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A Study on the Impact of Multiple Methods of the Data Normalization on the Result of SAW, WED and TOPSIS Ordering in Healthcare Multi-Attributte Decision Making Systems based on EW, ENTROPY, CRITIC and SVP Weighting Approaches

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Abstract

Objectives: To study the impact of the seven normalization methods on the results of ranking using three ranking methods and based on four objective methods. It is,furthermore, analyzes the characteristics of eighty four integrated approaches for multi-attribute decision making (MADM) problems. **Methods/Statistical Analysis:** Definitely, the proposed combinations of ranking approaches are developed based on the TOPSIS, the Simple Additive Weighting and Weighted Euclidian distance ranking methods and based on the equal weight, Entropy, The Criteria Importance Through Inter-criteria Correlation and Statistical variance procedure objective weighting methods, through the implementation of seven normalization techniques' namely the Weitendorf's, Korth's, Nikamp's, Unitization, Quotient Transformation (Q-T) - R, Q-T mean, and Q-T-PSK normalization methods. Absolutely, the whole proposed approaches are applied to the field of healthcare decision making in Yemen respectively. The Pearson Correlation Coefficient (PCC), Change and the overall level of change in the positions of the alternatives are used to compare the impact of the selected normalization methods on the result of ranking obtained by all ranking approaches. **Findings:** The result shows that the normalization formula influences the result of the ranking using both TOPSIS and SAW methods, but the level of the impact is changed by the changing of the objective method. It also, offers that the choice of normalization formula doesn't influence the result of the ranking using WED method. In this study, high and very high numerical correlation coefficients between places in the different rankings are observed. Deferent changes in the positions, and in the overall level of change in case of particular governorates are also observed. The normalization methods are ordered by its impact on the result of the ranking for each weighting method used with each ranking one. **Application:** The ordering of the normalization methods by its impact on the ranking's results obtained using SAW and TOPSIS and based on deferent types of weighting methods must be taken into consideration while solving related MADM problem. And, the ordering results of these methods in our study give some recommendations for amending this problem.

Keywords: Euclidian Distance, Impact of the Data Normalization Methods, Weighted Euclidean Distance, SAW, TOPSIS

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1. Introduction

Definitely, Multi-Attributte Decision Making (MADM) is one of the most widely used and well-known decision-making methods. It is one of the modeling methods associated with the operations of the research that deals with various decision problems under a set of attributes called decision attributes. The decision-making process is a cognitive process that is often designed to identify the best choice among a set of alternatives through a combination of processes related to information gathering and evaluation of alternatives based on either the objective weights of importance of the attributes or the subjective values, beliefs and preferences (judgments) of the decision makers. Resolving the resolution problem described above is the focus of the decision computing. Actually, There are lots of techniques that can be used in MADM to solve such ranking problems; Some of well-known methods are the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), the Simple Additive Weighting (SAW) and Weighted Euclidian distance (WED).

To implement these approaches in a practical way, farther calculations should be considered such as normalization of variables, standardization and weighting (the importance of attributes).

Normalization of the variables is the problem that is often considered in the literature in the field of multidimensional statistics[1]. Most information about the normalization of the variables can be found in scientific papers containing the results of empirical comparative studies of complex economic phenomena that are preceded by a theoretical part describing the methodology used for supplying data for comparability. Detailed and in-depth discussion of normalization can be found in few works. Studies[2,3] are some of the noteworthy studies in this field.

The present study offers the results of an experimental research, aiming to analyze the impact of various normalization procedures on the result of SAW, TOPSIS and WED, CRITIC, and SVP ordering of objects. And based on four objective weighting method, namely equal weight, Entropy, The Criteria Importance Through Inter-criteria Correlation (CRITIC) and Statistical Variance Procedure (SVP).

Generally, The present study is organized as follows: Section 1 contains introduction; section II presents the review of previous related works associated with the various MADM approaches, normalization, objective weighting methods; section III describes the methodology of the research; section IV describes the practical implementation steps, results ranking, comparing issues and discussion; Conclusions of the research work are presented in the section V and the last section contains the references.

2. Background

2.1 Normalization Methods

The Multi-Attribute Decision Making (MADM) as a ranking problem can be concisely expressed as how to evaluate a previously defined set of alternatives (A) A={a_i|i=1,2,…,m} (for the selected and identified set of (attributes) C={c_j|j=1,2,……,2} Cby the evaluation matrix (X) format (n x m) As shown below in matrix (x), which may include qualitative, quantitative or both types of information with the reflecting of the relevant importance vector weight – (W) for the defined vector of criteria W={w_1,w_2,… w_n }.

$$x = \begin{matrix} x_{11} & \cdots & x_{1n} \\ \vdots & \vdots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{matrix}$$

Where x_{ij}={X_{ij}|i=1,2,…,n;j=1,2,……,2} represents the evaluation of the i-th alternative by means of j-th attribute. For each attribute it is necessary to define the type of the attribute, which can be classified to either maximization (benefit attribute) or minimization (cost attribute). The X_{ij}values of each attribute have the same measurement unit (scale), while the values of different attributes have the different types of this units. Hence, the alternatives will be assessed using different scales (units). The solution of the MADM problem consists of a number of procedures such as normalization, weighting and evaluation (ranking).

The normalization process is implemented to bring the elements of the (X) decision matrix to have a compatible measurement unites.

In this study, the normalization process is required to derive the standardized decision matrix as a fundamental process to carry out the ranking process using Weighted Euclidean Distance approach (WED), and to derive the normalized decision matrix as a main component for the

Table 1. Types of variable normalization formulas

Type of normalization	Type of attribute		
	Benefit $x_j^{\max}$	Cost $x_j^{\min}$	
Weitendorf's (W),	$\frac{x_{ij-}x_j^{\max}}{x_j^{\max}-x_j^{\min}}$	$\frac{x_j^{\max}-x_{ij}}{x_j^{\max}-x_j^{\min}}$	(1)
Korth's N. (K)	$\frac{x_{ij}}{x_j^{\max}}$	$1-\frac{x_{ij}}{x_j^{\max}}$	(2)
Nikamp's (N)	$1-\frac{x_j^{\max}-x_{ij}}{x_j^{\max}-x_j^{\min}}$	$1-\frac{x_{ij-}x_j^{\min}}{x_j^{\max}-x_j^{\min}}$	(3)
Unitization (U)	$\frac{x_{ij-}\overline{x}_j}{x_j^{max}-x_j^{min}}$		(4)
Quotient transformation–R (R)	$\frac{x_{ij}}{x_j^{\max}-x_j^{\min}}$		(5)
Quotient transformation - $\overline{x}$ (M)	$\frac{x_{ij}}{\overline{x}_j}$		(6)
Quotient transformation (PSK)	$\frac{x_{ij}}{\sum_{i=1}^{m}x_{ij}}$		(7)

ranking based on Simple Additive Weighting (SAW) and TOPSIS. It is also used to derive the importance of criteria using the Statistical Variance Procedure (SVP). A set of seven normalization formulas of the most commonly used form were presented in Table 1[1–3].

