EVALUATION OF BANKING PERFORMANCE OF THE BALKAN COUNTRIES WITH AN INTEGRATED MCDM APPROACH CONSIST OF ENTROPY AND OCRA TECHNIQUES

Mustafa Canakcıoglu

Faculty of Business at Kadir Has University, Cibali- Fatih, Istanbul 34083, Turkey

Abstract

The purpose of this study is to evaluate the financial performances of Balkan region banks listed on their own country exchanges by using multi criteria decision-making methods: Entropy and OCRA (Occupational Repetitive Actions). For this purpose, 44 banks in 10 Balkan countries are included in the study. Data from 2015-2018 financial statements of these banks are utilized. We use total equity / total assets, total deposits / total assets and efficiency ratio as input factors; and net loans / total assets, net income / total assets, net income / total equity, non-interest income / operation income and net interest margin as output factors. Entropy and OCRA methods are used together for the first time in evaluating the financial performance of banks in Balkan countries. The weights of the criteria are determined by the Entropy method, and banks are ranked in terms of performance by the use of OCRA method. Our results exhibit that the large banks have the best performance in terms of financial performance value.

Keywords: *Banking Sector, Performance Analysis, OCRA, Entropy, Finance, MCDM*

1. INTRODUCTION

Balkans is one of the important regions of the world in aspects of economically and politically and its importance has continued to increase gradually depending on increases of the global and regional trade. According to report published by The European Commission, overall, in the second quarter (Q2) of 2018, the Western Balkan's GDP growth reached 4.3%, up from 3.6% in the first quarter (Q1). However, economic growth accelerated only in Bosnia and Herzegovina, Montenegro, Kosovo and the former Yugoslav Republic of Macedonia. In Serbia and Albania, GDP growth slowed marginally, whereas, in Turkey, economic growth slowed down from 7.1% to 5.5% in Q2. According to figures of World Bank for 2016, some selected values about development levels of the banking and finance sectors of the Balkan countries can be seen in Table 1.

Balkan Country	Bank assets, percent of GDP	Non-performing loans as percent of all bank loans	Bank concentration: percent of bank assets held by top three banks,	Bank capital to assets ratio (%)
Albania	58.51	18.27	71.10	10.17
Bosnia & Herz.	60.59	11.78	38.97	14.01
Bulgaria	62.93	13.17	55.94	11.39
Croatia	88.80	13.61	60.35	14.04
Greece	122.39	36.30	77.04	11.99
Macedonia	53.28	6.29	64.78	10.61
Montenegro	59.39	10.30	48.91	13.32
Romania	39.79	9.62	59.39	8.89
Slovenia	65.32	5.07	59.70	Not available
Turkey	73.27	3.23	38.70	10.72

Table 1. Selected Development Ratio for Banking Sector in the Balkan

National economies of Balkan countries are in the positive conditions for not only international stimuli and external situations but their financial positions are not strong and it may at issue to confront external and domestic financial risks for these countries in near future. Therefore, they have to improve own banking and finance sector and should take some improving measures as soon as. Because their banking and finance sector can be accepted as a propulsive force of development and very important tool to gain competitive power for the national economies. Within this scope, the most important needs of these countries to continue own economic development is to aware whether their banking and finance sector is efficient and sufficient for economic development. Essentially, they have to make efficiency analysis to monitor their banking sector continuously and may need an effective tool to make a realistic evaluation. This study proposes an effective tool for efficiency analysis and it consists of two multi-criteria decision-making techniques, so proposed approach can be accepted as a hybrid MCDM model, because performance analysis for banking and finance sector is a multi-criteria decision-making problem and it can be solved with only MCDM techniques. The suggested model consists of Entropy method and The Operational Competitiveness Rating (OCRA) technique. While weight values of factors are calculated with the help of the entropy method, performance scores of decision alternatives are computed with OCRA technique.

This study consists of five sections. In the first section, the scope and main aim of this study have been summarized. In the second section, literature that involved studies and researches about performance analysis of banking and finance sector has been reviewed completely. While materials and method, which used in this study, have been described in the third section, a numerical analysis about the banking and finance sector of Balkan countries has been realized in the fourth section. In the final and fifth section, obtained results and outputs of this study have been discussed and some recommendations have been asserted in order to improve the banking and finance sector of these countries.

