



ANALYSIS OF THE MACROECONOMIC PERFORMANCES OF EUROPEAN COUNTRIES BY GREY RELATIONAL ANALYSIS

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ABSTRACT

Purpose - A macroeconomic analysis is a statistical analysis showing the current situation of the economy. Thanks to this analysis, individuals, investors, companies, states, and the public can perceive the strengths and weaknesses of the economy and make decisions accordingly. In this study, the macroeconomic performances of forty-four European countries was analyzed.

Methodology- The Grey relational analysis method was used in the study.

Findings- As evaluation criteria, nine macroeconomic variables were determined and thus two important results were obtained. The first was the indication of the Grey relational analysis (GRA) method application, an analysis method consisting of six stages. The second result was the macroeconomic performances of European countries.

Conclusion- According to the obtained findings, the ten countries with the most successful macroeconomic performance were Ireland, Russia, Germany, Azerbaijan, Malta, Luxembourg, Netherlands, United Kingdom, Armenia, and Poland, and the ten countries with the lowest macroeconomic performance were France, Serbia, Finland, Portugal, Italy, Bosnia and Herzegovina, Croatia, Belgium, Montenegro, Ukraine, and Greece. Turkey ranked thirty-third among the forty-four countries

Keywords: Grey theory, Grey relational analysis, economic performances, European countries, Index of Economic Freedom.

JEL Codes: C00, C02, G11

1. INTRODUCTION

Macroeconomic analysis is a statistical analysis showing the current situation of the economy. Thanks to this analysis, individuals, investors, companies, states, and the public can perceive the strengths and weaknesses of the economy and make decisions accordingly. In the periods of economic progress and recession, the decisions that are taken show differences.

If the price of an asset comprises all information that may affect this price, market is assumed to be active. However, in daily life, decisions are taken in an environment where the assumption of full information is not valid. If the assumption of full information were valid, each decision to be taken would be evaluated as optimal decision. Conversely, the parties have information different from each other when the missing information is valid. The party with this particular knowledge uses the current situation for its own benefit. Simply put, insiders have more information than outsiders. In such an environment, it becomes extremely important to make correct decisions.

Multi-criteria decision making methods are used in the literature to solve various decision-making problems. The solution of the problem arrives at the conclusion with the selection of the highest satisfaction rating alternative among a series of alternatives. One of these methods is the Grey relational analysis method (GRA). GRA is a method used to analyze the relationships between discrete data. The most important advantage of the GRA method is that its results are based on original data, and its calculation is easy to make. The Grey method, which consists of six steps, starts with the preparation of the decision-making matrix and ends with the comparison of the comparability series and the reference series.

In this study, the macroeconomic performances of forty-four European countries were analyzed by using the Grey relational analysis method. As evaluation criteria, nine economic variables were used. Each of these variables was a risk factor, and these risk factors are affected by every new piece of information in the market and the general condition of the economy. These risk factors consist of two components. The first is systematic risk. The second is unsystematic risk. Unsystematic risk can be completely eliminated. However, systematic risk is a risk that the entire market is exposed to. This risk can be reduced but not completely eliminated. These effects constantly change the economic performance of countries.

2. LITERATURE REVIEW

In the literature, there are a large number of studies conducted in the fields of health sciences, social sciences, and sport sciences based on the GRA method. Some of these studies are summarized below. Nevertheless, there was no study in the literature examining the economic performances of countries based on the GRA method.

Wu (2002) examined the GRA method in his study in which it was concluded that the GRA method is simple and easy to calculate and understand. On the other hand, it is not easy to determine which method is more reliable and reasonable for the problem of multiple attribute decision making (MADM). The best way to cope with this deficiency is to apply several MADM method to the same problem, compare the results, and make the final decision based on the results obtained.

Lin and Lin (2002) evaluated the process of electric discharge machining (EDM) with Grey Relational Analysis method. To solve the EDM process with multi-performance characteristics, the Grey relational classification acquired from the Grey relational analysis was used. Optimal processing parameters were then calculated with the Grey relational degree as the performance index. The experimental results show that the processing performance in EDM process could be effectively improved with this approach.

Kao and Hocheng (2003) used the Grey relational analysis method in their study. According to Grey system theory, the Grey relational analysis is a method used to analyze the relationships between multi-factor series and less data, which is considered to be more advantageous than statistical regression analysis. The analysis of multi-performance characteristics was made with the Grey relational degree. Grey relational analysis can be used for multiple input, discrete data, and uncertain experimental studies. The experiments carried out indicated the efficiency of Grey relational analysis, and the efficiency of this approach was confirmed by the experiment and variance analysis.

Tsai, Chang, and Chen (2003) used the GRA method for the selection of an appropriate vendor. They recommended this method for determining the performances of the vendors due to the advantages of the Grey multiple attributes decision. The suggested approach provided to be performed measurement in accordance with the requirements of every enterprise for the supplier evaluation. It determined the general performance of a supplier and the order of selection of suitable vendors. The optimal decision was also made in compliance with the general performance.

Chang, Tsai, and Chen (2003) indicated that Grey relational analysis method can be used in the analysis of sport technologies, the selection of a trainer, and the evaluation of general performance in the decathlon. The most important advantage of the Grey theory is to consider not only imperfect knowledge but also uncertain problems in detail. It serves as an analysis tool particularly when there is not enough data. Thanks to the quantitative analysis of the Grey relationship, more accurate and subjective data are provided. It is thought that this method might be a reliable analytic approach for the decathlon evaluation models.

Singh, Raghukandan, and Pai (2004) made use of Grey relational analysis in their study when examining the optimization of electric discharge machining parameters. In this process, they normalized the results obtained from the experiment which they conducted in the first step. In the second step, they calculated Grey's relational coefficient and, in the third step, the relational degree of Grey. After that, in the fourth step, they made a statistical variance analysis and, in the fifth step, determined the optimal level of the parameters. Finally, in the last step, the correctness of the parameters was confirmed with a validity check. During the application of this technique, the Grey relational analysis transformed the multi-response variable to a single response Grey relational degree. In this way, the optimization procedure became simple and intelligible.

