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A CLUSTERING STUDY ON TWITTER USAGE OF STATE UNIVERSITY RECTORS IN TURKEY

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ABSTRACT

The purpose of clustering analysis is to group several ungrouped data homogeneously based on their similarities. Clustering analysis is a multivariate statistical method, widely used especially in a variety of disciplines such as medicine, engineering, agriculture and social sciences. This study aims to classify the rectors of state universities in Turkey according to their Twitter use in the first six months of the COVID-19 outbreak. Since COVID-19 cases were first seen in Turkey on 11 March, the data collection interval was set as 11th March – 11th September. Firstly, the rectors were clustered using the Weka program based on Twitter usage data. As a result of the clustering analysis, these rectors were collected in six separate clusters. Then, the performance analysis for the clusters was carried out with the help of the MULTIMOORA method, which is one of the Multi-Criteria Decision-Making approaches. Finally, the Twitter usage performances of the groups were discussed based on the findings from the performance analysis.

Keywords: *Social Media, Clustering Analysis, Multi-MOORA Method.*

1. INTRODUCTION

Social media differs from traditional media instruments by enabling the participation of individuals, as well as allowing mutual interaction, cohesion by creating a community, sharing different multimedia content with links, and content production (Boyd & Ellison, 2008). The information speed affects the behavior of individuals and organizations (Acar & Acar, 2020). Nowadays, with the prevalent use of virtual environments, the prospects of the target audiences have begun to change, and diverse consumption types have emerged because the information could be accessed within a few seconds. Hence, the information age has added the concepts of moment and speed to individuals' lives. Currently, Twitter offers the opportunity to reach hundreds of thousands of people simultaneously and mobilize the masses as an instant messaging platform (Atikkan & Tunç, 2011). Twitter, whose effects on social life are felt intensely, endures becoming prevalent with the increasing number of users every day. According to the 'Digital 2020-Global Digital View' report, published by the We Are Social website in 2020, there are a total of 3.8 billion world-wide social media users. Twitter currently has almost 340 million users. There are 11.8 million active Twitter users in Turkey that makes the country rank sixth globally, and second in Europe after the UK in Twitter usage (Digital in Report, 2020).

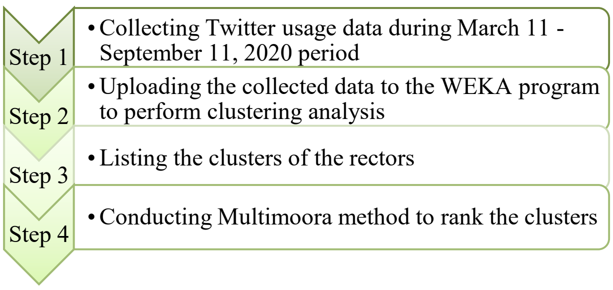
In the last decade, social media has been so popular that organizations, public institutions, universities, leaders and senior executives felt pressure to use it actively to reach and interact with social media users. The virtual public space brought along by social media has pushed universities and university rectors to use Twitter actively (Çiftçi Topa & Doğan, 2019). According to Boumarafi (2015), social media applications are typically used for socializing and entertainment purposes today. Nevertheless, the use of social media has many other benefits. Some of the benefits of social media existence for universities and rectors are the opportunity of communication with existing and potential students, increasing the appeal of the university, and maintaining relationships with parents and graduates (Peruta & Shields, 2017). In addition to this, universities use social media for a variety of purposes such as reflecting or altering their corporate image, creating their brand or strengthening trust, and finding instantaneous solutions by directing incoming problems (Tanova & Amca, 2016).

In this study, a clustering analysis for the rectors of state universities based on Twitter usage, covering the first six months of the COVID-19 outbreak has been carried out. Based on the findings of the clustering analysis, performances of the clusters were also examined. In the following sections of the study, the MULTIMOORA method and clustering analysis, one of the multi-criteria decision-making methods, are explained. Then, the analysis of the data, analysis results and findings are given. Finally, discussion of the finding and suggestions for future studies are presented.

2. MATERIALS AND METHODS

In this study, it was aimed to examine how effectively the rectors used Twitter during the early period of the COVID-19 outbreak. For this purpose, the usage data of 73 state university rectors of Turkey, during 11 March - 11 September 2020 period has been collected to analyze using the WEKA program, which contains a number of clustering algorithms. Then, the clusters have been ranked by using MULTIMOORA method, which is one of the multi-criteria decision-making methods. The steps of the research are given in Figure 1.

Figure 1. Research Steps



2.1. Clustering Analysis

Clustering analysis is the process of classifying a series of scattered and disorganized data according to their various similarities. The main purpose of the usage of clustering analysis is to certify whether the data set we have contained distinctive groups according to certain similarities and if it does, these groups are determined. While this is being applied; all components that make up the cluster are classified according to their similarities and differences with objects in other clusters (Hajizadeh & Shahrabi, 2010). Clustering analysis focuses on clusters and groups that will emerge by calculating the values of observed units, objects, or individuals on all variables measured and gathering similar units into the same cluster. Clustering methods comprise diverse methods such as Center-Based Segmentation Clustering Techniques, Hierarchical Clustering Techniques, Density-Based Clustering Techniques, Grid-Based Clustering Techniques, and Probabilistic Model-Based Clustering Techniques (Kumar & Khatri, 2017). The commonly acknowledged approach is, however, the classification suggested by Han, et al. (2012). The first step of clustering analysis is the construction of the data matrix. In the second step, the data is organized. Finally, the clustering technique is selected for the analyses. As a result of the application, the objects are divided into clusters and the elements that make up the clusters are related to each other and vary from the elements of other clusters.