As a result, proposed an integrated approach in this study can be useful for decision and policy makers of these countries about banking and finance sector and it can be used as a systematic and structural tool for performance analysis. In addition to that, it can contribute literature and can beneficial for further studies and research in the future.

2. LITERATURE REVIEW

There are a few studies about performance analysis of the banks of the Balkan countries. when it is summarized: in the study of Hunjak ve Jakovčević (2001), the performance of the Croatian banks for 1999 was measured by using the Analitik Hiyerarşi Process (AHP) method. Halkos ve Salamouris (2004) employed the Data Envelopment Analysis (DEA) technique and evaluated the performance of the Greek banks and this performance analysis involved 1997 to 1999. With the help of Promethee method, Kosmidou and Zopounidis (2008) examined the performances of the Greek commercial and cooperation banks between 2003 and 2004. Finally, Mandic et al. (2014) analyzed the performances of thirty-five banks that operated between 2005 and 2010 in Serbia by using the Fuzzy AHP and TOPSIS technique.

When the studies about performance analysis of banks that operand in the stock market of Turkey are reviewed, there are some studies exist by using different MCDM techniques such as fuzzy AHP and VIKOR method for 2008 (Çetin ve Çetin 2010), with Promethee method from 2007 to 2011 (Sakarya ve Aytekin 2013), Grey Relational Analysis, TOPSIS and VIKOR methods between 2004-2014 (Kandemir ve Tuğrul 2016), with the Fuzzy MOORA and Fuzzy AHP methods between the years of 2007- 2016 (Altunöz 2017) and finally, with the Multi-MOORA technique between 2010-2016 (Atukalp 2018).

The studies about banks of the Balkan countries are related to the measurement of productivity and efficiency of the banks. Some of these researches and studies are: with the help of the DEA method, four-years efficiency analysis of fifteen Romanian banks. There is research, which examined the relations between efficiency of Romanian banks and the Integration process with the EU, for between 2002 and 2010 (Ilut and Chırleşan 2012); Munteanu et al (2013) realized a study that focussed on the Romanian banks' efficiency by using the DEA method and Malmquist index; from 2005 to 2008, a study

tried to estimate the efficiency of banks and their determinative factors for eleven middle and east European countries (CEEC) (Pancurova and Lyocsa, 2013); examining the efficiencies of eleven deposit banks, which operand in the stock market of Istanbul by using the Malmquist total factor productivity analysis (Akyüz et al. 2013); an evaluation of productivity of Albanian banks for period of 2006 and 2013 (Erjola and Orfea 2015); evaluation of cost effiiency and determinants for efficiency of the commercial banks in the Romanian banking system for six years between 2005 and 2011. (Mihai and Cristi 2016); an analysis of the technical productivity of the selected countries in the middle and east European countries (Horvatova, 2018); a study that examined the productivity of banking organizations in Turkey, sixteen east European countries and the Balkan countries (Lemonakis et al. 2018).

When the studies, which examined the relations between sectoral development and economic indicators are reviewed, in the period between 1986 and 1999 examination of relations between the development of the banking sector of Greece and stock exchange and economic performance (Hondroyiannis et al. 2005); a study that evaluated the impacts of the macroeconomic factors on the productivity of Bulgarian banks (Nenovsky et al. 2008); a study, which examining the relations between banking sector and economic growth of ten new European Union member countries for the period of 1994 and 2007 (Caporale et al. 2009); a study that reviewing of the macroeconomic determinants, which related to the banking sector with the financial performance of the middle and east European countries' banks bases on the CAMEL ratios (Antoun et al. 2018); a research on the different micro and macro-economic factors, which affects the profitability of the commercial banks in the Romania, Poland, Latvia, Lithuania, Hungary, Czech Republic and Bulgaria (Onofrei et al. 2018).

Also, a study that examined the factors, which affected the profitability of the banks were performed by Căpraru and Ihnatov in 2014. In this study, the main determinants for the profitability of 143 commercial banks from Bulgaria, Czech Republic, Poland, and Hungary were evaluated.