In Tosun's (2006) study, the optimum parameters were determined for the multi-performance characteristics in the terebration process by using GRA (surface roughness and burr height). Optimal processing parameters were calculated with the Grey relational degree obtained from the Grey relational analysis for multi-performance characteristics. The experimental results showed that surface roughness and burr height in the terebration process can be effectively improved with the new approach.

Wu (2007) made a comparison between the Grey relational analysis to be used and RIDIT methods in order to examine the data obtained from Likert scale questionnaires. The Likert scale is one of the most used methods in social sciences for

collecting data about attitudes, perceptions, values, habits, and behavioral changes. The sample size used influences the reliability of the results produced by using conventional statistical analysis techniques. It was determined that the results obtained by applying the methods used were extremely consistent with each other.

Kuo, Yang and Huang (2008) examined the decision-making process with the GRA method. There are many different situations in daily life and workplace that cause a decision problem. Some of them are related to the selection of the best among the existing multiple alternatives. However, only one alternative does not produce the best result for the all performance features. For the solution of these kind of problems, it is suggested that the multiple attribute decision-making (MADM) method using Grey relational analysis (GRA). The two cases examined show that GRA is an effective tool for solving a MADM problem.

Hsu and Wang (2009) analyzed the effect of multiple determinants on the integrated circuit industry by using Grey relational analysis and a Grey prediction model in their study. Advanced technology industries play an important role in the period of social economic change. Reliable data are an indispensable source of information for a prediction model. Technological forecasting in general suffers from limited historical data and imperfect information. Within this framework, while conventional time series models do not exceed the requirement of historical data collection, multi-variable predictions are more suitable than single variables for complex decision problems.

Zhai, Khoo, and Zhong (2009) examined the design concept assessment with the GRA method in their study. The design concept assessment is a multi-criteria decision-making process consisting of a large quantity of generally indefinite data and expert information. The suggested rough-grey analysis indicated that indefinite design and expert information can be modelled more effectively and objectively.

Hou (2010) developed an optimization model based on the fundamental assumption of a conventional Grey relational analysis (GRA) method. Additionally, he examined multi-featured decision-making problems related to intuitionist fuzzy information in which the information is not exactly known, and the values of the features are in the form of intuitive fuzzy numbers. Consequently, the degree of the Grey relationship between every alternative and positive ideal solution was calculated. In the study, an explanatory example was given to show effectiveness and confirm the approach.

Al-Refaie, Al-Durgham, and Bata (2010) suggested an approach to optimize multiple responses in the Taguchi method by using regression models and Grey relational analysis which uses every quality response to transform a single level of Grey. Accordingly, the larger level of Grey shows a better performance. The level of factor with the highest-level degree was selected as the most appropriate level for this factor. Moreover, this approach can be used for imperfect data.

Xiao, Wang, Fu, and Zhao (2012) examined the fundamental factors of the Web service quality by using Grey relational analysis theory which concentrates on uncertain situations; however, in this process, while part of the information is known, the other part is not known. Grey relational theory argues that the objective system and data characterization are very complicated. However, the factors in the system affect each other internally, and every factor has a very significant role. Grey relational analysis is the most common and dynamic component of the Grey system theory. Although the given information is limited, GRA produces a simple result for analyzing the series relationship or system behaviors. The basic element of the method is the quantitative comparison of the effect factors in the dynamic development trend of the system.

Liu, Baniyounes, Rasul, Amanullah, and Khan (2013) analyzed the sustainability of a renewable energy system (RES) based on Grey relational analysis. The object of the study was to improve a sustainability indicator in order to evaluate the sustainability of renewable energy sources precisely and comprehensively. Grey regression analysis method was used to cope with uncertainties in the determination and assessment of sustainability. The Grey indicator is one of the best ways to evaluate the sustainability of RES. It is a suitable and better tool for users, decision-makers, and researchers.

Hashemi, Karimi, and Tavana (2015) examined supplier selection decisions with an improved GRA method, in their study. To weight the significance level of evaluation criteria, the analytic hierarchy process (AHP) method was used. The suggested approach allows the linguistic evaluation system in the green supplier selection process to be used and the decision-makers to participate in the evaluation process.

Wang, Zhang, Chong and Wang (2017) evaluated supplier performance with seventeen flexible criteria under a combined methodology consisting of an analytic hierarchy process (AHP) and Grey relational analysis (GRA). A supplier selection suitable for effective information integration was suggested for supply chain management. The flexibility capability of a supplier is considerably important for supplier selection. The flexibility criteria influencing the selection priorities of the suppliers were determined by changing the weights given to each criterion. AHP and GRA examine the criteria and then rank the suppliers, respectively.

Chen and Lee (2019) examined the Grey relational analysis (GRA) method to estimate the electricity consumption of public buildings using weather conditions. Increasing environmental awareness has increased the importance of controlling and monitoring electricity consumption. Grey relational analysis has been proposed to analyze the relationship between weather conditions and electricity consumption. In addition, adaptive network-based fuzzy inference systems (ANFIS) method was used to estimate electricity consumption according to weather conditions and human activities. There are two important results. First, it shows that ANFISs achieve higher performance with fewer parameters. Second, the GRA can evaluate the magnitude of the relationship between the factors used and a particular output.

Tan, Chen and Wu (2019) used Analytic Hierarchy Process and Grey Relational Analysis Approaches in environmentally friendly product design. Increasing public awareness of environmental protection and environmental protection laws are entering into force worldwide. Green awareness and green product design have become a critical issue for companies. On the other hand, green sensitivity increases the production costs of companies. In this context, environmental performance and market value of green design has been examined. The proposed methods are an important tool for small and medium-sized enterprises to implement green initiatives in their new product design processes.

Lin, Cheng and Chen (2020) used Grey Relational Analysis (GRA) method for product design in their study. Designers experience uncertainties during the development of their new products. Without defined design goals, new product development negatively impacts productivity. Therefore, it is important for companies to find an optimization approach that facilitates the new product development process and reduces costs. For this, the grey relational analysis method is proposed to analyze and optimize the parameters of the new product design. The results show that the proposed method can increase variety in new product designs and reduce costs.

3. DATA AND METHODOLOGY

This study has two important aims, first, to demonstrate the application of the GRA method, and, second one, to analyze the macroeconomic performances of European countries with the GRA method.