Using the clustering analysis, Güleç & Işıkhan (2016) aimed to determine the social media usage status of the health ministries of the WHO region countries and to find and compare the clusters in which countries are divided according to social media usage variables. Amaro et al. (2016), used clustering analysis to pinpoint the different segments amid travelers based on the use of travel social media to measure how much travelers are affected by social media when determining their travel routes. Renjith et al. (2018), aimed to make comparisons by using clustering methods to find the utmost suitable option to be used in the field of tourism by using social media data sets such as comments, likes, forums, blogs, feedback etc. in the context of travel and tourism. Using Facebook data, Aristika & Hartono (2020) measured the influence of social media on small and medium-sized enterprises using clustering analysis. Hashimoto et al. (2020) emphasized that tweets sent on Twitter during a disaster could be both a source of help and danger, and based on the text content, separated the tweets sent after the Great East Japan earthquake on March 11, 2011, with the help of clustering analysis. Avşar & Serin (2020), classified cryptocurrencies whose market value has reached a certain size by clustering analysis according to 1-hour, 24-hour and 7-day variance data.

2.2. Multimoora Method

Multi-criteria decision-making methods deal with the decision-making process in circumstances where there are multiple criteria or substitutes. It also consists of a branch of operational research that deals with finding the best results in complex scenarios, including various alternatives and criteria (Aghdaie & Behzadian, 2010). Behzadian et al. (2012) assert that those methods are widely used in supply chain management, logistics, design, engineering and manufacturing systems, business, marketing, health, security, environment, human resources, energy, water resources management, chemical engineering and other areas. Some of the recent studies include assessment of smart bicycle sharing programs by Tian et al. (2018), evaluation of public transport passenger satisfaction by Li et al. (2020), ranking the renewable energy sources in Turkey by Alkan and Albayrak (2020), measuring the financial performance of companies traded in the IT sector by Kaygın (2020), evaluation of website quality by Özbek (2020), and electing the solid waste fields by Rahimi et al. (2020).

MOORA (Multi-Objective Optimization by Ratio Analysis), one of the precise criteria decision-making methods, was introduced by Willem Karel Brauers and Edmundas Kazimieras Zavadskas in 2006 in the study "Control and Cybernetics". The utmost significant feature that separates this method from other methods is to consider all the criteria and take all the interactions amongst alternatives and criteria at the same time. This method is articulated as the process of optimizing two or more conflicting targets with various constraints, while multi-purpose optimization is known as criteria decision making (Chakraborty, 2011).

2.2.1. Steps of the Multimoora Method

Multimoora method, which allows the rankings acquired from each other as a result of the ranking of the different MOORA methods (ratio method, reference point matrix and full multiplication form), prominently increases the consistency of research in this field.

The steps of the MULTIMOORA method are briefly described below (Brauers & Ginevicius 2010; Brauers et al., 2008a; Karaca, 2011; Önay & Çetin 2012)

Step 1: The creation of the decision matrix: Alternatives to the lines of the matrix while the decision matrix is formed, the criteria are positioned in the columns.

Step 2: The normalization process: With the proportion of the sum of the squares of each alternative to the criteria of the square root, the normalization procedure is done with the assistance of the equality (1) procedure.

$$r_{ij} = \frac{w_{ij}}{\sqrt{\sum_{i=1}^{j} w_{ij}^2}} \quad (1)$$

i = 1,2, …, m number of alternatives

j =1,2, …., n number of criteria

Step 3: Ratio Method: After the normalization process, criteria are determined and summed according to whether they are maximum or minimum. The minimum criterion values collected from the maximum criterion values collected are subtracted with the help of equality (2).

$$y_i^* = \sum_{j=1}^{g} x_{ij}^* - \sum_{j=g+1}^{n} x_{ij}^* \quad (2)$$

y_i^*; i It is the normalized assessment of the alternative according to all drives. The operation is completed with the sorting of y_i^*'s.

Step 4: Reference Point Decision: For each criterion; with the help of equality (3), if the criteria are the maximum points then maximum points, if the criteria are the minimum points then the minimum points, are to be determined and reference points i.e. r_j's are selected. The detected points are calculated according to their distance, from each x_{ij}^* to each x_{ij}^* point and the matrix is generated with these values.

$$r_j - x_{ij}^* \quad (3)$$

i = 1, 2, ….,m number of alternatives,

j = 1, 2, ……,n number of criteria,

x_{ij}^* = i. alternative j. criteria's normalized value,

r_j = j. shows the reference point of the criteria.

Reference point theory is a very respectable theory going back to such forerunners as Tchebycheff (1821–1894) and Minkowski (1864–1909). The choice of a reference point and the distance to the reference point is essential for reference point theory. In Reference Point Theory, preference is given to the Tchebycheff Min-Max Metric with the maximum objective reference point. This reference point per objective possesses as coordinates the dominating coordinates of the candidate alternatives. For minimization, the lowest coordinates are chosen (Brauers et al., 2008b).

Tchebycheff min-max metric process is applied with the help of the formed matrix equality (4) for sorting the alternatives.

$$min\{maksj(|r_j - x_{ij}^*|)\} \quad (4)$$

Step 5: Full multiplication form: Values and Meanings of Criteria when expressed in the form of multiplications; x_{ij} values are normalized with the help of the following equality (5):

$$U'j = \frac{A_j}{B_j},\ A_j = \prod_{g=1}^{i} X_{gi},\ B_j = \prod_{k=i+1}^{n} Xkj \quad (5)$$

U'j: j. the availability of the criteria

3. DATA ANALYSIS

Twitter usage statistics of the rectors of state universities in Turkey constitute the dataset of the study. Although there are 129 state universities in Turkey, after a detailed search, only 73 rectors were found to use Twitter actively. Hence, the dataset is incorporated in the 73 state university rectors with a Twitter account. Hence, Twitter usage statistics of 73 state university rectors are incorporated into the dataset for the period of March 11, 2020 - September 11, 2020. The following 16 criteria used in the study (Table 1), while the decision matrix is given in Appendix-A.

