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RANKING OF COUNTRIES WITH GREY RELATIONAL ANALYSIS METHOD ACCORDING TO GLOBAL GENDER GAP INDEX

ÜLKELERİN KÜRESEL CİNSİYET UÇURUMU ENDEKSİNE GÖRE GRİ İLİŞKİSEL ANALİZ YÖNTEMİ İLE SIRALANMASI

Dr. Seda BAĞDATLI KALKAN

Assistant Professor, Department of Statistics, İstanbul Commerce University, İstanbul, Turkey

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ABSTRACT

Particularly since 2000s, many institutions and organizations conduct studies to expose the situation of countries related to gender or gender inequality. These studies examine data from countries from a statistical perspective and various indices are created. These indices help countries track their annual improvement. It is also possible to observe country rankings and make a comparison. This way, countries can study the policies in countries that achieved gender equality and work on solutions.

The main objective of this study is to rank countries using Global Gender Gap Index data from World Economic Forum and present an alternative ranking method to Global Gender Gap Index. For this objective, a country ranking is first formed with grey relational analysis using 4 sub-indices that were used in the creation of Global Index. Then, another country ranking is formed with grey relational analysis using the 14 variables used in the creation of Global Index. These rankings formed are compared to Global Index ranking using Spearman's Rank Correlation Coefficient and results are interpreted.

Key Words: Global Gender Gap Index, Gender Inequality, Grey Relational Analysis

ÖZ

Özellikle 2000'li yıllardan itibaren birçok kurum ve kuruluş ülkelerin toplumsal cinsiyet veya cinsiyet eşitsizliği durumunu ortaya koymak adına çalışmalar yapmaktadırlar. Bu çalışmalarda ülkelere ait birçok veri istatistiksel olarak incelenmekte ve çeşitli endeksler oluşturulmaktadır. Oluşturulan endekslerle, ülkeler yıllar bazında kendi gelişimlerini görebilmektedirler. Ayrıca, ülke sıralamalarını da görerek diğer ülkelerle karşılaştırma yapma imkanıda bulmaktadırlar. Böylelikle ülkeler, cinsiyet eşitliğini sağlayabilmiş ülkelerin politikalarını inceleyerek yeni politikalar ve çözümler üretebilmektedirler.

Bu çalışmanın temel amacı, Dünya Ekonomik Forumu tarafından oluşturulan Küresel Cinsiyet Uçurumu Endeksi verilerini kullanarak ülkelerinin sıralamalarını ortaya çıkartmak ve Küresel Cinsiyet Uçurumu Endeksi sıralamasına alternatif bir sıralama yöntemi sunmaktır. Bu amaçla öncelikle, Global Endeks'in oluşturulmasında kullanılan 4 altendeks kullanılarak gri ilişkisel analiz yöntemi ile ülkelerin sıralaması elde edilmiştir. Daha sonra ise Global Endeks'in oluşturulmasında kullanılan 14 değişken kullanılarak gri ilişkisel analiz yöntemi ile ülkelerin bir diğer sıralaması elde edilmiştir. Oluşturulan sıralamalar, Global Endeks sıralamaları ile Spearman'ın sıra korelasyon katsayısı kullanılarak karşılaştırılmış ve sonuçlar yorumlanmıştır.

Anahtar Kelimeler: Küresel Cinsiyet Uçurumu Endeksi, Cinsiyet Eşitsizliği, Gri İlişkisel Analiz

1. INTRODUCTION

Gender and gender inequality are two concepts that have been discussed for many years. However, with women being more active in social and work environments, these concepts have come to light again. Gender is defined as the role and responsibility of men and women as designated by society (İlhan, Uğraş Dikmen, & Ak, 2017). Consequently, gender is a concept related to the culture of the society, how it views man and woman and how it expects them to behave. As an example to the responsibility assigned to genders, women are expected to take care of the house and children, and men are expected to work and provide for the household. Gender equality is when men and women enjoy equal opportunity in

participating in all areas of the social life. In other words, it is to provide equal rights and opportunities to individuals regardless of gender (Gençoğlu & Kuşkaya, 2016). Most gender studies focus on conditions of women because women are on the downside in terms of equality of opportunity in most areas. Three of the most important of these areas are education, social life and politics. It is required to put forth concrete evidences in order for gender inequality between men and women to be accepted. But this is not possible in most cases. Consequently, many organizations and institutions conduct studies that measure gender inequality in order to expose this situation. The main objective in such studies is to make the problem visible, attract the attention of parties, and pave the way for policy planning (Karakaş & Çevik, 2016).