The forty-four European countries are evaluated, and the nine evaluation criteria are indicated in the range of A3 -A47 and in the range of C1-C9, respectively, in Table 1. The assessment criteria were determined as tax burden percentage of GDP, government expenditure percentage of GDP, inflation percentage, public debt percentage of GDP, unemployment percentage, GDP (billions, PPP), GDP growth rate percentage, GDP per Capita (PPP), and FDI inflow (millions). The data from 2020 were taken from the Index of Economic Freedom.

3.1. Grey Relational Analysis Method

The mathematical form of the model is as below. In its construction, we benefited from the study by Wu (2002, p. 211 -212).

Step 1. Preparation of Data Set and Decision Matrix

The series to be subjected to the comparison of the decision problem is determined.

$$x_i = (x_i(1), x_i(2), \dots, x_i(j), \dots, x_i(n)), \quad \begin{matrix} i = 1, 2, 3, \dots, m \\ j = 1, 2, 3, \dots, n \end{matrix} \quad (1)$$

Step 2. Formation of the Reference (x_0) and Compared (x_i) Series.

The reference series is (x_0), $x_0 = (x_0(1), x_0(2), \dots, x_0(j), \dots, x_0(n))$. The compared series is (x_i), $x_i(1), x_i(2), \dots, x_i(j), \dots, x_i(n)$. The compared x_i series can be represented in a matrix form:

$$X_j = \begin{bmatrix} x_1(1) & x_1(2) & x_1(3) & \dots & x_1(n) \\ x_2(1) & x_2(2) & x_2(3) & \dots & x_2(n) \\ x_3(1) & x_3(2) & x_3(3) & \dots & x_3(n) \\ \dots & \dots & \dots & \dots & \dots \\ x_n(1) & x_n(2) & x_n(3) & \dots & x_n(n) \end{bmatrix} \quad (2)$$

Step 3. Normalization of the Data Set

The data can be processed as one of the three types, that is, the larger is better, the smaller is better, and the nominal is the best.

The formula for the larger-better conversion is defined as below:

$$x_i^*(j) = \frac{x_i(j) - \min_j x_i(j)}{\max_j x_i(j) - \min_j x_i(j)} \quad (3)$$

$x_i^*(j)$ shows the value converted.

The formula to be converted for the smaller-better:

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

The formula to be converted for nominal-the best:

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

Furthermore, the reference x_0 series should be normalized with the equation of (3) or (5). For example, if the larger-better transformation is applied,

$$x_i^* = \frac{x_0(j) - \min_j x_i(j)}{\max_j x_i(j) - \min_j x_i(j)}$$

In this way, the normalized reference series of x_0 can be calculated.

After the original data set is normalized by one of the three of them, the conversion types shown in Equation (2) can be revised as follows:

$$X_i^* = \begin{bmatrix} x_1^*(1) & x_1^*(2) & x_1^*(3) & \dots & x_1^*(n) \\ x_2^*(1) & x_2^*(2) & x_2^*(3) & \dots & x_2^*(n) \\ x_3^*(1) & x_3^*(2) & x_3^*(3) & \dots & x_3^*(n) \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ x_n^*(1) & x_n^*(2) & x_n^*(3) & \dots & x_n^*(n) \end{bmatrix} \tag{6}$$

Step 4. Calculation of the Distance of $\Delta_{0i}(j)$

The obtained value is the absolute difference between x_0^* and x_i^* .

$$\Delta_{0i}(j) = |x_0^*(j) - x_i^*(j)|$$

$$= \begin{bmatrix} \Delta_{01}(1) & \Delta_{01}(2) & \Delta_{01}(3) & \dots & \Delta_{01}(n) \\ \Delta_{02}(1) & \Delta_{02}(2) & \Delta_{02}(3) & \dots & \Delta_{02}(n) \\ \Delta_{03}(1) & \Delta_{03}(2) & \Delta_{03}(3) & \dots & \Delta_{03}(n) \\ \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ \Delta_{0m}(1) & \Delta_{0m}(2) & \Delta_{0m}(3) & \dots & \Delta_{0m}(n) \end{bmatrix} \tag{7}$$

Step 5. Application of Grey Relational Equation to Calculate the Grey Relational Coefficient $\Gamma_{0i}(j)$

The Grey relational equation is applied to calculate the Grey relational coefficient $\Gamma_{0i}(j)$ by using the equation given below:

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

$\Delta \max = \max_i \max_j \Delta_{0i}(j), \Delta \min = \min_i \min_j \Delta_{0i}(j)$, in cases where

and $\zeta \in [0,1]$

Step 6. Calculation of the Degree of the Grey Coefficient Γ_{0i} .

When the weight of the criteria (W_i) is determined, the degree of the Grey coefficient Γ_{0i} is calculated as follows:

$$\Gamma_{0i} = \sum_{j=1}^n [W_i(j) \times r_{0i}(j)] \tag{9}$$

For the decision-making processes, if any alternative has the highest Γ_{0i} value, it is the most important alternative. For this reason, the priorities of the alternatives can be ranked based on the Γ_{0i} values.

4. FINDINGS AND DISCUSSIONS

The study by Yıldırım (2018, p. 236-242) was used for the solution of the problem.

Step 1. Determination of the Decision Matrix

Nine assessment criteria were determined to state the macroeconomic performances of the countries in the decision problem. The countries subject to performance evaluations and criteria values are shown in Table 1 by using a Microsoft Excel spreadsheet.