Table 1. Twitter Usage Criteria

Code	Criteria	Code	Criterias
C1	Tweets	C9	Tweets retweeted (%)
C2	Followers	C10	Total of retweet times
C3	Tweets per day	C11	Tweets favorited (%)
C4	Retweets	C12	Total of favorited times
C5	User mentions	C13	Tweets most retweeted
C6	Replies	C14	Tweets most favorited
C7	Hashtags	C15	Likes
C8	Links	C16	Use of visual tweets

3.1. Data-Mining Analysis

The data mining program called WEKA is a software developed by Waikato University. The program allows its users to analyze data from countless different dimensions or angles and is known to categorize and summarize the defined relationships. It is a data machine-tool, including many machine learning algorithms and provides the data to group data through various algorithms (Sharma vd. 2012).

The data that is installed in the WEKA program is used to select the most suitable cluster algorithms that are used separately by trialing the numeric data according to the data set. The most consistent results in the clustering analysis were observed to give the 'Canopy Algorithm'. In this algorithm, the number of clusters are determined by the user by using various formulas (Tatlıdil, 2002). The number of clumps has many formulas in the literature on determining.

In this study, the number of clusters in the canopy algorithm was determined as 6 by the k= √(n/2) equation. After loading the data to the WEKA program, basic statistical analyzes were carried out. As seen in Figure 2, the parameters such as the mean and standard deviation of variables, frequency distribution, lowest and highest values are analyzed for the dataset.

Figure 2. WEKA Screenshot of the Analysis

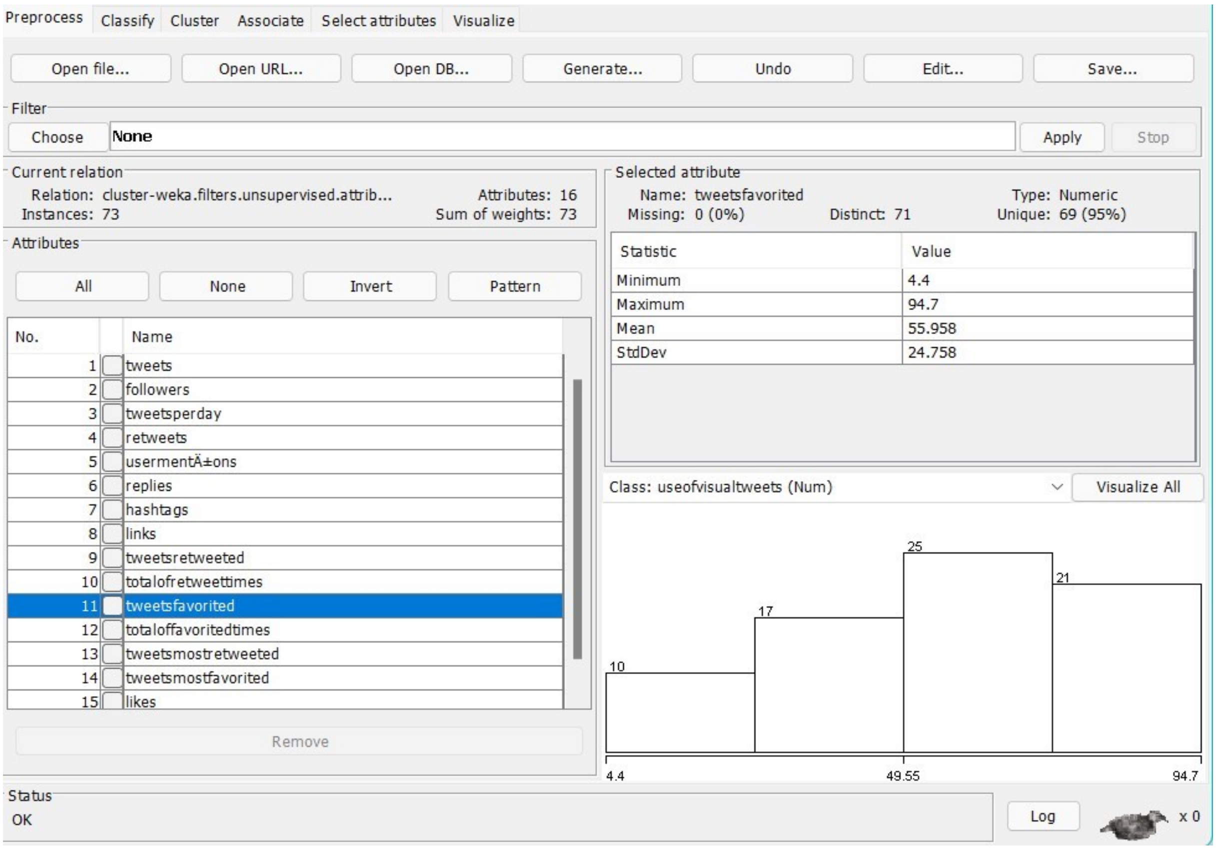


Table 2. Ratios of Cluster Distributions for Canopy Algorithm (k=6)

Cluster	Number of elements	Ratio
Cluster 0	27	37%
Cluster 1	3	4%
Cluster 2	17	23%
Cluster 3	5	7%
Cluster 4	9	12%
Cluster 5	12	16%

As seen in Table 2, 73 rectors grouped under 6 clusters with Canopy. While 27 of them (37%) are in Cluster 0, only 3 of them (4%) are in Cluster 1. The WEKA result panel in Figure 3 shows the visual distribution of the elements in the clusters. List of the rectors, grouped in each clusters are given in Table 3.

