E)}{\sum_{l=1}^{t}\gamma^{\alpha}{}_{FSS}(F_k,E)} \quad , \textit{where } \alpha \in R.$$

Definition 2.8 (Entropy Measure) [24] Suppose that FS(Z) is a collection of all fuzzy sets over $\boldsymbol{Z}$ and $\boldsymbol{A}$ is a FS over $\boldsymbol{Z}$. A real value function $\boldsymbol{H} : \boldsymbol{FS(Z)} \rightarrow [\boldsymbol{0}, \boldsymbol{1}]$ is called an entropy measure on FS $\boldsymbol{A}$ over $\boldsymbol{Z}$ if $\boldsymbol{H}$ satisfies the following properties

1. $H(A) = 0$ *if and only if* $\mu_A(x_i) = 1$ *or* $\mu_A(x_i) = 0$, *for each* $x_i \in Z$;
2. $H(A) = 1$, *if and only if* $\mu_A(x_i) = 0.5$, *for each* $x_i \in Z$;
3. $H(A) = H(A^c)$;
4. $H(A^*) \leq H(A)$ *if*

   i. $\mu_A * (x_i) \geq \mu_A(x_i)$ *for* $\mu_A(x_i) \geq \frac{1}{2}$,

   ii. $\mu_A * (x_i) \leq \mu_A(x_i)$ *for* $\mu_A(x_i) \leq \frac{1}{2}$.

The Entropy Quantifies the degree of uncertainty. The entropy measure means that if the value of $H(A)$ is closer to zero, the decision-maker is firmer or has no hesitation in providing or defining an FSS. Conversely, if it is closer to one, means the decision-maker is hesitant.

Theorem 2.9 [25] Suppose that A is FS over Z. Defined

$$H(A) = 1 - \frac{d(A, A^c)}{n}$$

where $d(A, A^c) = \sum_{i=1}^{n} |\mu_A(x_i) - \mu_{A^c}(x_i)|, x_i \in Z$. $H(A)$ *is an entropy measure on FS A.*

3. RESULTS AND DISCUSSION

MAGDM (Multiple Attribute Group Decision Making) is a method of making decisions on a problem that exists in real life, which is done to assess the best object among existing objects. Decision-making is done by paying attention to more than one parameter and decision-makers.

Suppose that $Z = \{x_1, x_2, \ldots, x_n\}$ is a set of objects and $E = \{e_1, e_2, \ldots, e_m\}$ is a set of parameters. Let $D = \{D_1, D_2, \ldots, D_t\}$ be a collection of t decision-makers, and each D_k represents the decision-making problem in the form of a fuzzy soft set.

3.1 Algorithm

The following is the algorithm for decision-making using the MAGDM method in FSS.

1. Each decision-maker (DM) D_k , $k = 1, 2, \ldots, t$ assesses the problem in the form of the FSS (F_k, E).
2. Determine the generalized correlation coefficient of FSSs $(F_k, E) = \{(e_j, \{(x_i, \mu_{F_{kj}}(x_i))|x_i \in Z\}) \mid e_j \in E\}$ and (F_l, E) using α assumed by the DM.
3. Calculate generalized correlation efficiency and generalization of normalized correlations efficient $N\gamma^{\alpha}{}_{FSS}(F_k, E)$ for each fuzzy soft set (F_k, E). We denote $N\gamma^{\alpha}{}_{FSS}(F_k, E) = w_k$.
4. Defined a new fuzzy soft set $R = \{(e_j, \{(x_i, \mu_{e_j}(x_i))|x_i \in Z\}) \mid e_j \in E\}$ over Z, with
$$\mu_{e_j}(x_i) = \sum_{k=1}^{t} w_k \, . (\mu_{F_{kj}}(x_i)).$$
Note that $\{(x_i, \mu_{e_j}(x_i))|x_i \in Z\} := R_j$ is a FS over Z related to the parameter e_j.
5. Determine the weight ω_j for each parameter e_j using the entropy method with following step:
   a. Calculate the entropy measure H_j of fuzzy set R_j over Z for each parameter e_j by
   $$H_j = 1 - \frac{\sum_{i=1}^{n} |\mu_{e_j}(x_i) - \mu_{e_j{}^c}(x_i)|}{n}, \text{ with } j = 1,2, \ldots, m.$$
   b. Calculate divergence degree for each parameter e_j, $DV_j = 1 - H_j$.
   c. Determine the weight ω_j for each parameter e_j, $\omega_j = \frac{DV_j}{\sum_{j=1}^{m} DV_j}$.
6. Determine the score for each x_i of fuzzy soft set R over Z, $S_i = \sum_{j=1}^{m} \omega_j (\mu_{e_j}(x_i))$.
7. Rank the score S_i. The best object is the maximum value of S_i.