Table 1: Data Set

	A	B	C	D	E	F	G	H	I	J
1		C1	C2	C3	C4	C5	C6	C7	C8	C9
2		Min	Min	Min	Min	Min	Max	Max	Max	Max
3	Albania	26	29	2	69	14	38	4	13345	1294
4	Armenia	21	25	3	48	18	30	5	10176	254
5	Austria	42	49	2	74	5	463	3	52137	7618
6	Azerbaijan	13	35	2	19	5	180	1	18076	1403
7	Belarus	25	39	5	48	6	189	3	20003	1469
8	Belgium	45	53	2	101	6	551	1	48245	4873
9	Bosnia and Herzegovina	38	41	1	37	21	47	3	13491	468
10	Bulgaria	28	34	3	21	5	162	3	23156	2059
11	Croatia	39	47	2	74	9	107	3	26221	1159
12	Cyprus	34	37	1	103	8	35	4	39973	3285
13	Czech Republic	35	40	2	33	2	396	3	37371	9479
14	Denmark	46	52	1	34	5	301	1	52121	1789
15	Estonia	33	39	3	8	6	45	4	34096	1309
16	Finland	43	54	1	61	8	257	2	46430	1225
17	France	46	56	2	99	9	2963	2	45775	37294
18	Georgia	26	30	3	45	14	43	5	11485	1232
19	Germany	38	44	2	60	3	4356	1	52559	25706
20	Greece	39	48	1	183	19	313	2	29123	4257
21	Hungary	38	47	3	69	4	312	5	31903	6389
22	Iceland	38	43	3	35	3	20	5	55917	-336
23	Ireland	23	27	1	65	6	386	7	78785	-66346
24	Italy	42	49	1	132	10	2397	1	39637	24276
25	Kosovo	23	28	1	17	31	21	4	11552	3590
26	Latvia	30	37	3	38	8	58	5	29901	879
27	Lithuania	30	34	3	36	6	97	3	34826	905
28	Luxembourg	39	43	2	22	6	64	3	106705	-5615
29	North Macedonia	26	31	1	40	22	33	3	15709	737
30	Malta	33	36	2	45	5	21	6	45606	4061
31	Moldova	33	31	3	27	3	26	4	7305	228

32	Montenegro	36	48	3	72	16	12	5	19043	490
33	Netherlands	39	43	2	54	4	969	3	56383	69659
34	Norway	38	50	3	37	4	396	1	74356	-18215
35	Poland	34	41	2	48	4	1213	5	31939	11476
36	Portugal	35	45	1	121	7	329	2	32006	4895
37	Romania	25	31	5	37	4	516	4	26447	5888
38	Russia	24	35	3	14	5	4213	2	29267	13332
39	Serbia	36	41	2	54	14	123	4	17555	4126
40	Slovakia	33	41	3	49	7	191	4	35130	475
41	Slovenia	36	44	2	68	6	76	4	36746	1419
42	Spain	34	42	2	97	16	1864	3	40139	43591
43	Sweden	44	50	2	39	6	542	2	52984	11148
44	Switzerland	29	34	1	41	5	549	3	64649	-87212
45	Turkey	25	35	16	29	11	2293	3	27956	12944
46	Ukraine	34	42	11	64	9	390	3	9283	2355
47	United Kingdom	33	41	2	87	4	3038	1	45705	64487

Step 2. The Formation of the Reference Series and the Comparison Matrix

While creating the reference series of the application, the data set was calculated as indicated in Table 2 by using the values belonging to the aforesaid countries. For this reason, the formula =IF(M1="Min"; MIN(M3:M47);MAX(M3:M47)) is written in line M2.

Table 2: Adding Reference Series to the Data Set

	L	M	N	O	P	Q	R	S	T	U
1		Min.	Min.	Min.	Min.	Min.	Maks.	Maks.	Maks.	Maks.
2	Referans	13	25	1	8	2	4356	7	106705	69659
3	Albania	26	29	2	69	14	38	4	13345	1294
4	Armenia	21	25	3	48	18	30	5	10176	254
5	Austria	42	49	2	74	5	463	3	52137	7618
6	Azerbaijan	13	35	2	19	5	180	1	18076	1403
7	Belarus	25	39	5	48	6	189	3	20003	1469
8	Belgium	45	53	2	101	6	551	1	48245	4873
9	Bosnia and Herzegovina	38	41	1	37	21	47	3	13491	468
10	Bulgaria	28	34	3	21	5	162	3	23156	2059
11	Croatia	39	47	2	74	9	107	3	26221	1159
12	Cyprus	34	37	1	103	8	35	4	39973	3285
13	Czech Republic	35	40	2	33	2	396	3	37371	9479
14	Denmark	46	52	1	34	5	301	1	52121	1789
15	Estonia	33	39	3	8	6	45	4	34096	1309
16	Finland	43	54	1	61	8	257	2	46430	1225
17	France	46	56	2	99	9	2963	2	45775	37294

18	Georgia	26	30	3	45	14	43	5	11485	1232
19	Germany	38	44	2	60	3	4356	1	52559	25706
20	Greece	39	48	1	183	19	313	2	29123	4257
21	Hungary	38	47	3	69	4	312	5	31903	6389
22	Iceland	38	43	3	35	3	20	5	55917	-336
23	Ireland	23	27	1	65	6	386	7	78785	-66346
24	Italy	42	49	1	132	10	2397	1	39637	24276
25	Kosovo	23	28	1	17	31	21	4	11552	3590
26	Latvia	30	37	3	38	8	58	5	29901	879
27	Lithuania	30	34	3	36	6	97	3	34826	905
28	Luxembourg	39	43	2	22	6	64	3	106705	-5615
29	North Macedonia	26	31	1	40	22	33	3	15709	737
30	Malta	33	36	2	45	5	21	6	45606	4061
31	Moldova	33	31	3	27	3	26	4	7305	228
32	Montenegro	36	48	3	72	16	12	5	19043	490
33	Netherlands	39	43	2	54	4	969	3	56383	69659
34	Norway	38	50	3	37	4	396	1	74356	-18215
35	Poland	34	41	2	48	4	1213	5	31939	11476
36	Portugal	35	45	1	121	7	329	2	32006	4895
37	Romania	25	31	5	37	4	516	4	26447	5888
38	Russia	24	35	3	14	5	4213	2	29267	13332
39	Serbia	36	41	2	54	14	123	4	17555	4126
40	Slovakia	33	41	3	49	7	191	4	35130	475
41	Slovenia	36	44	2	68	6	76	4	36746	1419
42	Spain	34	42	2	97	16	1864	3	40139	43591
43	Sweden	44	50	2	39	6	542	2	52984	11148
44	Switzerland	29	34	1	41	5	549	3	64649	-87212
45	Turkey	25	35	16	29	11	2293	3	27956	12944
46	Ukraine	34	42	11	64	9	390	3	9283	2355
47	United Kingdom	33	41	2	87	4	3038	1	45705	64487

Step 3. The Normalization Process and the Formation of the Normalization Matrix

In the normalization process, the calculation was made by assigning the minimization status for the criteria labeled Min and the maximization statuses for the criteria labeled Max. The normalization calculations are shown in Table 3.