Figure 3. WEKA Result Panel, Showing the Visual Cluster Distributions for Canopy Algorithm (k=6)

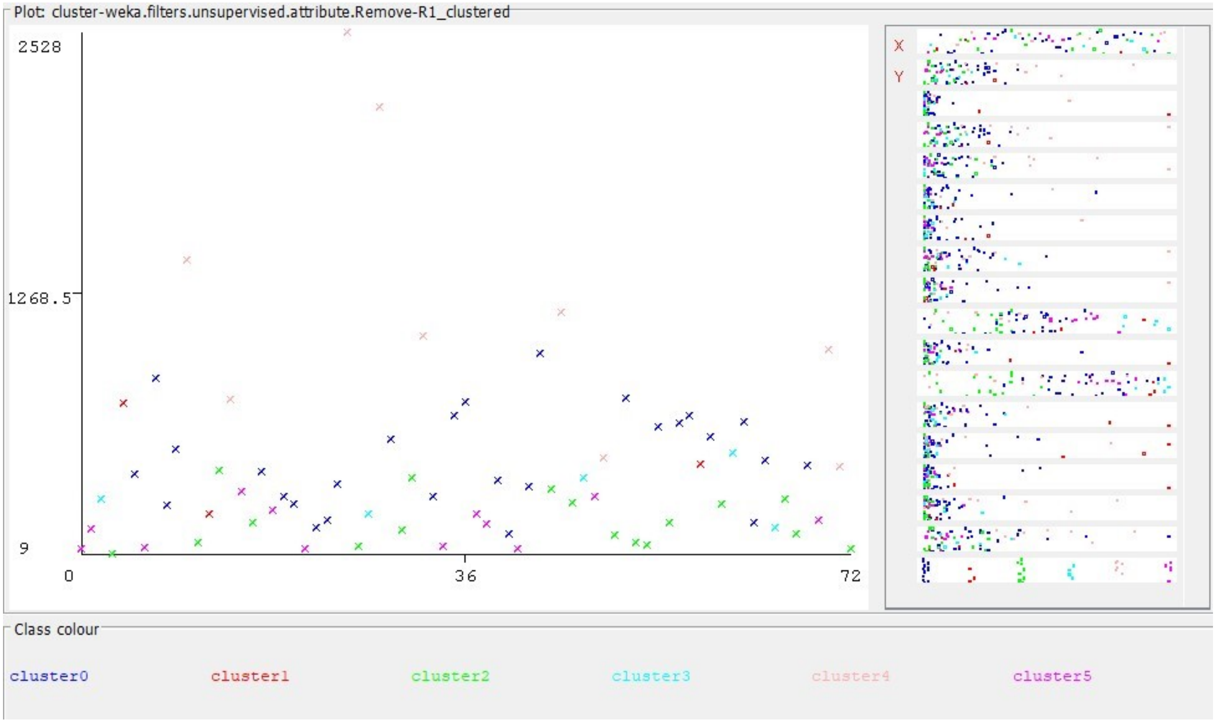


Table 3. Distribution of the Clusters

CLUSTER 0	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	CLUSTER 5
Abdulhalik Karabulut	Cevdet Erdöl	Babür Özçelik	Ahmet Saim Kılavuz	Alim Yıldız	Ahmet Kızılay
Adem Korkmaz	Nihat Hatipoğlu	Bülent Çakmak	Hüseyin Karaman	Kurtuluş Karamustafa	Aydın Durmuş
Ahmet Hamdi Topal	Sadettin Hülagü	Ekrem Savaş	İbrahim Aydınlı	Muhsin Kar	Ekrem Kalan
Ahmet Karadağ		Erhan Tabakoğlu	İbrahim Diler	Musa Kazım Arıcan	Erol Özvar
Ali Osman Öztürk		Gülfettin Çelik	Mustafa Alişarlı	Orhan Uzun	Fahrettin Tilki
Arif Karademir		Hamdullah Şevli		Saffet Köse	Hüseyin Çiçek
Aysun Bay Karabulut		Hasan Kaya		Semih Aktekin	İhsan Sabuncuoğlu
Bedriye Tunçsiper		Hüsnü Kapu		Yusuf Şahin	Mahmut Aydın
Cem Zorlu		Kazım Uysal		Yusuf Tekin	Muhammed Hasan Aslan
Emin Aşıkkutlu		Mehmed Özkan			Mustafa Çalış
Fatih Savaşan		Mehmet Kul			Refik Polat
Handan İnci Elçi		Mehmet Turgut			Selçuk Coşkun
Hasan Ayrancı		Mustafa Berktaş			
İbrahim Özcoşar		Mustafa Çufalı			
İlker Hüseyin Çarıkçı		Niyazi Can			
Mehmet Akgül		Süleyman Özdemir			
Mehmet Karakaş		Şükrü Beydemir			
Mehmet Sabri Çelik					
Mehmet Sarıbıyık					
Murat Türk					

Mustafa Doğan Karacoşkun
Mümin Şahin
Necdet Budak
Nigar Demircan Çakar
Nükhet Hotar
Vural Kavuncu
Yusuf Baran

3.2. MULTIMOORA Method

In the next stage, performances of the clusters in Table 2 were examined by the MULTIMOORA method to determine which similarities and differences caused the distribution of the rectors among the clusters. Before applying the MULTIMOORA method, the criteria values of each cluster were calculated by taking the criterion averages in each cluster, based on the values in the decision matrix. The average values calculated are the values in the new decision matrix for the MULTIMOORA method.