2.2 Objective Weighting Methods in MADM

Determination of the Criteria Weights (CWs)- the relative importance of criteria- is one of the main considerations in the rank ordering decision making processes. There are four different ways to determine weights: Equal Weights (EW), Subjective Weights (SW), Objective Weights (OW) and combination of Subjective and Objective methods. Equal Weights (EW) method is a type of weighting that gives the same weight to each criteria. The Equal Weight method (EW) requires minimal knowledge about priorities of criteria and minimal input of decision maker. If the decision maker has no information about true weights then the true weights could be represented as a uniform distribution on the unit in simplex of weights; in case no information about weights distribution, the expected value of the weight distribution determines the following weight formula:

$$w_j = \frac{1}{n}, j = 1, 2, \ldots, n \tag{8}$$

In addition, Shannon Entropy, CRITIC and Statistical variance procedure are some of the most popular and widely objective weighting methods.

Entropy is generally understood as a measure of uncertainty in the information, as defined by[4].

Determination of objective criteria weights according to the entropy method can be expressed in the following steps:

First step : Normalization of criteria values of variants X_{ij} contained in the decision matrix.

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (9)$$

Second step : Computing an entropy value ej:

$$E_j = -K \sum_{i=1}^{m} p_{ij} \bullet \ln p_{ij} \quad (10)$$

Where K as a constant is calculated based on the Equation (12) and E_j is a value between 0 and 1.

$$K = \frac{1}{\ln(n)} \quad (12)$$

Third step : Calculating the deviation degree (d_j), it can be calculated using Equation (13)

$$D_j = 1\text{-}E_j \quad (13)$$

Step 4: Obtaining the degree of importance of i-th attribute based on the following equation :

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \quad (14)$$

The Criteria Importance Through Inter-criteria Correlation (CRITIC) is a methodology often used to assess performance ratings basis different criteria or variables using their correlations[5]. CRITIC method uses correlation analysis to determine conflicts between decision criteria. Determination of objective criteria weights according to the CRITIC method can be expressed in the following steps.

First step: Transformation of the values of criteria as follows:

$$r_{ij} = \frac{x_{ij-} x_j^{\min}}{x_j^{\max} - x_j^{\min}} \quad (15)$$

Second step: Calculating amount of information (C) contained in each jth criteria. Using Equation (16), to find it, the standard deviation σ of each j^{th} criteria should be obtained firstly.

$$C_j = \sigma_j \sum_{i=1}^{m} 1 - r_{ij} \quad (16)$$

Final step: Obtaining the degree of importance(weight) of criteria by Equation (17) :

$$w_j = \frac{C_j}{\sum_{j=1}^{n} C_j} \quad (17)$$

Statistical Variance Procedure (SVP) is a suitable method for comparing the criteria weights after normalization[6]. So, in this study, the U normalization method will be used to derive the weights by SVP. If (Z) is a normalized decision matrix, and z_{ij} is the i_{th} observation with the respect to the jh criterion, then the weight of j^{th} criterion of Z can be calculated as follows6:

$$w_j = \frac{V_j}{\sum_{j=1}^{n} V_j} \quad (18)$$

Where :

$$V_j = \frac{\sum_{i=1}^{m} \left(z_{ij-} \overline{z}_j \right)^2}{m-1} \quad (19)$$

2.3 Ranking Methods and its Procedures

2.3.1 Sample Additive Weighting Method

Simple Additive Weighting (SAW) method is a simple and most often used multi attribute decision technique. The method, first utilized by[7], It is based on the weighted average. An evaluation score is calculated for each alternative by multiplying the scaled value given to the alternative of that attribute with the weights of relative importance directly assigned by decision maker followed by summing of the products for all criteria. The step-wise procedure of the SAW method is given as follows:

First step: Define and state the problem objectives (O) and Define Alternatives (M) and Criteria (M) factors for evaluating.

Second step: Establish a Decision Matrix DM – (X) for alternative performance

Third step: Normalize original Decision Matrix (X) to obtain the Normalized Decision Matrix (Z)

Fourth step: Calculate the weights of criteria - Weighting vector – (W);,

Fifthstep :Evaluate each alternative, Ai by the following formula:

$$A_i = \sum_{j=1}^{n} w_j \bullet z_{ij} \quad (20)$$

Where is the weight of criteria j and n is the total number of criteria, is the score of the ith alternative with respect to the jth criteria.

If the ranking process carried out using standardization formula (S), the Z_{ij} can be replaced by Sij. Where Sij is the standardized DM obtained by the standardization formula as follows: If (X) is a DM then the standardized decision matrix S is given as follows:

And is the standardized value ofand can be calculated as:

$$s_{ij} = (x_{ij-}\overline{x}_j)/\sigma_j \quad (21)$$

Whereis the expected value or mean value of the attribute j and is the standard deviation of the attribute j.

2.3.2 Weighed Euclidean Distance

The Euclidean distance is an established concept in the field of Mathematics[8], The WED method is based on the concept that the chosen alternative (optimum) should have the shortest distance from the ideal solution (best possible alternative) and be farthest from the anti-ideal solution (worst possible alternative). The measure ensures that the top ranked alternative is closest to the ideal solution and farthest from the anti-ideal solution. Euclidean distance is the shortest distance between two points. The overall performance index score of an alternative is determined by its Euclidean distance to ideal solution and anti-ideal solutions. This distance is interrelated with the attribute's weights. The step-wise procedure of the WED method is given as follows[9]:

First–three steps: Repeating the same initial three steps included in the SAW method presented above.

Fourth step: Standardize the normalized attribute data using Equation (21).

Fifth step - Determine the positive ideal solution A^* and negative ideal solution A^- from standardized decision matrix.

Sixth step: Determine the **criteria** weights,

Seventh step: Calculate the distance of each alternative using Equation (22) and (23):

$$D_j^* = \left[\sum_{i=1}^{m}\left\{w_j \bullet \left(s_{ij} - A_j^*\right)\right\}^2\right]^{0.5}, i = 1,2,\ldots,m \quad (22)$$

$$D_j^- = \left[\sum_{i=1}^{m}\left\{w_j \bullet \left(s_{ij} - A_j^-\right)\right\}^2\right]^{0.5}, i = 1,2,\ldots,m \quad (23)$$

Eighth step : Calculate the relative closeness to the positive ideal solution. The relative closeness of the alternative is defined as:

$$RC_j^* = \frac{D_j^-}{D_j^* - D_j^-}, j = 1,2,..,n \quad (24)$$

2.3.3 TOPSIS Method

The step-wise procedure of the TOPSIS method is given as follows:

First-four steps: Repeating the first initial four steps of the SAW ranking procedure steps;

Fifth step- determine the weighted normalized decision matrix using Equation (25):

$$v_{ij} = w_j \bullet z_{ij} \quad (25)$$

Sixth step: Determine the positive ideal solution A^* and negative ideal solution A^- from the standardized decision matrix.

Seventh step : Measure distances from the ideal and nadir solutions. The two Euclidean distances for each alternative are calculated as:

$$D_j^* = \left[\sum_{i=1}^{m}\left\{\left(v_{ij} - A_j^*\right)\right\}^2\right]^{0.5}, i = 1,2,\ldots,m \quad (26)$$

$$D_j^- = \left[\sum_{i=1}^{m}\left\{\left(v_{ij} - A_j^-\right)\right\}^2\right]^{0.5}, i = 1,2,\ldots,m \quad (27)$$

Eighth step: Calculate the relative closeness to the ideal solution. The relative closeness to the ideal solution can be determined by Equation (24).