United Nations and World Economic prepare two notable studies in order to present gender inequality by countries. United Nations measure gender inequality of countries every year under the name of Gender Inequality Index. This index is calculated using data about health, rate of representation in parliament, education and rate of participation in work force (Kavas, 2018). The study by World Economic Forum is brought in under the name Global Gender Gap Report. This report is regularly shared with public since 2006. It calculates a general index of countries, named as Global Index. This index is composed of four sub-indices. These are Economic Participation and Opportunity, Educational Attainment, Health and Survival, and Political Empowerment. These indices are in turn composed of 14 variables. Each country is ranked according to a sub-index and general index (World Economic Forum, 2017). Global Gender Gap Index aims to show the gap between men and women. This gap is attempted to be measured through outputs rather than inputs. It means that factors such as socioeconomic factors, culture or legal regulations that have the potential to affect mechanisms related to health, education, economic participation and political empowerment are not considered, and that only results that can be viewed as outputs in this context are not taken into account (Karakaş & Çevik, 2016). Global Gender Gap Index is considered to be more realistic compared to other indices as it includes a wide range of indicators. Hence, many studies related to gender inequality work with Global Gender Gap Index results.

There are a high number of studies in literature concerning gender and gender inequality. In their studies, Gençoğlu and Kuşkaya(2016) aim to present gender equality in European and Middle Eastern countries using 2015 data from Global Gender Gap Index. The study clusters countries using cluster analysis. In the conclusion of the study, countries are placed in 6 clusters of gender gap and it was observed that countries with similar income per capita are in the same cluster. In his study, Tunç (2018) investigates the effect of gender inequality on human development level using regression analysis. He considers 99 countries in the study and concludes that women have an essential role in development and gender equality and development are causally related. In their studies, Yıldırım, Ergüt and Camkıran (2018) attempt to measure public awareness on gender inequality in Turkey. They concluded that women's awareness is statistically higher than men's and awareness decreases as education level drops down.

A literature review reveals that there are a large number of studies on gender and gender inequality, although studies on comparison of countries in this scope are not as many. The main objective of this study is to rank Upper-Middle Income countries using Global Gender Gap Index data put together by World Economic Forum, and to present an alternative ranking method to Global Gender Gap Index ranking. To this end, it is first obtained a ranking of countries through grey relational analysis method using the four sub-indices that were used in the formation of Global Index. Then, another ranking is performed through grey relational analysis method using the 14 variables that were used in the formation of Global Index. These rankings created are compared to Global Index ranking using Spearman's Rank Correlation Coefficient and finally the results are interpreted.

2. MATERIALS AND METHODS

2.1. Data Source

The data used in the study are taken from the Global Gender Gap report in 2017 by World Economic Forum. This report is released every year since 2006 to expose the state of countries with respect to gender inequality. The report first calculates a general index as a basis for ranking countries according to gender inequality. This index is named as Global Index. The Global Index is composed of four sub-indices. These are Economic Participation and Opportunity, Educational Attainment, Health and Survival, and Political Empowerment. The variable used in calculating these sub-indices are shown in Table 1.

Table 1: Variables of Sub-Indices

Sub-index	Variable
Economic Participation and Opportunity	Ratio: female labor force participation over male value
	Wage equality between women and men for similar work (survey data, normalized on 0 to 1 scale)
	Ratio: female estimated earned income over male value
	Ratio: female legislators, senior officials and managers over male value.
	Ratio: female professional and technical workers over male value.
Educational Attainment	Ratio: female literacy rate over male value
	Ratio: female net primary enrolment rate over male value
	Ratio: female net secondary enrolment rate over male value
	Ratio: female gross tertiary enrolment rate over male value
Health and Survival	Sex ratio at birth (converted to female-over-male ratio)
	Ratio: female healthy life expectancy over male value.
Political Empowerment	Ratio: females with seats in parliament over male value
	Ratio: females at ministerial level over male value
	Ratio: number of years with a female head of state (last 50 years) over male value

The scores for the sub-indices in Table 1 are formed by determining certain weights and calculating weighted averages and the Global Index is found by averaging sub-index scores. The Global Index and each sub-index take on a value between 0 and 1, where 1 represents parity and 0 represents imparity (World Economic Forum, 2017).