For this, the formula $=IF(M\$1="Maks";(M2-MIN(M\$2:M\$47))/(MAX(M\$2:M\$47)-MIN(M\$2:M\$47));((MAX(M\$2:M\$47)-M2)/(MAX(M\$2:M\$47)-MIN(M\$2:M\$47))))$ is written in line B51.

Table 3: Normalization Process

	A	B	C	D	E	F	G	H	I	J
50		C1	C2	C3	C4	C5	C6	C7	C8	C9
51	Reference	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000

52	Albania	0,623	0,882	0,916	0,654	0,591	0,006	0,553	0,061	0,564
53	Armenia	0,772	1,000	0,884	0,769	0,456	0,004	0,699	0,029	0,558
54	Austria	0,134	0,231	0,910	0,622	0,915	0,104	0,309	0,451	0,605
55	Azerbaijan	1,000	0,687	0,898	0,935	0,900	0,039	0,079	0,108	0,565
56	Belarus	0,641	0,559	0,734	0,773	0,883	0,041	0,362	0,128	0,565
57	Belgium	0,049	0,125	0,897	0,467	0,861	0,124	0,093	0,412	0,587
58	Bosnia and Herzegovina	0,252	0,494	0,958	0,835	0,345	0,008	0,374	0,062	0,559
59	Bulgaria	0,562	0,736	0,877	0,929	0,897	0,035	0,391	0,159	0,569
60	Croatia	0,231	0,315	0,949	0,624	0,769	0,022	0,308	0,190	0,563
61	Cyprus	0,380	0,622	0,995	0,461	0,797	0,005	0,505	0,329	0,577
62	Czech Republic	0,343	0,539	0,907	0,858	1,000	0,088	0,343	0,302	0,616
63	Denmark	0,006	0,151	1,000	0,850	0,907	0,067	0,057	0,451	0,567
64	Estonia	0,401	0,547	0,827	1,000	0,890	0,008	0,503	0,270	0,564
65	Finland	0,088	0,065	0,971	0,701	0,808	0,056	0,261	0,394	0,564
66	France	0,000	0,000	0,911	0,483	0,758	0,679	0,108	0,387	0,794
67	Georgia	0,623	0,864	0,878	0,792	0,584	0,007	0,645	0,042	0,564
68	Germany	0,264	0,404	0,922	0,705	0,964	1,000	0,096	0,455	0,720
69	Greece	0,207	0,279	0,996	0,000	0,402	0,069	0,205	0,219	0,583
70	Hungary	0,258	0,313	0,863	0,650	0,954	0,069	0,684	0,247	0,597
71	Iceland	0,258	0,428	0,874	0,844	0,982	0,002	0,629	0,489	0,554
72	Ireland	0,711	0,963	1,000	0,674	0,883	0,086	1,000	0,719	0,133
73	Italy	0,116	0,245	0,966	0,292	0,722	0,549	0,000	0,325	0,711
74	Kosovo	0,696	0,916	0,978	0,949	0,000	0,002	0,526	0,043	0,579
75	Latvia	0,480	0,617	0,882	0,831	0,804	0,011	0,656	0,227	0,562
76	Lithuania	0,498	0,734	0,883	0,841	0,872	0,020	0,432	0,277	0,562
77	Luxembourg	0,228	0,444	0,916	0,921	0,890	0,012	0,350	1,000	0,520
78	North Macedonia	0,629	0,817	0,952	0,820	0,317	0,005	0,301	0,085	0,561
79	Malta	0,410	0,643	0,934	0,787	0,922	0,002	0,929	0,385	0,582
80	Moldova	0,395	0,828	0,850	0,891	0,964	0,003	0,526	0,000	0,557
81	Montenegro	0,310	0,286	0,879	0,635	0,534	0,000	0,610	0,118	0,559
82	Netherlands	0,225	0,441	0,943	0,735	0,947	0,220	0,279	0,494	1,000
83	Norway	0,243	0,214	0,868	0,836	0,947	0,088	0,087	0,675	0,440
84	Poland	0,374	0,488	0,943	0,770	0,954	0,276	0,711	0,248	0,629
85	Portugal	0,350	0,374	0,971	0,353	0,840	0,073	0,202	0,249	0,587
86	Romania	0,653	0,806	0,749	0,837	0,932	0,116	0,547	0,193	0,593
87	Russia	0,669	0,699	0,861	0,966	0,918	0,967	0,245	0,221	0,641
88	Serbia	0,307	0,499	0,920	0,736	0,605	0,026	0,585	0,103	0,582
89	Slovakia	0,404	0,505	0,884	0,767	0,843	0,041	0,547	0,280	0,559
90	Slovenia	0,310	0,413	0,934	0,655	0,890	0,015	0,609	0,296	0,565

91	Spain	0,380	0,481	0,938	0,492	0,534	0,426	0,278	0,330	0,834
92	Sweden	0,067	0,216	0,915	0,823	0,858	0,122	0,246	0,460	0,627
93	Switzerland	0,538	0,723	0,986	0,815	0,911	0,124	0,278	0,577	0,000
94	Turkey	0,647	0,705	0,000	0,880	0,698	0,525	0,284	0,208	0,638
95	Ukraine	0,365	0,466	0,345	0,681	0,751	0,087	0,406	0,020	0,571
96	United Kingdom	0,392	0,496	0,887	0,550	0,943	0,696	0,087	0,386	0,967

Step 4. The Calculation of the Absolute Value Table

Table 4 was calculated by showing the absolute differences between the normalized reference curve value and the normalized alternative value. For this, the formula =1-B52 is written on the M52 line.