3. Methodology of Research

To achieve the goal of this study the following stages are implemented:

STAGE 1: Definition of the ranking problem.

STAGE 2: This stage consists the following sub tasks:

2-1 Constructing the ranking problem model;

2-2 Collecting necessary data;

2-3 Normalizing of collected data by using seven normalization methods presented in the study, namely (W, K,N ,U, QT- R, QT-M and QT-PSK) using formulas (1-7)

2-4 Standardization of the basic DM using Equation (21) to derive the weighs using SVP;

2-5 Standardization of obtained normalized decision matrixes using Equation (21).

STAGE 3: Calculating the importance of criteria (Weighting them), four tasks included in this stage:

3-1 calculating the importance of criteria based on the EW method, using Equation (8);

3-2 Calculating the importance of criteria using Entropy method throw Equations (9-14).

3-2 Calculating the importance of criteria by the CRITIC method using Equations (15-17).

3-3 Calculating the importance of criteria by the SVP method using Equations 18 and 19.

STAGE 4: Evaluating the Alternatives in terms of the following four criteria (the following four tasks):

4-1 Ranking alternatives using SAW method through the implementation of all seven normalization methods and based on the four types of weightings (EW, ENTROPY, CRITIC and SVP) and using SAW persuader presented in Section 2.

4-2 Repeat the same task (4-1) using WED method as well as using the WED procedure illustrated in section 2 .

4-3 Repeat the same task (4-1) using TOPSIS method as well as using the TOPSIS procedure illustrated in section 2.

4- Summarizing the results and grouping them by the type of weighting method.

STAGE 5: Analyzing and discussing the result's rankings:

5-1 Determining the Correlation Matrix among results of ranking obtained by using different normalization formulas, for each group of weighting methods based on all three ranking methods and comparing the effects of using all the seven methods on the obtained ranking's results based on all three ranking methods for each weighting method individually.

5-2 : Determine and compare the change in the positions of alternatives (Number of alternatives whose position has changed by means of the number "shifts" position in the SAW- ranking

5-2-1: Based on the SAW ranking's results, determine and compare the change in the positions of alternatives related to ranking with standardization formula as a normalization method for SAW.

5-2-2 Based on the TOPSIS- ranking's results, determine and compare the change in the positions of alternatives related to ranking with vector normalization formula as a main normalization method for it

5-2-3 Based on the WED- ranking's results, determine and compare the change in the positions of alternatives related to ranking with vector normalization formula as well.

Table 2. The decision matrix values of 16 governorates

Alternatives	C1	C2	C3	C4	C5	C6
Abyan	71707	30192	5361	27	6.8	10.4
Aden	177630	27755	444074	42.7	14	4.5
Al Amana	345988	55605	622778	20	6.9	2.24
Al Baydha	91684	17890	8529	11.2	2.4	4.6
Al Dhalae	137926	22988	7110	11.8	3.2	5.07
Al Jawf	207626	62288	21479	6	1.6	1.6
Amran	88164	37784	6451	11.7	2.9	7.3
Hajah	187352	57246	8770	10	4.8	8.47
Hodeida	192453	45959	10655	8	2.1	1.5
Ibb	175288	24388	15581	10.7	4.16	7.7
Lahj	64915	44260	5762	21.9	7.45	4
Ma'areb	18291	29930	6331	34	24.7	3.05
Sa'adah	171206	57069	13341	6.3	2.3	3.8
Sana'a	143812	13861	7934	13.1	2	6.05
Shabwah	40662	23459	5398	24.5	12.4	23.2
Taiz	126229	27205	14279	16.1	4.5	38

Source (Final report of Service Availability and Health Facilities Functionality in 16 Governorates[10]

5-3 Define the (overall) changing level of all normalization methods for each ranking technique by each objective weighting method and compare the results.

5-4 Rank all normalization variants by the overall position change level of the alternatives for each ranking method based on all objective weighting methods.

STAGE 6: Concluding and giving the appropriate recommendations.

4. Experimental Research Results

STAGE 1: The ranking problem is taken from our previous work. In this case study,16 governorates in Yemen were ranked by the population coverage of the main services provided by its health system.

STAGE 2:

Task 2-1: The main structure of the defined problem is summarized, as follows: the top level determines the objective, the next level includes the criteria affecting the decision (on which basis the alternatives are ranked). Six major criteria are selected for this objective according to the International Health Services and Resources Availability Mapping System14: C1: The population coverage per one hospital unit, C2: the population coverage per one health center unit, C3: The population coverage per one health unit, C4: number of health staff per 10,000 population, C5: Number of beds per 10,000 population and C6: No of basic emergency obstetric care (BeMOC) per 500,000 population. For more detailed see report [10].

Task 2-2: The DM, presented in the Table 2 is used to construct the decision matrix values (X) of the attributes with m number of alternatives (16 governorates) and n number of criteria (6).

Task 2-3: The DM is normalized using seven methods using the normalization formulas presented in the Table 1, the normalized decision matrixes illustrated in the Tables 3-9 respectively.

Tasks (2-4) and (2-5): To obtain standardized decision matrix S, matrix S was defined using (8), the standard scores are calculated for the basic DM (X) and for each (Z) normalized matrix. The same standardized matrix (S) is obtained for all of them as shown in Table 10.

STAGE 3: Calculating the importance of criteria (Weighting them) ,In this stage the relative importance of each criteria is calculated using the equations (8) , (9-14), (15-17) and (18 and 19) using the EW, ENTROPY, CRITIC and SVP objective weighting methods respectively. The obtained criteria importance vectors are illustrated in Table 11.

STAGE 4:

TASKS (4-1)-(4-3) Alternatives were ranked using SAW, TOPSIS and WED methods and using all seven variants of normalization methods and based on the four

Table 3. Normalized dm using weitendorf's method (w)

Alternatives	C1	C2	C3	C4	C5	C6
Abyan	-0.837	-0.663	-1.000	-0.428	-0.775	-0.756
Aden	-0.514	-0.713	-0.289	0.000	-0.463	-0.918
Al Amana	0.000	-0.138	0.000	-0.619	-0.771	-0.980
Al Baydha	-0.776	-0.917	-0.995	-0.858	-0.965	-0.915
Al Dhalae	-0.635	-0.812	-0.997	-0.842	-0.931	-0.902
Al Jawf	-0.422	0.000	-0.974	-1.000	-1.000	-0.997
Amran	-0.787	-0.506	-0.998	-0.845	-0.944	-0.841
Hajah	-0.484	-0.104	-0.994	-0.891	-0.861	-0.809
Hodeida	-0.469	-0.337	-0.991	-0.946	-0.978	-1.000
Ibb	-0.521	-0.783	-0.983	-0.872	-0.889	-0.830
Lahj	-0.858	-0.372	-0.999	-0.567	-0.747	-0.932
Ma'areb	-1.000	-0.668	-0.998	-0.237	0.000	-0.958
Sa'adah	-0.533	-0.108	-0.987	-0.992	-0.970	-0.937
Sana'a	-0.617	-1.000	-0.996	-0.807	-0.983	-0.875
Shabwah	-0.932	-0.802	-1.000	-0.496	-0.532	-0.405
Taiz	-0.671	-0.724	-0.986	-0.725	-0.874	0.000