World Bank countries are divided into four groups according to values of GNI per capita (current US$). These groups are Low Income, Lower-Middle Income, Upper-Middle Income and High Income. World Economic Forum analyzes and ranks the countries separately based on this grouping. This study considers Upper-Middle Income countries (US$ 3,956 – 12,235) which include Turkey.

2.2 Grey Relational Analysis

Grey Relational Analysis (GRA) is a multi-criteria decision making method based on grey system theory. Grey system theory is developed by Prof. Ju Long Deng (Deng, 1982). Systems with completely unknown information are defined as black systems, systems with completely known information as white systems, and systems with partially known and partially unknown information are defined as grey systems (Baş & Çakmak, 2010). Grey system theory aim to investigate the state of systems with uncertain and incomplete data sets using estimation and decision making techniques on such systems, enabling formation of relational analyses and models (Bektaş & Tuna, 2013). GRA is a rating, classifying and decision making technique that requires no assumption. It is especially preferred when sample is small and sample distribution is unknown. The difference of GRA from other multi-criteria decision making techniques is that it can use reference sequence (Tayyar, Akcanlı, Genç, & Erem, 2014). Moreover, ease of calculation operations and lack of need to use custom packaged software make it more preferable by researchers. GRA has six steps. These steps are briefly explained below.

Step 1: Preparing data set and forming the decision matrix

m factor sequences of the decision problem are determined to be subject to comparison.

$$x_i = \big(x_i(j), \dots, x_i(n)\big), \qquad i = 1,2,\dots,m \qquad j = 1,2,\dots,n \tag{1}$$

After forming *m* sequences, these are shown on matrix X to form the decision matrix (Yıldırım & Önder, 2014).

$$X = \begin{bmatrix} x_1(1) & x_1(2) & \dots & x_1(n) \\ x_2(1) & x_2(2) & \dots & x_2(n) \\ \vdots & \vdots & \ddots & \vdots \\ x_m(1) & x_m(2) & \dots & x_m(n) \end{bmatrix} \tag{2}$$

Step 2: Forming reference sequence and comparison matrix

$$x_0 = \big(x_0(j)\big) \qquad j = 1,2,\dots,n \tag{3}$$

$x_0(j)$ in Equation 3 is the largest value of j[th] criterion among normalized values. The reference sequence is inserted in the decision matrix in place of the first row to obtain the comparison matrix.

Step 3: Normalizing decision matrix and forming normalization matrix

Since criteria used in GRA may have varying measurement units and a wide range of distribution, data need to be normalized. This process is called grey relational generation (Çaydaş & Hasçalık, 2008). Normalization is done in three ways depending on the characteristic the sequence exhibits at the point of effect on objective function. Calculations are carried out in parallel with the principles that are described as the higher the better, the lower the better or the ideal is the better (Kung & Wen, 2007).

These calculations are shown in Equations 4, 5 and 6, respectively.

$$x_i^* = \frac{x_i(j) - \min_j x_i(j)}{\max_j x_i(j) - \min_j x_i(j)} \quad (4)$$

$$x_i^* = \frac{\max_j x_i(j) - x_i(j)}{\max_j x_i(j) - \min_j x_i(j)} \quad (5)$$

$$x_i^* = \frac{|x_i(j) - x_{ob}(j)|}{\max_j x_i(j) - x_{ob}(j)} \quad (6)$$

$x_{ob}(j)$ in Equation 6 is the optimal value determined and hence the target value of j[th] criterion. After using the appropriate equation based on the objective, the decision matrix shown in Equation 2 becomes the normalization matrix and is denoted X^* (Yıldırım & Önder, 2014).

Step 4: Forming absolute value table

Absolute values are found using Equation 7.

$$\Delta_{0i} = |x_0^*(j) - x_i^*(j)| \qquad i = 1,2,\dots,m \qquad j = 1,2,\dots,n \quad (7)$$

Absolute value matrix is formed using Equation 7.