Table 4: Absolute Value Table

	L	M	N	O	P	Q	R	S	T	U
51		C1	C2	C3	C4	C5	C6	C7	C8	C9
52	Albania	0,377	0,118	0,084	0,346	0,409	0,994	0,447	0,939	0,436
53	Armenia	0,228	0,000	0,116	0,231	0,544	0,996	0,301	0,971	0,442
54	Austria	0,866	0,769	0,090	0,378	0,085	0,896	0,691	0,549	0,395
55	Azerbaijan	0,000	0,313	0,102	0,065	0,100	0,961	0,921	0,892	0,435
56	Belarus	0,359	0,441	0,266	0,227	0,117	0,959	0,638	0,872	0,435
57	Belgium	0,951	0,875	0,103	0,533	0,139	0,876	0,907	0,588	0,413
58	Bosnia and Herzegovina	0,748	0,506	0,042	0,165	0,655	0,992	0,626	0,938	0,441
59	Bulgaria	0,438	0,264	0,123	0,071	0,103	0,965	0,609	0,841	0,431
60	Croatia	0,769	0,685	0,051	0,376	0,231	0,978	0,692	0,810	0,437
61	Cyprus	0,620	0,378	0,005	0,539	0,203	0,995	0,495	0,671	0,423
62	Czech Republic	0,657	0,461	0,093	0,142	0,000	0,912	0,657	0,698	0,384
63	Denmark	0,994	0,849	0,000	0,150	0,093	0,933	0,943	0,549	0,433
64	Estonia	0,599	0,453	0,173	0,000	0,110	0,992	0,497	0,730	0,436
65	Finland	0,912	0,935	0,029	0,299	0,192	0,944	0,739	0,606	0,436
66	France	1,000	1,000	0,089	0,517	0,242	0,321	0,892	0,613	0,206
67	Georgia	0,377	0,136	0,122	0,208	0,416	0,993	0,355	0,958	0,436
68	Germany	0,736	0,596	0,078	0,295	0,036	0,000	0,904	0,545	0,280
69	Greece	0,793	0,721	0,004	1,000	0,598	0,931	0,795	0,781	0,417
70	Hungary	0,742	0,687	0,137	0,350	0,046	0,931	0,316	0,753	0,403
71	Iceland	0,742	0,572	0,126	0,156	0,018	0,998	0,371	0,511	0,446
72	Ireland	0,289	0,037	0,000	0,326	0,117	0,914	0,000	0,281	0,867
73	Italy	0,884	0,755	0,034	0,708	0,278	0,451	1,000	0,675	0,289
74	Kosovo	0,304	0,084	0,022	0,051	1,000	0,998	0,474	0,957	0,421
75	Latvia	0,520	0,383	0,118	0,169	0,196	0,989	0,344	0,773	0,438
76	Lithuania	0,502	0,266	0,117	0,159	0,128	0,980	0,568	0,723	0,438
77	Luxembourg	0,772	0,556	0,084	0,079	0,110	0,988	0,650	0,000	0,480
78	North Macedonia	0,371	0,183	0,048	0,180	0,683	0,995	0,699	0,915	0,439

79	Malta	0,590	0,357	0,066	0,213	0,078	0,998	0,071	0,615	0,418
80	Moldova	0,605	0,172	0,150	0,109	0,036	0,997	0,474	1,000	0,443
81	Montenegro	0,690	0,714	0,121	0,365	0,466	1,000	0,390	0,882	0,441
82	Netherlands	0,775	0,559	0,057	0,265	0,053	0,780	0,721	0,506	0,000
83	Norway	0,757	0,786	0,132	0,164	0,053	0,912	0,913	0,325	0,560
84	Poland	0,626	0,512	0,057	0,230	0,046	0,724	0,289	0,752	0,371
85	Portugal	0,650	0,626	0,029	0,647	0,160	0,927	0,798	0,751	0,413
86	Romania	0,347	0,194	0,251	0,163	0,068	0,884	0,453	0,807	0,407
87	Russia	0,331	0,301	0,139	0,034	0,082	0,033	0,755	0,779	0,359
88	Serbia	0,693	0,501	0,080	0,264	0,395	0,974	0,415	0,897	0,418
89	Slovakia	0,596	0,495	0,116	0,233	0,157	0,959	0,453	0,720	0,441
90	Slovenia	0,690	0,587	0,066	0,345	0,110	0,985	0,391	0,704	0,435
91	Spain	0,620	0,519	0,062	0,508	0,466	0,574	0,722	0,670	0,166
92	Sweden	0,933	0,784	0,085	0,177	0,142	0,878	0,754	0,540	0,373
93	Switzerland	0,462	0,277	0,014	0,185	0,089	0,876	0,722	0,423	1,000
94	Turkey	0,353	0,295	1,000	0,120	0,302	0,475	0,716	0,792	0,362
95	Ukraine	0,635	0,534	0,655	0,319	0,249	0,913	0,594	0,980	0,429
96	United Kingdom	0,608	0,504	0,113	0,450	0,057	0,304	0,913	0,614	0,033

Step 5. The Formation of Grey Relational Coefficient Matrix

After the absolute values table was formed, the values of Δ_{max} and Δ_{min} were determined by making use of the values in this table. As distinguishing coefficient, $\zeta = 0.5$ was used. Grey relational coefficients, which were created by using the calculated parameters, are indicated in Table 5.

For this, the formula $= (\$B\$146 + (\$B\$147 * \$B\$145)) / (M52 + (\$B\$147 * \$B\$145))$ is written to the B100 line.

Table 5: Grey Relational Coefficients

	A	B	C	D	E	F	G	H	I	J
99		C1	C2	C3	C4	C5	C6	C7	C8	C9
100	Albania	1,017	1,443	1,526	1,055	0,981	0,597	0,942	0,620	0,953
101	Armenia	1,225	1,784	1,448	1,221	0,854	0,596	1,114	0,606	0,947
102	Austria	0,653	0,703	1,511	1,016	1,524	0,639	0,749	0,850	0,996
103	Azerbaijan	1,784	1,098	1,482	1,580	1,488	0,610	0,628	0,641	0,954
104	Belarus	1,039	0,948	1,164	1,227	1,445	0,611	0,784	0,650	0,954
105	Belgium	0,615	0,649	1,481	0,864	1,397	0,648	0,634	0,820	0,977
106	Bosnia and Herzegovina	0,715	0,887	1,645	1,341	0,773	0,598	0,792	0,620	0,948
107	Bulgaria	0,951	1,168	1,432	1,562	1,479	0,609	0,804	0,665	0,958
108	Croatia	0,703	0,753	1,620	1,019	1,220	0,604	0,748	0,681	0,952
109	Cyprus	0,796	1,016	1,767	0,858	1,269	0,597	0,897	0,762	0,966
110	Czech Republic	0,771	0,928	1,505	1,389	1,784	0,632	0,771	0,745	1,010
111	Denmark	0,597	0,661	1,784	1,373	1,506	0,622	0,618	0,850	0,957
112	Estonia	0,812	0,936	1,326	1,784	1,462	0,598	0,895	0,725	0,953