Table 4. Normalized DM using Corth's method

Alternatives	C1	C2	C3	C4	C5	C6
Abyan	0.207	0.485	0.009	0.632	0.275	0.274
Aden	0.513	0.446	0.713	1.000	0.567	0.118
Al Amana	1.000	0.893	1.000	0.468	0.279	0.059
Al Baydha	0.265	0.287	0.014	0.262	0.097	0.121
Al Dhalae	0.399	0.369	0.011	0.276	0.130	0.133
Al Jawf	0.600	1.000	0.034	0.141	0.065	0.042
Amran	0.255	0.607	0.010	0.274	0.117	0.192
Hajah	0.541	0.919	0.014	0.234	0.194	0.223
Hodeida	0.556	0.738	0.017	0.187	0.085	0.039
Ibb	0.507	0.392	0.025	0.251	0.168	0.203
Lahj	0.188	0.711	0.009	0.513	0.302	0.105
Ma'areb	0.053	0.481	0.010	0.796	1.000	0.080
Sa'adah	0.495	0.916	0.021	0.148	0.093	0.100
Sana'a	0.416	0.223	0.013	0.307	0.081	0.159
Shabwah	0.118	0.377	0.009	0.574	0.502	0.611
Taiz	0.365	0.437	0.023	0.377	0.182	1.000

Table 5. Normalized DM using Nikamp's method

Alternatives	C1	C2	C3	C4	C5	C6
Abyan	0.163	0.337	0.000	0.572	0.225	0.244
Aden	0.486	0.287	0.711	1.000	0.537	0.082
Al Amana	1.000	0.862	1.000	0.381	0.229	0.020
Al Baydha	0.224	0.083	0.005	0.142	0.035	0.085
Al Dhalae	0.365	0.188	0.003	0.158	0.069	0.098
Al Jawf	0.578	1.000	0.026	0.000	0.000	0.003
Amran	0.213	0.494	0.002	0.155	0.056	0.159
Hajah	0.516	0.896	0.006	0.109	0.139	0.191
Hodeida	0.531	0.663	0.009	0.054	0.022	0.000
Ibb	0.479	0.217	0.017	0.128	0.111	0.170
Lahj	0.142	0.628	0.001	0.433	0.253	0.068
Ma'areb	0.000	0.332	0.002	0.763	1.000	0.042
Sa'adah	0.467	0.892	0.013	0.008	0.030	0.063
Sana'a	0.383	0.000	0.004	0.193	0.017	0.125
Shabwah	0.068	0.198	0.000	0.504	0.468	0.595
Taiz	0.329	0.276	0.014	0.275	0.126	1.000

Table 6. Normalized DM using unitization method (U)

Alternatives	C1	C2	C3	C4	C5	C6
Abyan	-0.209	-0.122	-0.113	0.267	0.018	0.060
Aden	0.115	-0.173	0.597	0.695	0.330	-0.102

Al Amana	0.628	0.402	0.887	0.077	0.022	0.164
Al Baydha	-0.148	-0.376	-0.108	-0.163	-0.173	0.099
Al Dhalae	-0.007	-0.271	-0.110	-0.147	-0.138	-0.086
Al Jawf	0.206	0.540	-0.087	-0.305	-0.207	-0.181
Amran	-0.158	0.034	-0.111	-0.150	-0.151	-0.025
Hajah	0.144	0.436	-0.108	-0.196	-0.069	0.007
Hodeida	0.160	0.203	-0.105	-0.250	-0.186	-0.184
Ibb	0.108	-0.242	-0.097	-0.177	-0.096	-0.014
Lahj	-0.229	0.168	-0.113	0.128	0.046	-0.116
Ma'areb	-0.372	-0.128	-0.112	0.458	0.793	-0.142
Sa'adah	0.095	0.433	-0.100	-0.297	-0.177	-0.121
Sana'a	0.011	-0.460	-0.109	-0.111	-0.190	-0.059
Shabwah	-0.303	-0.261	-0.113	0.199	0.260	0.410
Taiz	-0.042	-0.184	-0.099	-0.030	-0.082	0.816

Table 7. Normalized DM using transformation (QT-R)

Alternatives	**C1**	**C2**	**C3**	**C4**	**C5**	**C5**
Abyan	0.219	0.623	0.009	0.736	0.294	0.285
Aden	0.542	0.573	0.719	1.163	0.606	0.123
Al Amana	1.056	1.148	1.009	0.545	0.299	0.061
Al Baydha	0.280	0.369	0.014	0.305	0.104	0.126
Al Dhalae	0.421	0.475	0.012	0.322	0.139	0.139
Al Jawf	0.634	1.286	0.035	0.163	0.069	0.044
Amran	0.269	0.780	0.010	0.319	0.126	0.200
Hajah	0.572	1.182	0.014	0.272	0.208	0.232
Hodeida	0.587	0.949	0.017	0.218	0.091	0.041
Ibb	0.535	0.504	0.025	0.292	0.180	0.211
Lahj	0.198	0.914	0.009	0.597	0.323	0.110
Ma'areb	0.056	0.618	0.010	0.926	1.069	0.084
Sa'adah	0.522	1.178	0.022	0.172	0.100	0.104
Sana'a	0.439	0.286	0.013	0.357	0.087	0.166
Shabwah	0.124	0.484	0.009	0.668	0.537	0.636
Taiz	0.385	0.562	0.023	0.439	0.195	1.041

Table 8. Normalized DM using transformation (QT-Mean)

Alternatives	**C1**	**C2**	**C3**	**C4**	**C5**	**C5**
Abyan	0.512	0.836	0.071	1.571	1.064	1.266
Aden	1.268	0.768	5.902	2.484	2.192	0.548
Al Amana	2.470	1.540	8.277	1.164	1.080	0.273
Al Baydha	0.655	0.495	0.113	0.652	0.376	0.560
Al Dhalae	0.985	0.636	0.094	0.687	0.501	0.617
Al Jawf	1.482	1.725	0.285	0.349	0.250	0.195

Amran	0.629	1.046	0.086	0.681	0.454	0.888
Hajah	1.338	1.585	0.117	0.582	0.751	1.031
Hodeida	1.374	1.272	0.142	0.465	0.329	0.183
Ibb	1.252	0.675	0.207	0.623	0.651	0.937
Lahj	0.463	1.225	0.077	1.274	1.166	0.487
Ma'areb	0.131	0.829	0.084	1.978	3.867	0.371
Sa'adah	1.222	1.580	0.177	0.367	0.360	0.462
Sana'a	1.027	0.384	0.105	0.762	0.313	0.736
Shabwah	0.290	0.650	0.072	1.425	1.941	2.823
Taiz	0.901	0.753	0.190	0.937	0.704	4.624

Table 9. Normalized dm using transformation (q-Psk)