The decision matrix, in which 16 Criteria and 6 alternatives are presented in Table 4, where alternatives (clusters) are shown in the rows of the decision matrix, while criteria are presented in the columns.

Table 4. Decision Matrix

	Tweets	*Followers*	*Tweets per day*	*Retweets*	*User mentions*	*Replies*	*Links*	*Hashtags*	*Tweets retweeted (%)*
Cluster 0	465	11.254	2,52	152	372	121	58	139	37
Cluster 1	458	213.570	2,47	36	274	255	12	47	59
Cluster 2	160	3.782	0,87	119	19	6	9	14	23
Cluster 3	294	7.974	1,59	27	162	33	92	71	84
Cluster 4	1.219	41.887	6,93	612	770	362	100	231	20
Cluster 5	133	6.752	0,72	35	28	13	14	32	60

Decision matrix (cont.)

	Total of retweet times	*Tweets favorited (%)*	*Total of favorited times*	*Tweets most retweeted*	*Tweets most favorited*	*Likes*	*Use of visual tweets*
Cluster 0	2.280	63	30.756	359	2.699	1.029	280
Cluster 1	12.306	89	187.989	4.014	18.998	398	99
Cluster 2	334	28	4.863	54	521	240	121
Cluster 3	2.067	91	33.070	139	991	981	213
Cluster 4	2.091	34	34.924	592	1.828	5.301	596
Cluster 5	916	71	19.888	141	1.323	295	81

After the decision matrix is created, the normalization of the data from the stages of the MULTIMOORA method (Appendix-B), the ratio method (Appendix-C), the reference point approach (Appendix-D) and the full multiplication form approach (Appendix-E) are implemented respectively. The findings are given in Table 5.

Table 5. Ranking of Alternatives with MULTIMOORA

	MOORA Ratio Method	*Ranking (Max)*	*MOORA Reference Point*	*Ranking (Min)*	*The full multiplicative form*	*Ranking (Max)*	*MULTIMOORA*
Cluster 0	4,28	3	9,34	3	3,31	3	**3**
Cluster 1	7,84	2	5,78	2	1,25	2	**2**
Cluster 2	1,21	6	12,41	6	7,69	6	**6**
Cluster 3	3,69	4	9,93	4	5,28	4	**4**
Cluster 4	**8,70**	**1**	**4,92**	**1**	**2,36**	**1**	**1**
Cluster 5	1,87	5	11,75	5	1,27	5	**5**

As shown in Table 5, the findings of the performance analysis highlight that the most active users of Twitter are rectors in the Cluster 4. The cluster is followed by Cluster 1, Cluster 0, Cluster 3, Cluster 5 and Cluster 2, respectively. The ratio method, which is among the stages of the MULTIMOORA method, shows that the clusters have the same sorting values when viewing the reference point approach and full multiplication form method. This shows that the implementation results are consistent and reliable.

In the performance analysis of MULTIMOORA, the rectors who take place in the first place in Cluster 4 were regularly sharing posts via Twitter, having a higher number of followers on Twitter, sharing approximately six tweets daily, having a higher percentage of the retweets and mentions, as well as higher number of shared hashtags and links, are observed. Hence, the findings highlight constant interaction with the followers in Cluster 4. As a result, the rectors in this cluster are labeled as “Power Users”.

Rectors in Cluster 1 had more interaction on their posts as they also had the highest number of followers. However, daily average of tweets of the rectors in this cluster were lower than Cluster 4. The response rate to their tweets, that are mentioned were also high, sharing link, hashtag and visuals were also high. Therefore, this the rectors in this cluster are labeled as “Heavy Users”.

According to the findings, Cluster 0 is ranked in third place in terms of performance. In this cluster, moderate-level Twitter using rectors are listed. When the data is observed, it is seen that they have a high number of followers, they share two tweets daily, the majority of the tweets have been observed as the retweets. They respond to mentions in their accounts with a high rate. At the same time, hashtags, links and visuals are used are frequently. The rectors in this cluster, for this reason, is called “Moderate Users”.

The rectors in Cluster 3 are ranked in fourth place in regard to the results of the performance analysis. The daily average number of shares of the five rectors in Cluster 3 is 1,59. It has been observed that the rate of return given to the mentions is around 20%. As a result of the performance analysis, Cluster 2 and Cluster 5 are under the daily average tweet numbers of one and under. Most tweet shares were observed to consist of retweets rather than original tweets. In addition, the use of links and hashtags are at low levels, as they reduce the interaction in terms of analysis and in terms of the use of Twitter are included in the last place in rankings. Thus, the rectors in Clusters 3, 2 and 5 are listed as “Light Users”.

The two-way communication and interaction of the rectors with students, academicians, employees and other persons or institutions, who are the stakeholders of the university, increase the number of their followers and increases the number of followers, retweets their shares and thus increases both their own recognition and the recognition of the university (Çiftçi Topa & Doğan, 2019). When the literature is reviewed, Rutter, Loper, and Lettice

(2016) confirm that the effective use of social media tools by senior administrators of the university both phenomena themselves and increase the recognition of the institutions. In this research, the Twitter data of the rectors between 11 March and 11 September 2020 were used. These dates cover the first six months from the announcement of the first COVID-19 case in Turkey. In this context, it can be said that especially in this period, the use of Twitter by the rectors to make announcements, solve the problems experienced during the distance education period, and answer questions and problems, provides convenience to the university stakeholders.

4. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

The fact that the use of social media is becoming increasingly widespread and the target audience of universities consists of individuals who use social media intensively, pushes senior university administrators to use social media. In this study, the level of use of Twitter by university administrators, whose effect has increased around the world, especially during the pandemic period, has been examined. For the implementation of clustering analysis, the Twitter usage data of the rectors were uploaded to the WEKA program. As a result of the clustering analysis, the rectors were divided into 6 clusters according to the similarities and differences of their Twitter usage behaviors. One of the differences of the research is the performance analysis of the clusters consisting of rectors as a result of the clustering analysis with Multi-Criteria Decision-Making Methods. As a result of the performance analysis of the clusters, the most active users of the Twitter application are the rectors in the 4th Cluster. Cluster 4 is followed by Cluster 1, Cluster 0, Cluster 3, Cluster 5 and Cluster 2, respectively. As a result of the analysis, it has been tried to explain how effectively the rectors who are members of Twitter use this social media tool, for what purpose they use it, and how they interact. Since there is a lack of analytical investigation of social media use of university senior executives, use of clustering analysis and multi-criteria decision-making methods make a significant contribute to the literature. An analysis of the social media usage of university senior executives with distinct clustering algorithms along with other multi-criteria decision-making methods in future studies will make substantial contributions to the literature.

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Appendix-A. Decision matrix

Alternatives	C1	C2	C3	C4	C5	C6	C7	C8
A1	29	2479	0,16	9	9	5	4	3
A2	123	3888	0,66	26	8	2	8	24
A3	266	7218	1,44	11	103	23	77	48
A4	9	1044	0,05	6	0	0	2	1
A5	733	112326	3,96	61	480	458	14	15
A6	391	1957	2,11	179	589	120	37	18
A7	33	6077	0,18	10	1	0	2	3
A8	855	21199	4,62	271	400	351	96	240
A9	240	9782	1,30	21	162	156	2	6
A10	512	17491	2,77	82	283	240	61	57
A11	1424	4748	7,70	1329	144	56	22	58
A12	61	2621	0,33	39	3	8	8	8
A13	200	27665	1,08	21	60	19	4	125
A14	412	9369	2,23	371	12	13	6	1
A15	750	13716	4,05	572	34	44	8	16
A16	303	15969	1,64	102	24	11	39	22
A17	153	7013	0,83	109	5	9	22	1
A18	405	1407	2,19	119	95	107	17	3
A19	215	2412	1,17	57	132	9	16	160
A20	280	2448	1,51	114	60	55	13	57
A21	245	1181	1,32	112	85	12	8	9
A22	31	1497	0,17	8	1	0	5	15
A23	132	3717	0,71	63	44	9	13	33
A24	173	3856	0,94	7	104	94	10	1
A25	344	8185	1,86	87	372	91	89	51
A26	2528	6045	13,66	522	4148	1732	125	339
A27	46	906	0,25	43	1	1	0	1
A28	199	3344	1,08	14	22	61	25	19
A29	2160	21715	14,79	249	2192	1119	435	1470
A30	565	9784	3,05	72	195	7	68	564
A31	119	6373	0,64	62	55	8	8	46
A32	374	3501	2,02	288	48	12	31	57
A33	1059	16016	5,72	580	268	159	71	71
A34	285	1230	1,54	132	64	42	28	37
A35	44	1985	0,24	15	4	6	1	19
A36	672	60978	3,63	238	60	0	26	441
A37	739	19740	3,99	121	805	398	118	106
A38	197	9771	1,06	34	35	21	29	99
A39	151	9865	0,82	22	76	61	31	3
A40	360	10254	1,95	83	153	53	62	137
A41	105	1764	0,57	52	16	3	5	29
A42	26	1710	0,14	9	11	6	2	0
A43	331	5010	1,79	91	223	108	20	41
A44	976	7812	5,28	427	1491	31	217	628
A45	318	4461	1,72	284	9	1	4	10
A46	1171	3306	6,33	595	119	128	127	75
A47	256	3156	1,38	162	15	11	12	0
A48	377	3550	2,04	61	514	49	170	134
A49	280	22022	1,51	87	12	11	21	1
A50	472	299547	2,55	329	5	11	83	21
A51	93	3496	0,50	69	11	5	6	0
A52	754	6919	4,08	245	340	221	63	383
A53	60	1808	0,32	38	1	4	2	5
A54	47	977	0,25	25	14	10	1	1
A55	622	3015	3,36	389	543	76	76	167
A56	153	893	0,83	100	28	9	5	21
A57	638	29413	3,45	374	55	25	46	101
A58	677	10846	3,66	3	2911	492	123	12
A59	443	500719	2,39	28	282	289	18	1
A60	570	30755	3,08	174	298	217	108	259
A61	244	11438	1,32	154	56	11	24	59
A62	493	20994	2,66	44	37	16	146	60
A63	646	11721	3,49	214	410	271	96	174
A64	156	5658	1,21	64	11	1	24	36
A65	456	5228	2,46	197	122	41	98	105
A66	135	4765	0,73	9	135	17	42	97
A67	266	4189	1,44	184	66	6	11	40
A68	100	2269	0,54	71	4	0	12	0
A69	434	12527	2,35	187	176	49	65	80
A70	170	3355	0,92	52	34	26	10	35
A71	987	4470	5,34	944	15	10	12	28
A72	428	7426	2,31	389	9	1	24	4
A73	25	787	0,14	20	3	2	0	1

Decision matrix (cont.)