When studies realized for efficiency and performance analysis are reviewed, it can be seen that there are many studies using OCRA method in various fields. If they are summarized, some studies exist, which using the OCRA method such as Ozbek (2015a, 2015b, 2015c); Wang (2006); Parkan, Lam and Hang (1997); Jayanthia, Kochab and Sinha (1999); Somogyi (2011); Stanujkic et al. (2017).

3. MATERIALS AND METHODS

3.1. Materials

In this study, forty-four deposit banks from ten Balkan countries that seen in Table-2 were selected in order to analyze the financial performance of the banking sector of the Balkan countries. The most important criterion for this selection is to be a publicly-traded company in the global stock market. In addition to that, three input factors and five output factors have been determined to make efficiency analysis. Afterward, data related to these factors were collected from the databases that hosted annual financial statistics, which published by the official international institutions. Financial data about Balkans national deposit banks are related to a three-year period from 2018 to 2016.

BOSNIA AND HERZEGOVINA		**MONTENEGRO**	
KIBB.SJ	KIB Banka dd Velika Kladusa	FFBN.MOT	Universal Capital Bank ad Podgorica
NBLB.BJ	UniCredit Bank ad Banja Luka	HIBP.MOT	Hipotekarna Banka ad Podgorica
NOVB.BJ	Nova Banka ad Banja Luka	NKBA.MOT	Prva Banka Crne Gore ad Podgorica
PBSB.SJ	Privredna Banka Sarajevo dd Sarajevo	OBPG.MOT	Erste Bank ad Podgorica
UPIB.SJ	Intesa Sanpaolo Banka dd Bosnia Hercegovina	**ROMANIA**	
VBBB.BJ	NLB Banka ad Banja Luka	ROBRD.BX	BRD Groupe Societe Generale SA
ZGBMP.SJ	Unicredit Bank dd Mostar	ROPBK.BX	Patria Bank SA

ZPKB.BJ	Sberbank ad Banja Luka	ROTLV.BX	Banca Transilvania SA
BULGARIA		**SERBIA**	
5BN.BB	Bulgarian American Credit Bank AD	KMBN.BEL	Komercijalna Banka ad Beograd
5CP.BB	Texim Bank AD	JBMN.BEL	Jubmes Banka ad Beograd
CROATIA		**SLOVENIA**	
HPBZ.ZA	HPB dd	NLBR.LJ	NLB dd
IKBA.ZA	Istarska Kreditna Banka Umag dd	**TURKEY**	
KABA.ZA	Karlovacka Banka dd	AKBNK.IS	Akbank TAS
KBZA.ZA	Agram Banka dd	DENIZ.IS	Denizbank AS
PBZ.ZA	Privredna Banka Zagreb dd	GARAN.IS	Turkiye Garanti Bankasi AS
SNBA.ZA	Slatinska Banka dd	HALKB.IS	Turkiye Halk Bankasi AS
GREECE		ICBCT.IS	ICBC Turkey Bank AS
ACBr.AT	Alpha Bank SA	ISCTR.IS	Turkiye Is Bankasi AS
BOAr.AT	Attica Bank SA	QNBFB.IS	QNB Finansbank AS
BOPr.AT	Piraeus Bank SA	SKBNK.IS	Sekerbank TAS
EURBr.AT	Eurobank Ergasias SA	VAKBN.IS	Turkiye Vakiflar Bankasi TAO
NBGr.AT	National Bank of Greece SA	YKBNK.IS	Yapi ve Kredi Bankasi AS
MACEDONIA			
OHB.MKE	Ohridska Banka AD Skopje		
STB.MKE	Stopanska Banka AD Skopje		
TNB.MKE	NLB Banka AD Skopje		