Alternatives	C1	C2	C3	C4	C5	C5
Abyan	0.112	0.193	0.007	0.338	0.195	0.211
Aden	0.278	0.177	0.580	0.535	0.402	0.091
Al Amana	0.541	0.355	0.813	0.250	0.198	0.045
Al Baydha	0.143	0.114	0.011	0.140	0.069	0.093
Al Dhalae	0.215	0.147	0.009	0.148	0.092	0.103
Al Jawf	0.324	0.398	0.028	0.075	0.046	0.032
Amran	0.138	0.241	0.008	0.147	0.083	0.148
Hajah	0.293	0.366	0.011	0.125	0.138	0.172
Hodeida	0.301	0.294	0.014	0.100	0.060	0.030
Ibb	0.274	0.156	0.020	0.134	0.120	0.156
Lahj	0.101	0.283	0.008	0.274	0.214	0.081
Ma'areb	0.029	0.191	0.008	0.426	0.710	0.062
Sa'adah	0.267	0.365	0.017	0.079	0.066	0.077
Sana'a	0.225	0.089	0.010	0.164	0.057	0.123
Shabwah	0.064	0.150	0.007	0.307	0.356	0.471
Taiz	0.197	0.174	0.019	0.202	0.129	0.771

Table 10. The standardized DM (SDM)

Alternatives	C1	C2	C3	C4	C5	C5
Abyan	-0.883	-0.393	-0.397	0.967	0.070	0.238
Aden	0.485	-0.555	2.095	2.514	1.289	-0.405
Al Amana	2.661	1.293	3.109	0.277	0.087	-0.651
Al Baydha	-0.625	-1.209	-0.379	-0.590	-0.676	-0.394
Al Dhalae	-0.028	-0.871	-0.387	-0.531	-0.540	-0.343
Al Jawf	0.873	1.736	-0.305	-1.102	-0.811	-0.721
Amran	-0.670	0.111	-0.391	-0.541	-0.591	-0.100
Hajah	0.611	1.401	-0.377	-0.708	-0.269	0.028
Hodeida	0.677	0.653	-0.367	-0.905	-0.726	-0.732
Ibb	0.455	-0.778	-0.339	-0.639	-0.377	-0.056

Lahj	-0.971	0.540	-0.395	0.464	0.180	-0.460
Ma'areb	-1.573	-0.410	-0.391	1.657	3.102	-0.563
Sa'adah	0.402	1.390	-0.352	-1.073	-0.693	-0.481
Sana'a	0.049	-1.476	-0.382	-0.403	-0.743	-0.236
Shabwah	-1.284	-0.840	-0.397	0.720	1.018	1.633
Taiz	-0.179	-0.591	-0.346	-0.107	-0.320	3.245

Table 11. The relative weights of criteria

Method	C1	C2	C3	C4	C5	C6
EW	0.166	0.166	0.166	0.166	0.166	0.166
Entropy	0.058	0.032	0.567	0.059	0.123	0.161
CRITIC	0.127	0.144	0.216	0.164	0.173	0.175
SVP	0.127	0.221	0.185	0.174	0.149	0.144

Table 12. The positions of governorates in the ranking using EW-SAW

Variant	1	2	3	4	5	6	7
Abyan	8	7	8	8	8	7	7
Aden	2	2	2	2	2	2	2
Al Amana	1	1	1	1	1	1	1
Al Baydha	16	16	16	16	16	16	16
Al Dhalae	14	14	14	14	14	14	14
Al Jawf	7	8	7	7	7	10	9
Amran	13	13	13	13	13	12	13
Hajah	5	6	5	5	5	6	6
Hodeida	11	11	11	11	11	13	12
Ibb	12	12	12	12	12	9	11
Lahj	9	9	9	9	9	8	8
Ma'areb	3	3	3	3	3	4	4
Sa'adah	10	10	10	10	10	11	10
Sana'a	15	15	15	15	15	15	15
Shabwah	6	5	6	6	6	5	5
Taiz	4	4	4	4	4	3	3

types of weightings (EW,ENTROPY, CRITIC and SVP) and using SAW persuader presented in Section 2.

TASK (4-4): The results are grouped by the objective method as follows:

GRPUP A: EQUAL WEIGHING BASD RANKING
GRPUP B: ENTROPY WEIGHING BASD RANKING
GRPUP C: CRITIC WEIGHING BASD RANKING
GRPUP D: SVP WEIGHING BASD RANKING

The positions of governorates in the rankings in each group are summarized by the ranking method.

5. Discussion of Results

STAGE 5: The data presented in Tables 12-14 shows that the change in the normalization procedure affects the change of position in the analyzed governorates rankings

Table 13. The positions of governorates in the ranking using EW-WED

Variant	1	2	3	4	5	6	7
Abyan	10	10	10	10	10	10	10
Aden	2	2	2	2	2	2	2
Al Amana	1	1	1	1	1	1	1
Al Baydha	16	16	16	16	16	16	16
Al Dhalae	14	14	14	14	14	14	14
Al Jawf	7	7	7	7	7	7	7
Amran	13	13	13	13	13	13	13
Hajah	5	5	5	5	5	5	5
Hodeida	9	9	9	9	9	9	9
Ibb	12	12	12	12	12	12	12
Lahj	11	11	11	11	11	11	11
Ma'areb	3	3	3	3	3	3	3
Sa'adah	8	8	8	8	8	8	8
Sana'a	15	15	15	15	15	15	15
Shabwah	6	6	6	6	6	6	6
Taiz	4	4	4	4	4	4	4

Table 14. The positions of governorates in the ranking using EW-TOPSIS

Variant	1	2	3	4	5	6	7
Abyan	11	10	11	11	11	7	8
Aden	2	2	2	2	2	2	2
Al Amana	1	1	1	1	1	1	1
Al Baydha	16	16	16	16	16	16	16
Al Dhalae	14	14	14	14	14	15	15
Al Jawf	6	7	6	6	6	8	7
Amran	13	13	13	13	13	13	13
Hajah	5	6	5	5	5	6	6
Hodeida	10	9	10	10	10	12	11
Ibb	12	12	12	12	12	11	12
Lahj	9	11	9	9	9	10	10
Ma'areb	3	3	3	3	3	4	4
Sa'adah	8	8	8	8	8	9	9
Sana'a	15	15	15	15	15	14	14
Shabwah	7	5	7	7	7	5	5
Taiz	4	4	4	4	4	3	3

using both SAW and TOPSIS methods, We can see them even in the top five governorates, for instance, governorates of Mareb, Taiz and Shabwah changed their positions in the presented classifications using SAW and TOPSIS methods even by a few places (maximum 2 places). On the other hand, the change in the normalization procedure doesn't affect the change in their position where the WED is applied, and this is due to the replacement of the normalized DM by the standardized DM (S-DM). The S-DM is achieved by the implementation of standardization procedure for all normalized DM. The same S-DM is obtained as a result. So, the ranking's result was customized into one variant for all normalization methods under study.

In addition, the data presented in Tables 15-23 shows that the change in the normalization procedure also affects the change of position in the analyzed governorates rankings using both SAW and TOPSIS methods, but the level of change in the position of governorates is changed by the changing of the weighting method. We can easily observe, for instance, that Taiz governorate changed its position in the presented classifications using SAW with Weitendorf's normalization approach by one place with the implementation of Entropy method for objective weighting of elements of the DM, and by 2 places with the implementation of SVP method, but by the using of CRITIC method, the position of Taiz doesn't changed ,comparing with those results obtained by the same normalization and ranking methods with the EW method.