Alternatives	C9	C10	C11	C12	C13	C14	C15	C16
A1	51,7	72	69	947	46	148	11	20
A2	74,8	614	78,9	14934	43	880	17	86
A3	88,3	1564	94,7	26363	96	568	1235	170
A4	33,3	3	33,3	68	1	48	0	7
A5	52,7	8736	90	230700	4400	5817	296	171
A6	29,4	445	51,2	5388	32	228	870	280
A7	63,6	256	69,7	4456	58	621	7	31
A8	33,92	2318	59,42	52139	205	3270	945	318
A9	23,30	778	78,3	25517	71	1594	217	45
A10	38,5	2447	78,5	87680	92	2636	330	148
A11	2,7	396	6,5	6610	91	1010	8705	812
A12	27,9	89	36,1	1250	35	329	343	47
A13	84	3261	89,5	29685	4868	4756	122	94
A14	7,3	458	9,5	5912	293	1575	1256	318
A15	19,7	1708	23,6	50301	820	5756	2694	594
A16	65,3	3514	66	56035	196	2105	479	191
A17	27,5	363	28,8	2944	62	307	295	77
A18	15,3	139	67,7	6853	23	263	647	97
A19	61,9	495	72,1	9638	83	465	27	123
A20	32,5	304	48,6	8477	23	439	98	140
A21	50,2	978	53,5	5542	60	103	781	161
A22	48,4	83	74,2	2042	30	424	2334	17
A23	47	391	51,5	8151	49	594	887	80
A24	32,4	315	79,2	12547	31	581	0	46
A25	61,3	1792	74,1	22955	589	640	4710	207
A26	10,7	2119	65,1	27052	62	786	14440	573
A27	4,3	11	6,5	68	10	32	150	36
A28	76,9	754	93	10944	46	690	10	86
A29	36,3	4539	79,6	127777	52	1217	11460	1015
A30	0	0	87,1	32863	0	330	796	1172
A31	29,4	235	47,9	6248	25	742	81	96
A32	20,3	677	23	14050	36	1029	525	283
A33	32,2	3737	41	32942	118	693	28	432
A34	38,2	416	50,9	4878	19	202	729	233
A35	63,6	116	65,9	1200	17	186	16	22
A36	52,08	16177	64,5	78537	1268	2805	2028	595
A37	35,6	3671	80,1	99593	166	2801	2292	216
A38	66	990	82,7	38415	133	1951	310	116
A39	48,3	927	76,8	13458	322	1584	16	60
A40	2,2	27	76,4	9407	143	599	948	277
A41	45,7	313	50,5	3629	37	469	29	79
A42	57,7	70	61,5	466	43	416	115	15
A43	45,6	2038	70,4	18815	167	2059	425	278
A44	54,6	6581	56	20574	292	380	1291	786
A45	10,4	237	10,7	3107	44	432	86	238
A46	39,6	1401	48,1	16769	359	1163	6060	489
A47	29,7	220	36,7	6397	51	597	259	288
A48	76,1	1440	83	11182	37	258	3456	277
A49	63,6	3338	68,9	87156	653	6617	8	189
A50	29,7	4293	30,3	46735	3746	4991	4	398
A51	19,4	254	24,7	3903	86	939	131	32
A52	44,8	1052	66,7	12961	1867	21983	444	466
A53	33,3	89	36,7	1279	13	198	33	46
A54	25,5	90	44,7	1178	16	222	76	17
A55	27,7	1355	34,1	7466	27	207	1313	361
A56	30,7	308	34	1567	35	124	148	24
A57	39,2	2544	41,1	46178	446	1225	892	453
A58	45,9	4944	91	53235	173	1342	1496	115
A59	42	24922	88	303583	2775	46423	777	34
A60	35,4	2422	65,4	36013	2283	18755	1249	313
A61	35,2	1646	36,9	20509	81	871	208	148
A62	88,8	5249	91,1	101553	259	2492	72	424
A63	44,7	3611	64,7	69896	99	1522	1806	278
A64	55,1	839	59	22934	150	1778	207	24
A65	46,9	1326	56,6	27718	99	1463	814	229
A66	93,3	1329	93,3	15311	257	951	135	108
A67	29,3	848	30,5	11745	73	764	295	302
A68	26	150	29	2130	60	554	199	79
A69	48,2	4339	54,6	50484	1308	4609	1552	172
A70	56,5	525	68,8	9911	69	486	207	106
A71	4,1	268	4,4	2112	33	484	3216	705
A72	9,1	363	9,1	4023	51	355	1104	351
A73	12	15	20	332	7	106	4	22

Appendix-B. Normalizing the data

	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	*C16*
Cluster 0	0,33	0,05	0,31	0,24	0,41	0,26	0,39	0,49	0,29	0,18	0,38	0,16	0,09	0,14	0,19	0,39
Cluster 1	0,32	0,98	0,31	0,06	0,30	0,55	0,08	0,16	0,46	0,95	0,54	0,95	0,98	0,98	0,07	0,14
Cluster 2	0,11	0,02	0,11	0,18	0,02	0,01	0,06	0,05	0,18	0,03	0,17	0,02	0,01	0,03	0,04	0,17
Cluster 3	0,21	0,04	0,20	0,04	0,18	0,07	0,62	0,25	0,66	0,16	0,55	0,17	0,03	0,05	0,18	0,30
Cluster 4	0,85	0,19	0,86	0,95	0,84	0,79	0,67	0,81	0,16	0,16	0,21	0,18	0,15	0,09	0,96	0,83
Cluster 5	0,09	0,03	0,09	0,05	0,03	0,03	0,09	0,11	0,47	0,07	0,43	0,10	0,03	0,07	0,05	0,11