Table 2. Balkan Countries and Selected Deposit Banks

Because banks of Albania and Kosovo are not operated in the own stock market, these countries were excluded the scope of this study. Due to scarce of data and information, some banks are not included the scope of this study, which are excluded also investment and development banks. These banks are those: Sparkasse Bank DD Sarajevo, Bobar Banka AD Bijeljina u stecaju, MF Banka AD Banja Luka, ASA Banka dd Sarajevo, Addiko Bank AD Banja Luka, Union Banka DD Sarajevo, Vakufska Banka DD Sarajevo, Stopanska Banka AD Bitola, CB Central Cooperative Bank, Centralna Kooperativna Banka AD Skopje, Kapital Banka AD Skopje, Silk Road Bank AD Skopje, Makedonska banka AD Skopje, ProCredit Bank AD Skopje, Postenska Banka AD Skopje, Jugobanka AD Podgorica, Ekos Banka AD Podgorica u stecaju, Zapad Banka AD Podgorica, Societe Generale Banka Montenegro AD Podgorica and Devin Banka AS.

Some variables for input factors are selected and some ratios are also determined as output factors. This factors can be seen in Table-3. Especially I3 Efficiency ratio is computed differently than other input and output factors and data about other factors are constant, but numerical values of the efficiency ratio should be calculated by using Eq a.

$$Efficiency\ Ratio = \frac{non - interest\ Expense}{Revenue} x100 \qquad (a)$$

Input Factors(I)		Output Factors (O)	
I1	Total Equity / Total Assets	O1	Net Loans / Total Assets
I2	Total Deposits / Total Assets	O2	Net Income / Total Assets
I3	Efficiency Ratio	O3	Net Income / Total Equity
		O4	Non-interest Income / Operating Income
		O5	Net Interest Margin

Table 3. Input and Output Factors

3.2. Methods

Evaluation of financial performance for the banking sector is very important in a highly competitive business environment. Therefore, making accurate and proper efficiency analysis for these kinds of sectors is critical and it requires a systematic and structural approach. Generally, some measurements related accounting can be used for performance analysis, but they are not sufficient for the banking and finance sectors. Performance and productivity of these sectors are affected by various and many factors and variables, so performance analysis cannot make with ordinary approaches. It shows that making a realistic and proper performance analysis can be possible by using only proper multi-criteria decision-making methods. Therefore, an integrated MCDM approach has been proposed and this model consists of entropy and OCRA technique. It is possible to make performance analysis for the banking sector with nine implementation steps of this model as seen in Fig. 1. In this approach, the entropy technique is applied to determine the weights of criteria. Some factors can take negative values, therefore, their entropy values cannot be calculated. As a result of that, Z score for all elements of input and output matrices should be computed. It can be seen that some factors have been taken negative values. Therefore, Z scores for all elements of the matrices have been calculated before applying the steps of the entropy method. Then the deposit banks are ranked by using the operational competitiveness rating (OCRA) technique. The results revealed that the proposed model can give more rational and right results compared to the traditional evaluation methods in financial performance evaluation of deposit banks. Performance scores of twenty deposit banks were calculated and they were ranked applying the proposed approach.