TASK 5-1 In order to compare the obtained rankings based on all three ranking approaches with the using of seven normalization methods and based on the EW weighting method, Pearson correlation coefficients (PPC) were calculated, whose values fluctuate in the range of (0.956 –1.0000; 1.000- 1.0000; 0.946 – 1.000) for SAW, WED and TOPSIS respectively (Table 24). For the same purpose, the PPC, and the range of its values for the ranking based on the other weighting methods were calculated as it shown in Tables 25-27 for ENTROPY, CRITIC and SVP methods respectively.

Despite a high and very high degree of correlation of ordering results, we can observe significant differences in the results of particular rankings based on SAW and TOPSIS methods.

The juxtaposition presented in Table 29 (EW-based) illustrates that the change in the normalization procedure, positions of evaluated governorates have changed as well. The biggest changes occurred in the case of replacement of the classic standardization by quotient transformation (mean based and PSK based) for the ranking using SAW method. While The biggest changes occurred in the case of replacement of the vector normalization (QT- PSK) by Weitendorf's, Nikamp's, Unitization, and R based quotient transformation. It is also illustrates that with the change in the normalization procedure, positions of evaluated governorates have changed as well for both SAW and TOPSIS ranking method with using all objective methods used in this study.

For all ENTROPY, CRITIC and SVP based SAW method, the biggest changes (shifts) occurred also in the case of replacement of the classic standardization by quotient transformation (mean based and PSK based), but the level of change is various for each of them. on the other hand, For all ENTROPY, CRITIC and SVP based TOPSIS method, the biggest changes (shifts) occurred in the case of replacement of the vector normalization (QT-PSK) by Weitendorf's, Nikamp's, Unitization, and R based quotient transformation.

For all ENTROPY, CRITIC and SVP based WED method, no changes (shifts) noticed (the ranked governorates haven't changed their positions in the ranking), because the same results are obtained, when the WED's normalization procedures (Normalization and standardization) was replaced by the standardization procedure (directly standardization of DM without normalization)

Task 5-3: Identical calculations were performed in the next stage of the research experiment to demine the overall level of the Change in the positions of governorates in the rankings, to compare the effects of the normalization methods on the ranking's results by means of using ENTROPY, CRITIC and SVP objective weighting based approaches, comparing with results obtained with the using if EW method. The following formula is used:

$$CL = \sum_{i=1}^{n} \frac{i \bullet N_i}{m} \tag{28}$$

Where i is the number of "shifts" position in the ranking of governorates relative to ranking with TOPSIS and is the number of governorates whose position has changed by i-th number. Table represents the overall level of change in the position of governorates in the ranking using WED, relative to ranking using WED-Utilization formula (WED-CL) , the overall level of change in the position of governorates using SAW relative to ranking using SAW- standardization formula (SAW- CL) and the overall level of change in the position of governor-

Table 15. The positions of governorates in the ranking using ENTROPY-SAW

Variant	1	2	3	4	5	6	7
Abyan	6	6	6	6	6	6	6
Aden	2	2	2	2	2	2	2
Al Amana	1	1	1	1	1	1	1
Al Baydha	16	16	16	16	16	16	16
Al Dhalae	14	13	14	13	13	14	13
Al Jawf	10	10	10	10	10	10	11
Amran	12	12	12	12	12	12	10
Hajah	7	7	7	7	7	7	7
Hodeida	13	14	13	14	14	15	15
Ibb	9	8	9	9	9	8	8
Lahj	8	9	8	8	8	9	9
Ma'areb	5	5	5	5	5	5	5
Sa'adah	11	11	11	11	11	11	12
Sana'a	15	15	15	15	15	13	14
Shabwah	4	4	4	4	4	4	4
Taiz	3	3	3	3	3	3	3

Table 16. The positions of governorates in the ranking using ENTROPY-WED

Variant	1	2	3	4	5	6	7
Abyan	6	6	6	6	6	6	6
Aden	2	2	2	2	2	2	2
Al Amana	1	1	1	1	1	1	1
Al Baydha	16	16	16	16	16	16	16
Al Dhalae	15	15	15	15	15	15	15
Al Jawf	8	8	8	8	8	8	8
Amran	13	13	13	13	13	13	13
Hajah	7	7	7	7	7	7	7
Hodeida	12	12	12	12	12	12	12
Ibb	9	9	9	9	9	9	9
Lahj	10	10	10	10	10	10	10
Ma'areb	4	4	4	4	4	4	4
Sa'adah	11	11	11	11	11	11	11
Sana'a	14	14	14	14	14	14	14
Shabwah	5	5	5	5	5	5	5
Taiz	3	3	3	3	3	3	3

Table 17. The positions of governorates in the ranking using ENTROPY-TOPSIS

Variant	1	2	3	4	5	6	7
Abyan	6	6	6	6	6	6	6
Aden	2	2	2	2	2	2	2
Al Amana	1	1	1	1	1	1	1

Al Baydha	16	16	16	16	16	16	16
Al Dhalae	15	15	15	15	15	14	15
Al Jawf	8	8	8	8	8	9	10
Amran	13	13	13	13	13	11	11
Hajah	7	7	7	7	7	7	7
Hodeida	12	12	12	12	12	15	14
Ibb	10	9	10	10	10	8	8
Lahj	9	10	9	9	9	10	9
Ma'areb	4	4	4	4	4	5	4
Sa'adah	11	11	11	11	11	13	13
Sana'a	14	14	14	14	14	12	12
Shabwah	5	5	5	5	5	4	5
Taiz	3	3	3	3	3	3	3

Table 18. The positions of governorates in the ranking using CRITIC-SAW

Variant	1	2	3	4	5	6	7
Abyan	7	7	7	7	7	6	6
Aden	2	2	2	2	2	2	2
Al Amana	1	1	1	1	1	1	1
Al Baydha	16	16	16	16	16	16	16
Al Dhalae	14	14	14	14	14	14	14
Al Jawf	9	9	9	9	9	10	10
Amran	13	13	13	13	13	12	12
Hajah	6	6	6	6	6	7	7
Hodeida	11	11	11	11	11	13	13
Ibb	12	12	12	12	12	9	9
Lahj	8	8	8	8	8	8	8
Ma'areb	3	3	3	3	3	4	4
Sa'adah	10	10	10	10	10	11	11
Sana'a	15	15	15	15	15	15	15
Shabwah	5	5	5	5	5	5	5
Taiz	4	4	4	4	4	3	3

Table 19. The positions of governorates in the ranking using CRITIC-WED

Variant	1	2	3	4	5	6	7
Abyan	8	8	8	8	8	8	8
Aden	2	2	2	2	2	2	2
Al Amana	1	1	1	1	1	1	1
Al Baydha	16	16	16	16	16	16	16
Al Dhalae	14	14	14	14	14	14	14
Al Jawf	7	7	7	7	7	7	7
Amran	13	13	13	13	13	13	13

Hajah	6	6	6	6	6	6	6
Hodeida	11	11	11	11	11	11	11
Ibb	12	12	12	12	12	12	12
Lahj	10	10	10	10	10	10	10
Ma'areb	3	3	3	3	3	3	3
Sa'adah	9	9	9	9	9	9	9
Sana'a	15	15	15	15	15	15	15
Shabwah	5	5	5	5	5	5	5
Taiz	4	4	4	4	4	4	4