3.2 A numerical illustration of the decision-making problem using the MAGDM method.

In banking matters, customers need to know the health condition of the bank. These conditions can be considered with various criteria. For example, we collect data from ten banks, $\{x_1, x_2, \ldots, x_{10}\}$. A group of four decision-makers D_k ; $k = 1,2,3,4$ assess the condition of the bank by considering seven criteria, namely: service to customers (e_1), facilities provided (e_2), convenience in transactions (e_3), bank cleanliness (e_4), security in managing funds (e_5), the credibility of the bank (e_6), respect for customers (e_7).

The decision-making problem is choosing a good bank from the existing ones, considering seven parameters and being assessed by four decision-makers. This problem will be solved using the MAGDM method. The following is the assessment of each decision maker, which is stated in **Table 1.**

Table 1. The Assessment Of All Decision-Makers D_k Represented in FSSs.

D_k		e_1	e_2	e_3	e_4	e_5	e_6	e_7
	x_1	0.27	0.53	0.52	0.29	0.27	0.29	0.29
	x_2	0.47	0.56	0.44	0.40	0.25	0.24	0.27
	x_3	0.46	0.27	0.57	0.50	0.23	0.22	0.30

D_k		e_1	e_2	e_3	e_4	e_5	e_6	e_7
D_1	x_4	0.55	0.30	0.30	0.60	0.14	0.30	0.29
	x_5	0.37	0.38	0.46	0.42	0.23	0.14	0.17
	x_6	0.37	0.43	0.34	0.37	0.29	0.24	0.21
	x_7	0.47	0.54	0.26	0.53	0.20	0.29	0.17
	x_8	0.31	0.43	0.42	0.37	0.24	0.17	0.14
	x_9	0.55	0.46	0.46	0.50	0.24	0.24	0.15
	x_{10}	0.37	0.43	0.47	0.56	0.23	0.14	0.15
D_2	x_1	0.42	0.35	0.55	0.55	0.20	0.29	0.25
	x_2	0.59	0.54	0.38	0.38	0.29	0.38	0.25
	x_3	0.42	0.62	0.65	0.30	0.25	0.20	0.26
	x_4	0.30	0.32	0.32	0.65	0.21	0.25	0.23
	x_5	0.42	0.31	0.52	0.45	0.22	0.33	0.20
	x_6	0.41	0.45	0.41	0.48	0.30	0.22	0.35
	x_7	0.59	0.52	0.53	0.48	0.21	0.29	0.36
	x_8	0.44	0.39	0.48	0.43	0.35	0.19	0.40
	x_9	0.35	0.48	0.35	0.42	0.29	0.22	0.25
	x_{10}	0.39	0.59	0.45	0.59	0.25	0.19	0.35
D_3	x_1	0.48	0.41	0.48	0.19	0.31	0.29	0.35
	x_2	0.21	0.39	0.36	0.45	0.29	0.25	0.19
	x_3	0.63	0.48	0.39	0.53	0.31	0.22	0.28
	x_4	0.35	0.58	0.41	0.50	0.25	0.30	0.36
	x_5	0.42	0.55	0.43	0.65	0.32	0.25	0.30
	x_6	0.41	0.39	0.62	0.51	0.19	0.38	0.16
	x_7	0.39	0.44	0.48	0.35	0.25	0.20	0.36
	x_8	0.58	0.42	0.50	0.60	0.29	0.26	0.29
	x_9	0.53	0.58	0.35	0.38	0.30	0.25	0.22
	x_{10}	0.49	0.35	0.56	0.38	0.27	0.21	0.26
D_4	x_1	0.32	0.54	0.57	0.39	0.33	0.19	0.33
	x_2	0.66	0.59	0.61	0.64	0.31	0.25	0.29
	x_3	0.31	0.40	0.44	0.22	0.26	0.23	0.38
	x_4	0.44	0.32	0.36	0.51	0.22	0.41	0.26
	x_5	0.56	0.56	0.42	0.39	0.30	0.29	0.36
	x_6	0.49	0.39	0.38	0.49	0.27	0.25	0.39
	x_7	0.40	0.46	0.52	0.50	0.35	0.22	0.23
	x_8	0.29	0.51	0.38	0.54	0.22	0.26	0.25
	x_9	0.40	0.45	0.49	0.42	0.25	0.31	0.26
	x_{10}	0.39	0.46	0.39	0.55	0.29	0.33	0.29