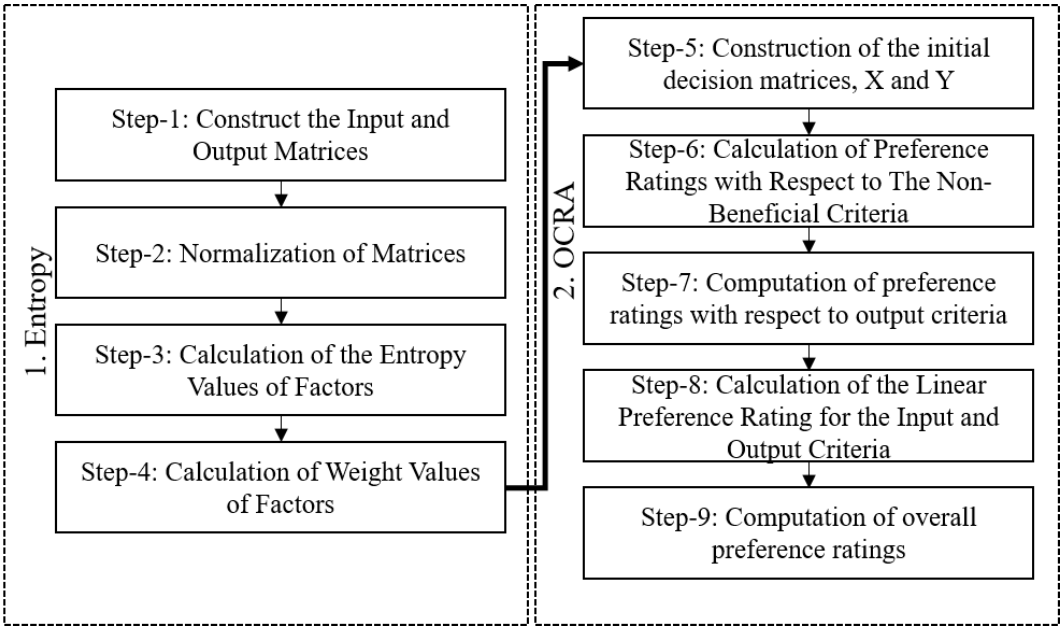


Fig. 1. Implementation Steps of the Model

3.2.1. Calculating the Z-Score

Linear scaling transformation is not applicable to a negative index value (Chen, Cha, and Li 2006; 88). By vector normalization, no variation exhibits between the positive and contrary indexes, making the assessment very difficult (Zhang et al: 2014; 4). As a result, some factors can take negative values, therefore, their entropy values cannot be calculated. As a result of that, z score for all elements of input and output matrices should be computed. It can be seen that some factors have been taken negative values. Therefore, z scores for all elements of the matrices have been calculated before applying the steps of the entropy method. In order to apply Z-score standardization, the following equation is used.

$$x_{ij} = \frac{(x_{ij} - \bar{x_i})}{S_i} \quad (1)$$

Where x_{ij} is the standardized data of the i^{th} index in the j^{th} region and X_{ij} is the original data, while X_{ij} and S_i are the mean value and standard deviation of the i^{th} index. The value of A that accepted as 0.1 is added to x_{ij} value in order to avoid inaccurate calculations as seen in Eq 2.

$$x_{ij}{}' = (x_{ij} + A) \quad (2)$$

After these calculations, final Z-scores of all elements of matrices computed with the help of Eq 3.

$$p_{ij} = \frac{x_{ij}{}'}{\sum_{j=1}^{n} x_{ij}{}'} \quad (2)$$

3.2.2. Entropy Method

The entropy method used to calculate the weight values of input and output factors consists of four implementation steps and it can be reached to the solution with these steps. These steps can be seen below: The entropy technique is a term in information theory, also known as the average amount of information (Ding and Shi, 2005). Entropy method is highly reliable and can be easily adopted in information measurement (Zou et al., 2005). The implementation steps are as follows:

Step-1: Construct the Input and Output Matrices

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1k} & \dots & x_{1K} \\ x_{21} & x_{22} & \dots & x_{2k} & \dots & x_{2K} \\ \vdots & \vdots & \ddots & \vdots & \dots & \vdots \\ x_{i1} & x_{i2} & \dots & x_{ik} & \dots & x_{iK} \\ \vdots & \vdots & \dots & \vdots & \ddots & \vdots \\ x_{l1} & x_{l2} & \dots & x_{lk} & \dots & x_{lK} \end{bmatrix} \quad (3)$$

$\forall i = 1,2 \dots, l;\ \forall k = 1,2 \dots, K$

$$Y = \begin{bmatrix} y_{11} & y_{12} & \dots & y_{1j} & \dots & y_{1J} \\ y_{21} & y_{22} & \dots & y_{2j} & \dots & y_{2J} \\ \vdots & \vdots & \ddots & \vdots & \dots & \vdots \\ y_{i1} & y_{i2} & \dots & y_{ij} & \dots & y_{iJ} \\ \vdots & \vdots & \dots & \vdots & \ddots & \vdots \\ y_{l1} & y_{l2} & \dots & y_{lj} & \dots & y_{lJ} \end{bmatrix} \quad (4)$$

$\forall i = 1,2 \dots, l;\ \forall j = 1,2 \dots, J$

Step-2: Normalization of the Matrices

Normalization operation is realized by using the Eqs 5a and 5b for both matrices.