Appendix-C. Ratio method of MULTIMOORA

	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	*C16*	Σ	***Max***
Cluster 0	0,33	0,05	0,31	0,24	0,41	0,26	0,39	0,49	0,29	0,18	0,38	0,16	0,09	0,14	0,19	0,39	4,28	3
Cluster 1	0,32	0,98	0,31	0,06	0,30	0,55	0,08	0,16	0,46	0,95	0,54	0,95	0,98	0,98	0,07	0,14	7,85	2
Cluster 2	0,11	0,02	0,11	0,18	0,02	0,01	0,06	0,05	0,18	0,03	0,17	0,02	0,01	0,03	0,04	0,17	1,22	6
Cluster 3	0,21	0,04	0,20	0,04	0,18	0,07	0,62	0,25	0,66	0,16	0,55	0,17	0,03	0,05	0,18	0,30	3,69	4
Cluster 4	0,85	0,19	0,86	0,95	0,84	0,79	0,67	0,81	0,16	0,16	0,21	0,18	0,15	0,09	0,96	0,83	8,71	1
Cluster 5	0,09	0,03	0,09	0,05	0,03	0,03	0,09	0,11	0,47	0,07	0,43	0,10	0,03	0,07	0,05	0,11	1,87	5

Appendix-D. Reference point approach of MULTIMOORA

	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	*C16*	Σ	***Min***
Cluster 0	0,53	0,93	0,55	0,71	0,44	0,52	0,28	0,32	0,37	0,78	0,17	0,80	0,90	0,84	0,77	0,44	9,35	3
Cluster 1	0,53	0,00	0,56	0,89	0,54	0,23	0,59	0,65	0,20	0,00	0,01	0,00	0,00	0,00	0,89	0,70	5,79	2
Cluster 2	0,74	0,96	0,76	0,77	0,82	0,77	0,61	0,76	0,48	0,93	0,38	0,93	0,97	0,95	0,92	0,67	12,41	6
Cluster 3	0,65	0,94	0,67	0,91	0,67	0,71	0,05	0,56	0,00	0,79	0,00	0,78	0,95	0,93	0,78	0,54	9,94	4
Cluster 4	0,00	0,79	0,00	0,00	0,00	0,00	0,00	0,00	0,50	0,79	0,35	0,77	0,84	0,89	0,00	0,00	4,93	1
Cluster 5	0,76	0,95	0,77	0,90	0,81	0,76	0,58	0,70	0,19	0,88	0,12	0,85	0,95	0,91	0,91	0,72	11,76	5

Appendix-E. Full multiplicative form of MOORA

	1	*2*	*2,1*	*3*	*3,1*	*4*	*4,1*	*5*	*5,1*	*6*	*6,1*	*7*	*7,1*	*8*	*8,1*	*9*	*9,1*
	C1	C2	C1*C2	C3	C3*2,1	C4	C4*3,1	C5	C5*4,1	C6	C6*5,1	C7	C7*6,1	C8	C8*7,1	C9	C9*8,1
Cluster 0	465	11254	5233110	2,52	13187437,2	152	2004490454	372	7,457E+11	121	9,02261E+13	58	5,2E+15	139	7,27E+17	37	2,69139E+19
Cluster 1	458	213570	97815060	2,47	241603198,2	36	8697715135	274	2,383E+12	255	6,07709E+14	12	7,3E+15	47	3,43E+17	59	2,02221E+19
Cluster 2	160	3782	605120	0,87	526454,4	119	62648073,6	19	1,19E+09	6	7141880390	9	6,4E+10	14	9E+11	23	2,06972E+13
Cluster 3	294	7974	2344356	1,59	3727526,04	27	100643203	162	1,63E+10	33	5,38039E+11	92	4,9E+13	71	3,51E+15	84	2,95215E+17
Cluster 4	1219	41887	51060253	6,93	353847553,3	612	2,1655E+11	770	1,667E+14	362	6,03625E+16	100	6E+18	231	1,39E+21	20	2,78875E+22
Cluster 5	133	6752	898016	0,72	646571,52	35	22630003,2	28	633640090	13	8237321165	14	1,2E+11	32	3,69E+12	60	2,21419E+14

Full multiplicative form of MOORA (cont.)

	10	*10,1*	*11*	*11,1*	*12*	*12,1*	*13*	*13,1*	*14*	*14,1*	*15*	*15,1*	*16*	*16,1*	
	C10	C10*9,1	C11	C11*10,1	C12	C12*11,1	C13	C13*C12,1	C14	C14*13,1	C15	C15*14,1	C16	C16*C15,1	**Max**
Cluster 0	2280	6,14E+22	63	3,87E+24	30756	1,19E+29	359	4,27E+31	2699	1,15E+35	1029	1,19E+38	280	**3,32E+40**	**3**
Cluster 1	12306	2,49E+23	89	2,21E+25	187989	4,16E+30	4014	1,67E+34	18998	3,18E+38	398	1,26E+41	99	**1,25E+43**	**2**
Cluster 2	334	6,91E+15	28	1,94E+17	4863	9,41E+20	54	5,08E+22	521	2,65E+25	240	6,36E+27	121	**7,69E+29**	**6**
Cluster 3	2067	6,1E+20	91	5,55E+22	33070	1,84E+27	139	2,55E+29	991	2,53E+32	981	2,48E+35	213	**5,29E+37**	**4**
Cluster 4	2091	5,83E+25	34	1,98E+27	34924	6,92E+31	592	4,1E+34	1828	7,49E+37	5301	3,97E+41	596	**2,37E+44**	**1**
Cluster 5	916	2,03E+17	71	1,44E+19	19888	2,86E+23	141	4,04E+25	1323	5,34E+28	295	1,58E+31	81	**1,28E+33**	**5**