In **Table 1**, each value in column e_1 states how good the service from bank x_i is to customers. The same explanation applies to the other columns.

Using the algorithm, we will determine generalized correlation value for every two fuzzy soft sets. Here, we choose three kinds of $\alpha = 1, \alpha = 2, \alpha = 5$ in order to compare the score for each x_i. The generalized correlation coefficient for all α is represented in **Table 2**.

Table 2. The Generalized Correlation Values

α		(F_1, E)	(F_2, E)	(F_3, E)	(F_4, E)
1	(F_1, E)	0.4200	0.5575	0.5659	0.5833
	(F_2, E)	0.5575	0.7400	0.7507	0.7742
	(F_3, E)	0.5659	0.7507	0.7700	0.7859
	(F_4, E)	0.5833	0.7742	0.7859	0.8100
2	(F_1, E)	0.0954	0.1686	0.1659	0.1839
	(F_2, E)	0.1686	0.2980	0.2926	0.3250
	(F_3, E)	0.1659	0.2926	0.2989	0.3199
	(F_4, E)	0.1839	0.3250	0.3199	0.3545
5	(F_1, E)	0.0015	0.0063	0.0050	0.0078
	(F_2, E)	0.0063	0.0267	0.0207	0.0327
	(F_3, E)	0.0050	0.0207	0.0183	0.0256
	(F_4, E)	0.0078	0.0327	0.0256	0.0401

Then, we calculate generalized correlation coefficients, as in **Table 3.**

Table 3. The Generalized Correlation Coefficients

α		(F_1, E)	(F_2, E)	(F_3, E)	(F_4, E)
1	(F_1, E)	1	0.9999817	0.9950680	0.9999996
	(F_2, E)	0.9999817	1	0.9944492	0.9999757
	(F_3, E)	0.9950680	0.9944492	1	0.9951588
	(F_4, E)	0.9999996	0.9999757	0.9951588	1
2	(F_1, E)	1	0.9999430	0.9824472	0.9999987
	(F_2, E)	0.9999430	1	0.9803998	0.9999243
	(F_3, E)	0.9824472	0.9803998	1	0.9827502
	(F_4, E)	0.9999987	0.9999243	0.9827502	1
5	(F_1, E)	1	0.9999097	0.9431253	0.9999978
	(F_2, E)	0.9999097	1	0.9385720	0.999871
	(F_3, E)	0.9431253	0.9385720	1	0.9438233
	(F_4, E)	0.9999978	0.999871	0.9438233	1

The values in **Table 3** represent how strong the linear relationship between two FSSs.

Next, we calculate the generalized correlation efficiency $\gamma^{\alpha}{}_{FSS}(F_k, E)$ and the generalization of normalized correlations efficient $N\gamma^{\alpha}{}_{FSS}(F_k, Z)$, as in **Table 4**.