$$x^*{}_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (5a)$$

$$y^*_{ij} = \frac{y_{ij}}{\sum_{i=1}^{m} y_{ij}} \tag{5b}$$

Afterward, normalized input and output matrices are constructed.

$$X^* = \begin{bmatrix} x^*_{11} & x^*_{12} & \dots & x^*_{1k} & \dots & x^*_{1K} \\ x^*_{21} & x^*_{22} & \dots & x^*_{2k} & \dots & x^*_{2K} \\ \vdots & \vdots & \ddots & \vdots & \dots & \vdots \\ x^*_{i1} & x^*_{i2} & \dots & x^*_{ik} & \dots & x^*_{iK} \\ \vdots & \vdots & \dots & \vdots & \ddots & \vdots \\ x^*_{l1} & x^*_{l2} & \dots & x^*_{lk} & \dots & x^*_{lK} \end{bmatrix} \tag{6}$$

$\forall i = 1,2 \dots, l;\ \forall k = 1,2 \dots, K$

$$Y^* = \begin{bmatrix} y^*_{11} & y^*_{12} & \dots & y^*_{1j} & \dots & y^*_{1J} \\ y^*_{21} & y^*_{22} & \dots & y^*_{2j} & \dots & y^*_{2J} \\ \vdots & \vdots & \ddots & \vdots & \dots & \vdots \\ y^*_{i1} & y^*_{i2} & \dots & y^*_{ij} & \dots & y^*_{iJ} \\ \vdots & \vdots & \dots & \vdots & \ddots & \vdots \\ y^*_{l1} & y^*_{l2} & \dots & y^*_{lj} & \dots & y^*_{lJ} \end{bmatrix} \tag{7}$$

$\forall i = 1,2 \dots, l;\ \forall j = 1,2 \dots, J$

Step-3: Construction of the Entropy Matrices

Each element value of both matrices is multiplied by own logarithmic value and by using Eqs 8a and 8b, entropy value of each element is calculated. Afterward, entropy matrices are constructed.

$$e^*_{ij} = x^*_{ij} \,.\, lnx^*_{ij} \tag{8a}$$

$$e^-_{ij} = y^*_{ij} \,.\, lny^*_{ij} \tag{8b}$$

$$E^* = \begin{bmatrix} e^*_{11} & e^*_{12} & \dots & e^*_{1k} & \dots & e^*_{1K} \\ e^*_{21} & e^*_{22} & \dots & e^*_{2k} & \dots & e^*_{2K} \\ \vdots & \vdots & \ddots & \vdots & \dots & \vdots \\ e^*_{i1} & e^*_{i2} & \dots & e^*_{ik} & \dots & e^*_{iK} \\ \vdots & \vdots & \dots & \vdots & \ddots & \vdots \\ e^*_{l1} & e^*_{l2} & \dots & e^*_{lk} & \dots & e^*_{lK} \end{bmatrix} \tag{9a}$$

$\forall i = 1,2 \dots, l;\ \forall k = 1,2 \dots, K$

$$E^- = \begin{bmatrix} e^-_{11} & e^-_{12} & \dots & e^-_{1k} & \dots & e^-_{1K} \\ e^-_{21} & e^-_{22} & \dots & e^-_{2k} & \dots & e^-_{2K} \\ \vdots & \vdots & \ddots & \vdots & \dots & \vdots \\ e^-_{i1} & e^-_{i2} & \dots & e^-_{ik} & \dots & e^-_{iK} \\ \vdots & \vdots & \dots & \vdots & \ddots & \vdots \\ e^-_{l1} & e^-_{l2} & \dots & e^-_{lk} & \dots & e^-_{lK} \end{bmatrix} \tag{9b}$$

$\forall i = 1,2 \dots, l;\ \forall j = 1,2 \dots, J$

After the computation of the entropy value of each matrix element, the entropy value of each factor can be calculated by using Eq 10a and 10b.