Table 20. The positions of governorates in the ranking using CRITIC-TOPSIS

Variant	1	2	4	5	7	8	10
Abyan	9	8	9	9	9	6	6
Aden	2	2	2	2	2	2	2
Al Amana	1	1	1	1	1	1	1
Al Baydha	16	16	16	16	16	16	16
Al Dhalae	14	14	14	14	14	15	15
Al Jawf	7	7	7	7	7	9	8
Amran	12	13	12	12	12	13	13
Hajah	6	6	6	6	6	7	7
Hodeida	11	11	11	11	11	12	11
Ibb	13	12	13	13	13	11	12
Lahj	10	10	10	10	10	8	9
Ma'areb	3	3	3	3	3	4	4
Sa'adah	8	9	8	8	8	10	10
Sana'a	15	15	15	15	15	14	14
Shabwah	5	5	5	5	5	5	5
Taiz	4	4	4	4	4	3	3

Table 21. The positions of governorates in the ranking using SVP-SAW

Variant	1	2	4	5	7	8	10
Abyan	10	9	10	10	10	7	7
Aden	2	2	2	2	2	2	2
Al Amana	1	1	1	1	1	1	1
Al Baydha	16	16	16	16	16	16	16
Al Dhalae	14	14	14	14	14	14	14
Al Jawf	6	7	6	6	6	9	9
Amran	12	12	12	12	12	12	13
Hajah	4	5	4	4	4	6	6
Hodeida	11	11	11	11	11	13	12
Ibb	13	13	13	13	13	11	11
Lahj	8	8	8	8	8	8	8
Ma'areb	3	3	3	3	3	4	3

Sa'adah	9	10	9	9	9	10	10
Sana'a	15	15	15	15	15	15	15
Shabwah	7	6	7	7	7	5	5
Taiz	5	4	5	5	5	3	4

Table 22. The positions of governorates in the ranking using SVP-WED

Variant	1	2	3	4	5	6	7
Abyan	11	11	11	11	11	11	11
Aden	2	2	2	2	2	2	2
Al Amana	1	1	1	1	1	1	1
Al Baydha	16	16	16	16	16	16	16
Al Dhalae	14	14	14	14	14	14	14
Al Jawf	5	5	5	5	5	5	5
Amran	12	12	12	12	12	12	12
Hajah	4	4	4	4	4	4	4
Hodeida	10	10	10	10	10	10	10
Ibb	13	13	13	13	13	13	13
Lahj	9	9	9	9	9	9	9
Ma'areb	3	3	3	3	3	3	3
Sa'adah	7	7	7	7	7	7	7
Sana'a	15	15	15	15	15	15	15
Shabwah	8	8	8	8	8	8	8
Taiz	6	6	6	6	6	6	6

Table 23. The positions of governorates in the ranking using SVP-TOPSIS

Variant	1	2	3	4	5	6	7
Abyan	6	6	6	6	6	6	6
Aden	2	2	2	2	2	2	2
Al Amana	1	1	1	1	1	1	1
Al Baydha	16	16	16	16	16	16	16
Al Dhalae	15	15	15	15	15	14	15
Al Jawf	8	8	8	8	8	9	10
Amran	13	13	13	13	13	11	11
Hajah	7	7	7	7	7	7	7
Hodeida	12	12	12	12	12	15	14
Ibb	10	9	10	10	10	8	8
Lahj	9	10	9	9	9	10	9
Ma'areb	4	4	4	4	4	5	4
Sa'adah	11	11	11	11	11	13	13
Sana'a	14	14	14	14	14	12	12
Shabwah	5	5	5	5	5	4	5
Taiz	3	3	3	3	3	3	3

Table 24. Correlation matrix between result's rankings obtained by using different normalization formulas (EW Weighing based)

	1-2	**1-3**	**1-4**	**1-5**	**1-6**	**1-7**	**2-3**	**2-4**	**2-5**	**2-6**	**2-7**
SAW	0.994	1.000	1.000	1.000	0.956	0.982	0.994	0.994	0.994	0.968	0.991
WED	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TOPSIS	0.982	1.000	1.000	1.000	0.947	0.968	0.982	0.982	0.982	0.962	0.979
	3-4	3-5	3-6	3-7	4-5	4-6	4-7	5-6	5-7	6-7	Rang
SAW	1.000	1.000	0.956	0.982	1.000	0.956	0.982	0.956	0.982	0.988	0.956-1
WED	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000-1
TOPSIS	1.000	1.000	0.947	0.968	1.000	0.947	0.968	0.947	0.968	0.994	0.947-1

Table 25. Correlation matrix between result's rankings obtained by using different normalization formulas (ENTROPY based)

	1-2	1-3	1-4	1-5	1-6	1-7	2-3	2-4	2-5	2-6	2-7
SAW	0.994	1.000	0.997	0.997	0.985	0.979	0.994	0.997	0.997	0.991	0.988
WED	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TOPSIS	0.997	1.000	1.000	1.000	0.956	0.965	0.997	0.997	0.997	0.962	0.968
	3-4	3-5	3-6	3-7	4-5	4-6	4-7	5-6	5-7	6-7	Rang
SAW	0.997	0.997	0.985	0.979	1.000	0.988	0.985	0.988	0.985	0.988	0.979-1
WED	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000-1
TOPSIS	1.000	1.000	0.956	0.965	1.000	0.956	0.965	0.956	0.965	0.991	0.956-1

Table 26. Correlation matrix between result's rankings obtained by using different normalization formulas (CRITIC based)

	1-2	1-3	1-4	1-5	1-6	1-7	2-3	2-4	2-5	2-6	2-7
SAW	1.000	1.000	1.000	1.000	0.971	0.971	1.000	1.000	1.000	0.971	0.971
WED	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TOPSIS	0.994	1.000	1.000	1.000	0.953	0.968	0.994	0.994	0.994	0.971	0.982
	3-4	3-5	3-6	3-7	4-5	4-6	4-7	5-6	5-7	6-7	Rang
SAW	1.000	1.000	0.971	0.971	1.000	0.971	0.971	0.971	0.971	1.000	0.971-1
WED	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000-1
TOPSIS	1.000	1.000	0.953	0.968	1.000	0.953	0.968	0.953	0.968	0.994	0.953-1

Table 27. Correlation matrix between result's rankings obtained by using different normalization formulas (SVP based)

	1-2	1-3	1-4	1-5	1-6	1-7	2-3	2-4	2-5	2-6	2-7
SAW	0.991	1.000	1.000	1.000	0.941	0.950	0.991	0.991	0.991	0.971	0.976
WED	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
TOPSIS	0.997	1.000	1.000	1.000	0.956	0.965	0.997	0.997	0.997	0.962	0.968
	3-4	3-5	3-6	3-7	4-5	4-6	4-7	5-6	5-7	6-7	Rang
SAW	1.000	1.000	0.941	0.950	1.000	0.941	0.950	0.941	0.950	0.994	0.941-1
WED	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000-1
TOPSIS	1.000	1.000	0.956	0.965	1.000	0.956	0.965	0.956	0.965	0.991	0.956-1

ates relative to ranking using TOPSIS- QT-PSK formula (TOPSIS-CL).