Table 4. The Generalized Correlation Efficiencies (CE) and Normalized Correlations Efficient (NC)

α		CE	NC
1	(F_1, E)	0.9983498	0.2502283
	(F_2, E)	0.9981355	0.2501746
	(F_3, E)	0.9948920	0.2493617
	(F_4, E)	0.9983780	0.2502354

α		CE	NC
2	(F_1, E)	0.9941296	0.2508122
	(F_2, E)	0.9934224	0.2506337
	(F_3, E)	0.9818658	0.2477181
	(F_4, E)	0.9942244	0.2508361
5	(F_1, E)	0.9810109	0.2526075
	(F_2, E)	0.9794536	0.2522065
	(F_3, E)	0.9418402	0.2425212
	(F_4, E)	0.9812334	0.2526648

Refer to **Table 4**, we obtain w_k as in **Table 5.**

Table 5. $N\gamma^{\alpha}{}_{FSS}(F_k, E) = w_k$

α	w_1	w_2	w_3	w_4
1	0.2502283	0.2501746	0.2493617	0.2502354
2	0.2508122	0.2506337	0.2477181	0.2508361
5	0.2526075	0.2522065	0.2425212	0.2526648

Now, we define the fuzzy soft set R over Z, as in **Table 6**.

Table 6. Fuzzy Soft Set R

α		e_1	e_2	e_3	e_4	e_5	e_6	e_7
1	x_1	0.4224998	0.4575963	0.5299856	0.3548401	0.2775658	0.2649765	0.3050454
	x_2	0.4824227	0.5125093	0.4475643	0.4675780	0.2849956	0.2799147	0.2500035
	x_3	0.4550199	0.4423439	0.5123869	0.3875670	0.2625083	0.2175151	0.3050409
	x_4	0.4100988	0.3800408	0.3475206	0.5649294	0.2049934	0.3150578	0.2850435
	x_5	0.4425215	0.4501167	0.4574470	0.4775140	0.2675386	0.2524332	0.2575483
	x_6	0.4200097	0.4149708	0.4375136	0.4624825	0.2624714	0.2725396	0.2774443
	x_7	0.4623930	0.4899765	0.4474273	0.4649934	0.2525377	0.2499678	0.2799260
	x_8	0.4049595	0.4375426	0.4449663	0.4850419	0.2749338	0.2200241	0.2698861
	x_9	0.4575889	0.4925058	0.4125581	0.4300113	0.2699809	0.2550310	0.2199743
	x_{10}	0.4100129	0.4573910	0.4675097	0.5199471	0.2600083	0.2175250	0.2624245
2	x_1	0.4224998	0.4578431	0.5299480	0.3544269	0.2777352	0.2649164	0.3049934
	x_2	0.4822203	0.5125314	0.4477283	0.4677780	0.2849842	0.2796952	0.2498540
	x_3	0.4550736	0.4419431	0.5120947	0.3877413	0.2625301	0.2175540	0.3049703
	x_4	0.4103518	0.3801485	0.3475742	0.5647473	0.2049769	0.3152061	0.2851562
	x_5	0.4425764	0.4504180	0.4573106	0.4775522	0.2676384	0.2521798	0.2576728

α		e_1	e_2	e_3	e_4	e_5	e_6	e_7
	x_6	0.4200344	0.4148956	0.4375511	0.4624380	0.2623971	0.2726427	0.2772993
	x_7	0.4621169	0.4899154	0.4472407	0.4648143	0.2526343	0.2497151	0.2797370
	x_8	0.4048577	0.4376518	0.4448803	0.4848755	0.2747640	0.2199874	0.2695937
	x_9	0.4578183	0.4925220	0.4127064	0.4300396	0.2699323	0.2549704	0.2199081
	x_{10}	0.4100471	0.4571093	0.4675358	0.5198091	0.2600299	0.2175891	0.2622304
5	x_1	0.4225077	0.4586081	0.5298206	0.3531013	0.2782717	0.2647335	0.3048482
	x_2	0.4815352	0.5125788	0.4482252	0.4683995	0.2849490	0.2790017	0.2493840
	x_3	0.4552745	0.4406922	0.5111581	0.3883158	0.2626069	0.2176762	0.3047544
	x_4	0.4111353	0.3805215	0.3477530	0.5641656	0.2049324	0.3156671	0.2855232
	x_5	0.4427427	0.4513783	0.4568785	0.4777032	0.2679599	0.2513884	0.2580688
	x_6	0.4201089	0.4146556	0.4377009	0.4623060	0.2621513	0.2729851	0.2768223
	x_7	0.4612395	0.4897157	0.4466590	0.4641857	0.2529353	0.2489249	0.2791581
	x_8	0.4045702	0.4379903	0.4446212	0.4842926	0.2742344	0.2198844	0.2686796
	x_9	0.4585519	0.4925886	0.4131599	0.4301203	0.2697851	0.2547872	0.2196997
	x_{10}	0.4101685	0.4562068	0.4676350	0.5193518	0.2600986	0.2177898	0.2616200