113	Finland	0,632	0,622	1,685	1,116	1,289	0,618	0,720	0,806	0,953
114	France	0,595	0,595	1,514	0,877	1,202	1,087	0,641	0,802	1,263
115	Georgia	1,017	1,402	1,434	1,260	0,974	0,598	1,044	0,612	0,953
116	Germany	0,722	0,814	1,544	1,122	1,666	1,784	0,636	0,854	1,143
117	Greece	0,690	0,731	1,769	0,595	0,813	0,624	0,689	0,697	0,973
118	Hungary	0,718	0,751	1,401	1,049	1,633	0,623	1,094	0,712	0,988
119	Iceland	0,718	0,832	1,424	1,359	1,723	0,595	1,024	0,882	0,943
120	Ireland	1,131	1,660	1,783	1,080	1,445	0,631	1,784	1,142	0,653
121	Italy	0,644	0,711	1,670	0,739	1,147	0,938	0,595	0,759	1,130
122	Kosovo	1,110	1,528	1,708	1,619	0,595	0,596	0,916	0,612	0,968
123	Latvia	0,875	1,010	1,443	1,334	1,282	0,599	1,056	0,701	0,951
124	Lithuania	0,891	1,165	1,447	1,354	1,420	0,603	0,836	0,729	0,951
125	Luxembourg	0,701	0,845	1,528	1,542	1,462	0,600	0,776	1,784	0,910
126	North Macedonia	1,024	1,306	1,628	1,313	0,754	0,597	0,744	0,630	0,950
127	Malta	0,819	1,040	1,576	1,251	1,543	0,596	1,562	0,800	0,972
128	Moldova	0,807	1,327	1,372	1,465	1,666	0,596	0,916	0,595	0,946
129	Montenegro	0,750	0,735	1,436	1,031	0,923	0,595	1,003	0,646	0,948
130	Netherlands	0,700	0,843	1,601	1,167	1,612	0,697	0,731	0,887	1,784
131	Norway	0,710	0,694	1,412	1,344	1,612	0,632	0,631	1,081	0,841
132	Poland	0,792	0,881	1,602	1,222	1,633	0,729	1,131	0,712	1,024
133	Portugal	0,775	0,793	1,685	0,778	1,351	0,625	0,687	0,713	0,977
134	Romania	1,054	1,285	1,188	1,346	1,572	0,645	0,936	0,682	0,984
135	Russia	1,073	1,114	1,396	1,672	1,533	1,674	0,711	0,697	1,038
136	Serbia	0,748	0,892	1,538	1,167	0,997	0,605	0,975	0,639	0,972
137	Slovakia	0,814	0,897	1,448	1,217	1,359	0,612	0,936	0,731	0,948
138	Slovenia	0,750	0,821	1,576	1,056	1,462	0,601	1,001	0,741	0,954
139	Spain	0,796	0,875	1,588	0,885	0,923	0,831	0,730	0,763	1,339
140	Sweden	0,622	0,695	1,525	1,318	1,389	0,647	0,712	0,857	1,022
141	Switzerland	0,927	1,148	1,734	1,302	1,515	0,648	0,730	0,966	0,595
142	Turkey	1,046	1,121	0,595	1,439	1,112	0,915	0,734	0,690	1,035
143	Ukraine	0,786	0,863	0,772	1,090	1,191	0,631	0,816	0,603	0,960
144	United Kingdom	0,805	0,889	1,455	0,939	1,602	1,110	0,631	0,801	1,674
145	Δ_{MAX}	1,000								
146	Δ_{MIN}	0,392								
147	ζ	0,5								

Step 6. The Calculation of Grey Relational Degrees

Grey relational degrees are determined by using the calculated Grey relational coefficients, and then the analysis ends up with the determination of the best ideal alternative and the rankings of Grey relational degrees. When the criteria have equal importance, Grey relational degrees are the arithmetic mean of grey relational coefficients of the criteria for each alternative.

The calculations related to the above may be seen in Table 6. For this, the formula =AVERAGE (M100:U100) is written to V100 line. For the ranking of countries' performances, the formula =RANK (V100;\$V\$100:\$V\$144;0) is written to W100 line.