For the WED ranking method The data presented in last two tables summarize the following:

- Comparing with the results obtained by the EW, ENTROPY, SVP and CRITIC methods based on the standardization formula, the ranked governorates haven't changed their positions in the ranking when the all seven normalization methods are used.

For the SAW ranking method The data presented in last two tables summarize the following:

- Comparing with the results obtained based on the standardization formula:

- The ranked governorates have changed their positions in the ranking by 1,1,1,1,1,3 and 2 positions, with the overall level of change equals 0.13,0.13,0.13,0.13,0,13,0.88 and 0.50, for 1,..,7 normalization formulas respectively when the EW method is used,

- The governorates are changing their positions by a 1, 1,1,1,2 and 2 positions with the CL equals 0.25, ,0.25,0.13,0.13,0.25,0.38 for 1,3-7 normalization formulas respectively and they haven't changed their positions in the ranking for the second normalization formula when the Entropy method is used.
- When the CRITIC method is applied , it was observed that the ranked governorates haven't changed their positions in the ranking for 1-5 normalization methods, and have changed their positions by 3 positions with the overall level of change equals 0.75 for both sixth and seventh methods.
- The ranked governorates have changed their positions in the ranking by one position, with the CL equals 0.38 for all 1,3,4 and 5 normalization formulas, by two positions for the last two normalization formulas, and haven't changed their positions in the ranking for the second normalization formula when the SVP method is used.
- Comparing with the results obtained based on the standardization formula, normalization methods have the following order by means of the CL value :

For the EW : 1-5<7<6;
For the Entropy: 2<4,5< 1,3,6<7;
For the CRITIC: 1-5<6,7;
For the SVP : 2< 1,3,4,5<7<6

- Comparing with the results obtained based on the standardization formula, the normalization methods has the following order by means of the average CL values : (4,5 < 1,3 < 2<7<6) [QT- R and Unitization<Weitendorf's and Nicamp's<corth's< QT- PSK< QT- MEAN]
- The impact of the normalization methods on the ranking's results depends on the type of weighting method implemented in the ranking process. For instance, the order of the weighting methods by the effect of the Weitendorf's normalization is: SAW-CRITIC< SAW EW<SAW- ENTROPY< SAW-SVP, while the order is SAW-CRITIC, SAW- ENTROPY and SAW-SVP < SAW EW by the effect of the second (corth's) normalization formula.

For the TOPSIS ranking method The data presented in last two tables summarize the following:

- Comparing with the results obtained based on the Q-T PSK formula, the ranked governorates have changed their positions in the ranking by 3,2,3,3,3 and 1 positions, with the overall level of change equals 0.88,0.63,0.88,0.88, 0.88and 0.250 for (1-6) normalization formulas respectively when the EW, CRITIC and Entropy methods are used, while, When the SVP method is used, it was observed that the ranked governorates haven't changed their positions in the ranking by the using of (QT-MEAN) and have changed their positions by 2 positions with the overall level of change equals 0.75 for all other normalization methods
- Comparing with the results obtained based on the Q-T PSK formula, the normalization methods has the following order by means of the CL value :

- For the EW, Entropy, CRITIC and SVP : 6 <2< all others.
- For the SVP : 6< all others.

Table 28. Change in the positions of governorates in the rankings (SAW and TOPSIS ranking methods)

WM	NCP	Number of regions whose position has changed relative to ranking using SAW-standardization formula							Number of governorates whose position has changed relative to ranking using TOPSIS - QT-PSK formula						
		1	2	3	4	5	6	7	1	2	3	4	5	6	7
EW	(Zero)	14	14	14	14	14	7	9	5	8	5	5	5	12	-
	ONE	2	2	2	2	2	6	6	9	6	9	9	9	4	-
	TWO	0	0	0	0	0	1	1	1	2	1	1	1	0	-
	Three	0	0	0	0	0	2	0	1	0	1	1	1	0	-
ENTROPY	(Zero)	12	16	12	14	14	13	11	5	7	5	5	5	12	-
	ONE	4	0	4	2	2	2	4	9	8	9	9	9	4	-
	TWO	0	0	0	0	0	1	1	1	1	1	1	1	0	-
	Three	0	0	0	0	0	0	0	1	0	1	1	1	0	-
CRITIC	(Zero)	16	16	16	16	16	7	7	5	7	5	5	5	12	-
	ONE	0	0	0	0	0	7	7	9	8	9	9	9	4	-
	TWO	0	0	0	0	0	1	1	1	1	1	1	1	0	-
	Three	0	0	0	0	0	1	1	1	0	1	1	1	0	-
SVP	(Zero)	10	16	10	10	10	8	9	10	9	10	10	10	10	-
	ONE	6	0	6	6	6	4	4	0	2	0	0	0	6	-
	TWO	0	0	0	0	0	4	3	6	5	6	6	6	0	-
	Three	0	0	0	0	0	0	0	0	0	0	0	0	0	-

Table 29. The overall level of change in the position of governorates in the ranking

WM	WED-CL	SAW- CL							TOPSIS- CL						
Norm	ALL	1	2	3	4	5	6	7	1	2	3	4	5	6	7
EW	0	0.13	0.13	0.13	0.13	0.13	0.88	0.5	0.88	0.63	0.88	0.88	0.88	0.25	-
ENTROPY	0	0.25	0.00	0.25	0.13	0.13	0.25	0.38	0.88	0.63	0.88	0.88	0.88	0.25	-
CRITIC	0	0.00	0.00	0.00	0.00	0.00	0.75	0.75	0.88	0.63	0.88	0.88	0.88	0.25	-
SVP	0	0.38	0.00	0.38	0.38	0.38	0.75	0.63	0.75	0.75	0.75	0.75	0.75	0.00	-
AVG	0	0.190	0.033	0.190	0.160	0.160	0.658	0.565	0.848	0.660	0.848	0.848	0.848	0.188	
ORDER	equal	2	3	2	1	1	5	4	3	2	3	3	3	1	

- Comparing with the results obtained based on the standardization formula, the normalization methods has the following order by means of the average CL values : (6 < 2 < all others) [QT-MEAN <corth's< all others.

6. Conclusion

Drawing on the above discussions, it is realized the select of normalization formula influences the result of the ranking using both TOPSIS and SAW methods. Moreover, the influencing level of each formula is changed by the changing of the objective method. On the other hand, the select of normalization formula doesn't influence the result of the ranking using WED and this is due to the implementation of the standardization procedure after the implementation of the normalization process, which give the same normalized DM for all seven under study normalization formulas. By the realization of a research experiment it is noted that, despite high and very high levels of numerical correlation coefficients calculated between places in the different rankings determined by SAW and TOPSIS based on deferent weighting method and using deferent methods of normalization, we can

observe deferent changes in the positions in the rankings, and in the overall level of change in case of particular alternatives. Therefore, The ordering of the normalization methods by its impact on the ranking's results obtained using SAW and TOPSIS and based on deferent types of weighting methods should be taken into consideration while solving related MADM problem. And, the ordering results of this methods in our study give some recommendations for amending this problem.

7. References

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