Step 5: Forming grey relational coefficient

The elements of grey relational coefficient matrix is calculated using Equation 8.

$$\gamma_{0i}(j) = \frac{\Delta min + \zeta \Delta max}{\Delta_{0i}(j) + \zeta \Delta max} \quad (8)$$

$$\Delta max = \max_i \max_j \Delta_{0i}(j) \qquad \Delta min = \min_i \min_j \Delta_{0i}(j)$$

The parameter ζ in Equation 8 is the distinguishing factor and has a value in the range [1-0]. In cases where difference among data is high, distinguishing coefficient must be close to 0. In literature, distinguishing factor is observed to be taken as 0.5 in general (Kuo, Yang, & Huang, 2008).

Step 6: Calculating grey relational grades

Grey relational grade indicates how similar the compared sequence is to the reference sequence (Özbek, 2017). Equation 9 shows the calculation of grey relational grade in case criteria have equal levels of significance.

$$\Gamma_{0i} = \frac{1}{n}\sum_{j=1}^{n} \gamma_{0i}(j), \qquad i = 1,2,\dots,m \quad (9)$$

In cases criteria have varying levels of significance, grey relational grade is calculated using Equation 10.

$$\Gamma_{0i} = \sum_{j=1}^{n} [w_i(j)\gamma_{0i}(j)] \quad i = 1,2,\dots,m \quad (10)$$

$w_i(j)$ in Equation 10 is the weight of j[th] criterion. The level of significance of criteria can be determined either through consulting expert knowledge by the researcher or through methods such as Analytical Hierarchy Process, Analytical Network Process or Entropy (Özbek, 2017). After being calculated, grey relational grades are ordered from lowest to highest. Then, the first alternative at the first place in the order is decided to be the optimal alternative (Tosun, 2006).

3. RESULTS

The study first ranks countries with grey relational analysis using the 4 sub-indices used in the formation of Global Index. These rankings were obtained through equal weights and each sub-index is maximized. Table 2 shows Grey Relational Grades and rankings obtained using Grey Relational Analysis.

Table 2: Grey Relational Grade and Rankings of Countries

Countries	**Grey Relational Grade**	**Rankings**
Namibia	0.900	1
Belarus	0.846	2
South Africa	0.833	3
Botswana	0.823	4
Colombia	0.806	5
Cuba	0.804	6
Bulgaria	0.776	7
Costa Rica	0.773	8
Serbia	0.765	9
Kazakhstan	0.750	10
Argentina	0.742	11
Brazil	0.742	12
Panama	0.741	13
Russian Federation	0.738	14
Jamaica	0.737	15
Venezuela	0.736	16
Ecuador	0.735	17
Croatia	0.727	18
Romania	0.726	19
Mexico	0.699	20
Peru	0.685	21
Dominican Republic	0.682	22
Belize	0.671	23
Mauritus	0.654	24
Bosnia and Herzegovina	0.648	25
Maldives	0.643	26
Albania	0.640	27
Malaysia	0.639	28
Macedonia	0.633	29
Paraguay	0.629	30
Montenegro	0.625	31
Suriname	0.624	32
Fiji	0.618	33
Thailand	0.612	34
Turkey	0.519	35
Azerbajian	0.516	36
Algeria	0.475	37
Lebanon	0.450	38
China	0.431	39
Iran	0.429	40

Examining Table 2, the first five countries are Namibia, Belarus, South Africa, Botswana and Colombia, and the last five are Azerbaijan, Algeria, Lebanon, China and Iran, respectively.

In order to study the statistical relationship of rankings based on Grey Relational Analysis results with rankings based on the Global Index, Spearman's Rank Correlation Coefficient is calculated and results are displayed in Table 3.

Table 3: Correlation Between Rankings

			Grey Relational Analysis Rankings	**Global Index Rankings**
Spearman's rho	**Grey Relational Analysis Rankings**	Correlation Coefficient	1,000	**,848**
		Sig. (2-tailed)	.	,000
		N	40	40
	Global Index Rankings	Correlation Coefficient	**,848**	1,000
		Sig. (2-tailed)	,000	.
		N	40	40

When Table 3 is reviewed, it is seen that there is a statistical positive relationship of 85% between the rankings of countries acquired with Grey Relational Analysis and their Global Index Rankings.

In the next phase of the study, a grey relational analysis is conducted with the 14 variables used to obtain each sub-index. Because of lack of data about many countries, a linear interpolation is applied prior to the analysis and data are analyzed afterwards. Ranking is performed using equal weights and each variable is maximized.