Table 6: Grey Relational Degrees and Their Alternative Gradation

	L	M	N	O	P	Q	R	S	T	U	V	W
99		C1	C2	C3	C4	C5	C6	C7	C8	C9	Ri	RANK
100	Albania	1,02	1,44	1,53	1,06	0,98	0,60	0,94	0,62	0,95	1,01	22
101	Armenia	1,23	1,78	1,45	1,22	0,85	0,60	1,11	0,61	0,95	1,09	9
102	Austria	0,65	0,70	1,51	1,02	1,52	0,64	0,75	0,85	1,00	0,96	34
103	Azerbaijan	1,78	1,10	1,48	1,58	1,49	0,61	0,63	0,64	0,95	1,14	4
104	Belarus	1,04	0,95	1,16	1,23	1,44	0,61	0,78	0,65	0,95	0,98	30
105	Belgium	0,61	0,65	1,48	0,86	1,40	0,65	0,63	0,82	0,98	0,90	42
106	Bosnia and Herzegovina	0,71	0,89	1,65	1,34	0,77	0,60	0,79	0,62	0,95	0,92	40
107	Bulgaria	0,95	1,17	1,43	1,56	1,48	0,61	0,80	0,67	0,96	1,07	14
108	Croatia	0,70	0,75	1,62	1,02	1,22	0,60	0,75	0,68	0,95	0,92	41
109	Cyprus	0,80	1,02	1,77	0,86	1,27	0,60	0,90	0,76	0,97	0,99	29
110	Czech Republic	0,77	0,93	1,51	1,39	1,78	0,63	0,77	0,74	1,01	1,06	16
111	Denmark	0,60	0,66	1,78	1,37	1,51	0,62	0,62	0,85	0,96	1,00	24
112	Estonia	0,81	0,94	1,33	1,78	1,46	0,60	0,89	0,73	0,95	1,05	18
113	Finland	0,63	0,62	1,68	1,12	1,29	0,62	0,72	0,81	0,95	0,94	37
114	France	0,59	0,59	1,51	0,88	1,20	1,09	0,64	0,80	1,26	0,95	35
115	Georgia	1,02	1,40	1,43	1,26	0,97	0,60	1,04	0,61	0,95	1,03	20
116	Germany	0,72	0,81	1,54	1,12	1,67	1,78	0,64	0,85	1,14	1,14	3
117	Greece	0,69	0,73	1,77	0,59	0,81	0,62	0,69	0,70	0,97	0,84	45
118	Hungary	0,72	0,75	1,40	1,05	1,63	0,62	1,09	0,71	0,99	1,00	23
119	Iceland	0,72	0,83	1,42	1,36	1,72	0,60	1,02	0,88	0,94	1,06	17
120	Ireland	1,13	1,66	1,78	1,08	1,44	0,63	1,78	1,14	0,65	1,26	1
121	Italy	0,64	0,71	1,67	0,74	1,15	0,94	0,59	0,76	1,13	0,93	39
122	Kosovo	1,11	1,53	1,71	1,62	0,59	0,60	0,92	0,61	0,97	1,07	13
123	Latvia	0,87	1,01	1,44	1,33	1,28	0,60	1,06	0,70	0,95	1,03	21
124	Lithuania	0,89	1,16	1,45	1,35	1,42	0,60	0,84	0,73	0,95	1,04	19
125	Luxembourg	0,70	0,84	1,53	1,54	1,46	0,60	0,78	1,78	0,91	1,13	6
126	North Macedonia	1,02	1,31	1,63	1,31	0,75	0,60	0,74	0,63	0,95	0,99	28
127	Malta	0,82	1,04	1,58	1,25	1,54	0,60	1,56	0,80	0,97	1,13	5
128	Moldova	0,81	1,33	1,37	1,47	1,67	0,60	0,92	0,59	0,95	1,08	12
129	Montenegro	0,75	0,73	1,44	1,03	0,92	0,59	1,00	0,65	0,95	0,90	43
130	Netherlands	0,70	0,84	1,60	1,17	1,61	0,70	0,73	0,89	1,78	1,11	7
131	Norway	0,71	0,69	1,41	1,34	1,61	0,63	0,63	1,08	0,84	1,00	27
132	Poland	0,79	0,88	1,60	1,22	1,63	0,73	1,13	0,71	1,02	1,08	10
133	Portugal	0,78	0,79	1,69	0,78	1,35	0,63	0,69	0,71	0,98	0,93	38

134	Romania	1,05	1,29	1,19	1,35	1,57	0,64	0,94	0,68	0,98	1,08	11
135	Russia	1,07	1,11	1,40	1,67	1,53	1,67	0,71	0,70	1,04	1,21	2
136	Serbia	0,75	0,89	1,54	1,17	1,00	0,61	0,98	0,64	0,97	0,95	36
137	Slovakia	0,81	0,90	1,45	1,22	1,36	0,61	0,94	0,73	0,95	1,00	25
138	Slovenia	0,75	0,82	1,58	1,06	1,46	0,60	1,00	0,74	0,95	1,00	26
139	Spain	0,80	0,88	1,59	0,89	0,92	0,83	0,73	0,76	1,34	0,97	32
140	Sweden	0,62	0,69	1,53	1,32	1,39	0,65	0,71	0,86	1,02	0,98	31
141	Switzerland	0,93	1,15	1,73	1,30	1,51	0,65	0,73	0,97	0,59	1,06	15
142	Turkey	1,05	1,12	0,59	1,44	1,11	0,91	0,73	0,69	1,04	0,97	33
143	Ukraine	0,79	0,86	0,77	1,09	1,19	0,63	0,82	0,60	0,96	0,86	44
144	United Kingdom	0,81	0,89	1,45	0,94	1,60	1,11	0,63	0,80	1,67	1,10	8

In Table 6, it may be seen that the ten countries that have the most successful macroeconomic performance are Ireland, Russia, Germany, Azerbaijan, Malta, Luxembourg, Netherlands, United Kingdom, Armenia and Poland, respectively. Conversely, the ten countries which have the lowest macroeconomic performance were determined as France, Serbia, Finland, Portugal, Italy, Bosnia and Herzegovina, Croatia, Belgium, Montenegro, Ukraine and Greece, respectively. The ranking of Turkey was thirty-three among forty-four countries.

Nine evaluation criteria that can affect the economic performances of the countries were used. Each of these criteria, actually, is a risk factor. This risk is divided into two categories, basically. The first is systematic risk which can be defined as the risk factors the whole market is exposed to. The effects of these risk factors can be reduced, but it is not possible to eliminate it totally. The second is nonsystematic risk which is the risk factors in relation with the country itself. Unlike the first one, this risk factor can be eliminated completely. The possible changes in these risk factors will change the macroeconomic performances of the countries.

5. CONCLUSION

Two important results were obtained from this study. The first one is the presentation of the application of the Grey relational analysis (GRA) method. The solution of the GRA method consists of six steps, the determination of a decision matrix, the formation of a reference series and a comparison matrix, the realization of the normalization process, the acquisition of the absolute value table, the calculation of the Grey relational coefficient matrix, and, finally, creating Grey relational degrees and making the alternative rankings.

The second one is knowledge of the economic performances of the European countries. Based on this. It was seen that the ten countries with the most successful macroeconomic performance are Ireland, Russia, Germany, Azerbaijan, Malta, Luxembourg, Netherlands, United Kingdom, Armenia, and Poland. respectively. Conversely, it was found that the ten countries with the lowest economic performance are France, Serbia, Finland, Portugal, Italy, Bosnia and Herzegovina, Croatia, Belgium, Montenegro, Ukraine, and Greece. respectively.

The ranking of Turkey is thirty-three among forty-four countries. These rankings change depending upon the possible variance in the values of the used criteria.

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