The interpretation of values in **Table 6** is similar to Table 1, but FSS **R** in Table 6 is an accumulation of values of four decision-makers after considering the generalized correlation coefficients between two FSSs (F_i, E) and (F_j, E).

Next, we calculate the entropy measure H_j, the divergence degree DV_j and the weight ω_j for each parameter e_j and α, as in **Table 7.**

Table 7. The Weight of Parameters

α		e_1	e_2	e_3	e_4	e_5	e_6	e_7
1	H_j	0.8715	0.902	0.8840	0.8890	0.5235	0.5290	0.5425
	DV_j	0.1285	0.098	0.1160	0.1110	0.4765	0.4710	0.4575
	ω_j	0.0691	0.0527	0.0624	0.0597	0.2564	0.2534	0.2462
	H_j	0.8735	0.9020	0.8841	0.8891	0.5235	0.5090	0.5424
2	DV_j	0.1265	0.098	0.1159	0.1109	0.4765	0.4910	0.4576
	ω_j	0.0674	0.0522	0.0618	0.0591	0.2539	0.2617	0.2439
	H_j	0.8736	0.9020	0.8843	0.8894	0.5236	0.5090	0.5421
3	DV_j	0.1264	0.098	0.1157	0.1106	0.4764	0.4910	0.4579
	ω_j	0.0674	0.0523	0.0617	0.0590	0.2539	0.2617	0.2441

Finally, we obtain the score S_i for each x_i and α, as in **Table 8.**

Table 8. **The Score S_i**

	$\alpha = 1$	$\alpha = 2$	$\alpha = 5$
x_1	0.3203150	0.3203035	0.3202703
x_2	0.3211704	0.3210697	0.3207454
x_3	0.3063148	0.3062752	0.3061561
x_4	0.3063747	0.3064507	0.3066960
x_5	0.3066362	0.3066259	0.3065997
x_6	0.3099877	0.3099484	0.3098235
x_7	0.3096998	0.3095575	0.3091089
x_8	0.2995271	0.2993744	0.2988988
x_9	0.2964207	0.2963899	0.2962957
x_{10}	0.2980986	0.2980196	0.2977715

Refer to **Table 8**; we rank the score S_i as in **Table 9.**

Table 9. **The Rank of The Score S_i**

$\alpha = 1$	$S_2 > S_1 > S_6 > S_7 > S_5 > S_4 > S_3 > S_8 > S_{10} > S_9$.
$\alpha = 2$	$S_2 > S_1 > S_6 > S_7 > S_5 > S_4 > S_3 > S_8 > S_{10} > S_9$.
$\alpha = 5$	$S_2 > S_1 > S_6 > S_7 > S_5 > S_4 > S_3 > S_8 > S_{10} > S_9$.

Based on **Table 9,** we conclude that the object x_2 has the maximum score, so x_2 is the best bank for consideration.

4. CONCLUSIONS

In decision-making problems on fuzzy soft sets using the MAGDM method, it depends on the judgment of all decision-makers (DM) and the parameter weights used. In this article, an algorithm has been constructed where the judgments of all DMs are combined using the concept of a correlation coefficient so that the roles of all DMs are represented in the final decision. On the other hand, the preference level of parameters (the weight of the parameter) is determined using an entropy measure. This method is more realistic because the final decision accommodates the level of doubt from the DM represented by the entropy measure. Using the designed algorithm, a numerical illustration for the decision-making problem of determining the best bank is easy to apply. The generalization of this concept is that, in future, researchers can develop a similar idea but for intuitionistic fuzzy soft sets or hesitant intuitionistic fuzzy soft sets.

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