Table 4: Grey Relational Degrees and Rankings of Countries

Countries	Grey Relational Grade	Rankings
Argentina	0.703	1
Bulgaria	0.691	2
Bosnia and Herzegovina	0.689	3
South Africa	0.659	4
Namibia	0.614	5
Albania	0.597	6
Serbia	0.579	7
Panama	0.578	8
Colombia	0.563	9
Cuba	0.563	10
Croatia	0.562	11
Peru	0.559	12
Belarus	0.550	13
Dominican Republic	0.546	14
Brazil	0.545	15
Venezuela	0.543	16
Romania	0.540	17
Mexico	0.540	18
Kazakhstan	0.532	19
Ecuador	0.529	20
Mauritus	0.526	21
Thailand	0.524	22
Fiji	0.524	23
Russian Federation	0.519	24
Suriname	0.514	25
Azerbajian	0.513	26
Costa Rica	0.506	27
Macedonia	0.489	28
Botswana	0.487	29
Malaysia	0.474	30
Turkey	0.461	31
Montenegro	0.448	32
Jamaica	0.446	33
Belize	0.436	34
China	0.414	35
Algeria	0.402	36
Paraguay	0.399	37
Maldives	0.387	38
Lebanon	0.368	39
Iran	0.343	40

Examining Table 4, the first five countries are Argentina, Bulgaria, Bosnia and Herzegovina, South Africa and Namibia, and the last five are Algeria, Paraguay, Maldives, Lebanon and Iran, respectively.

In order to study the statistical relationship of rankings based on Grey Relational Analysis results with rankings based on the Global Gender Gap, Spearman's Rank Correlation Coefficient is calculated and results are displayed in Table 5.

Table 5: Correlation Between Rankings

			Grey Relational Analysis Rankings	Global Gender Gap Rankings
Spearman's rho	**Grey Relational Analysis Rankings**	**Correlation Coefficient**	1,000	**,761**
		Sig. (2-tailed)	.	,000
		N	40	40
	Global Gender Gap Rankings	**Correlation Coefficient**	**,761**	1,000
		Sig. (2-tailed)	,000	.
		N	40	40

When Table 5 is reviewed, it is seen that there is a statistical positive relationship of 76% between the rankings of countries acquired with Grey Relational Analysis and their Global Index rankings.

4. CONCLUSIONS

Although the concept of gender inequality is achieved legally in many countries, it has not yet reached a desired point on the social level. In many recent studies in this field, it is emphasized that countries that have ensured gender equality are also at a higher level of development. One of the major studies that aim to determine gender inequality in countries is the Global Gender Gap Report prepared by World Economic Forum. This report annually provides the gender gap index of countries. With these index values, countries obtain the opportunity to observe their own improvement over the years and view their place among other countries.

This study suggests an alternative ranking to the ranking by World Economic Forum and compares it to the Global Index rankings. Reviewing results of grey relational analysis with 4 index values, Namibia is in the first place, and Iran is in the last. Turkey is in the 35th place. When results of grey relational analysis with 14 variables are examined, it is observed that the first place holds Argentina and Iran ranks last. Turkey is in the 31th place in this ranking. Observing Global Index rankings, Namibia ranks first and Iran ranks last, and Turkey is placed 38th in the Global Index rankings. As it is seen, Iran's place does not change among the three rankings. Spearman's Rank Correlation Coefficients show that both rankings have strong positive correlation with the Global Index rankings. However, it is seen that the rankings obtained as a result of grey relational analysis with 4 indices have a higher correlation with the Global Index rankings.

The Global Index is calculated for 144 countries. However, since this study analyzes countries in the Upper-Middle Income group, it ranks 40 countries. Reviewing the Global Index, Namibia which is placed first in the first analysis results is placed 13th and Argentina which is placed second in the second analysis results is placed 34th. Turkey is observed to rank 131st and Iran has the 140th rank. In conclusion, the rankings based on grey relational analysis yield results consistent with the Global Index rankings.

This study can provide a basis for other studies in this field. Further studies can include other countries as well, or rank countries by different multi-criteria decision making methods and using different weights. The comparison and interpretation of rankings obtained can make meaningful contributions in the literature.

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