$$E^*_{ij} = \left(\frac{-1}{ln(m)}\right) \sum_{i=1}^{m} \left[x^*_{ij} \,.\, lnx^*_{ij}\right];\ \forall j \tag{10a}$$

$$E^-_{ij} = \left(\frac{-1}{ln(m)}\right) \sum_{i=1}^{m} \left[y^*_{ij} \,.\, lny^*_{ij}\right];\ \forall j \tag{10b}$$

Uncertainty value (dj) for each factor is calculated by using Eq. 11a and Eq.11b.

$$d^*_{ij} = 1 - E^*_{ij};\ \forall j \qquad (11a)$$

$$d^-_{ij} = 1 - E^-_{ij};\ \forall j \qquad (11b)$$

Step-4: Calculation of the Weight Values of the Input&Output Factors

By using Eq. 12a and 12b, weight values of all input and output factors can be calculated.

$$w^*_{ij} = \frac{d^*_{ij}}{\sum_{i=1}^{m} d^*_{ij}};\ \forall j \qquad (12a)$$

$$w^-_{ij} = \frac{d^-_{ij}}{\sum_{i=1}^{m} d^-_{ij}};\ \forall j \qquad (12b)$$

3.2.3. The Operational Competitiveness Rating (OCRA) technique

The Operational Competitiveness Rating (OCRA) technique is a relative efficiency measurement method based on a nonparametric model. performance analysis can be realized for a set of decision options by using OCRA method. although results that obtained by this technique are relative, it can be a very effective tool to measure the efficiency of the decision alternatives and it can help to rank them considering their relative importance scores.

The method uses an intuitive approach for incorporating the decision maker's preferences about the relative importance of the criteria (Parkan and Wu, 1997). OCRA has very important advantages and it may be the most proper technique to evaluate the efficiency of the banking and finance sector of the Balkan countries. The main advantage of the OCRA method is that it can deal with those MCDM situations when the relative weights of the criteria are dependent on the alternatives and different weight distributions are assigned to the criteria for different alternatives, as well as some of the criteria are not applicable to all the alternatives (Chatterjee and Chakraborty, 2012). This method follows five implementation steps (Parkan and Wu, 1997).

Step-5: Construction of the initial decision matrices, X and Y:

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1k} & \dots & x_{1K} \\ x_{21} & x_{22} & \dots & x_{2k} & \dots & x_{2K} \\ \vdots & \vdots & \ddots & \vdots & \dots & \vdots \\ x_{i1} & x_{i2} & \dots & x_{ik} & \dots & x_{iK} \\ \vdots & \vdots & \dots & \vdots & \ddots & \vdots \\ x_{l1} & x_{l2} & \dots & x_{lk} & \dots & x_{lK} \end{bmatrix} \qquad (13)$$

$\forall i = 1,2 \dots, l;\ \forall k = 1,2 \dots, K$

$$Y = \begin{bmatrix} y_{11} & y_{12} & \dots & y_{1j} & \dots & y_{1J} \\ y_{21} & y_{22} & \dots & y_{2j} & \dots & y_{2J} \\ \vdots & \vdots & \ddots & \vdots & \dots & \vdots \\ y_{i1} & y_{i2} & \dots & y_{ij} & \dots & y_{iJ} \\ \vdots & \vdots & \dots & \vdots & \ddots & \vdots \\ y_{l1} & y_{l2} & \dots & y_{lj} & \dots & y_{lJ} \end{bmatrix} \qquad (14)$$

$\forall i = 1,2 \dots, l;\ \forall j = 1,2 \dots, J$

After constructing the matrices, minimum and maximum values are also determined for each column of both matrices in this step.

$$max_{n=1,\dots K}(X^n_m);\ \ min_{n=1,\dots K}(X^n_m)\ \ for\ the\ matrix\ X, which\ construct\ for\ input\ values \qquad (15a)$$

$$max_{n=1,\dots K}(Y^n_m);\ \ min_{n=1,\dots K}(Y^n_m)\ \ for\ the\ matrix\ Y, which\ construct\ for\ input\ values \qquad (15b)$$

Step-6: Calculation of Preference Ratings with Respect to The Non-Beneficial Criteria

In the second step, it focuses on input factors and considers the values of these factors. The minimum values for each input factor are more preferable and taking minimum value for these factors is expected by a decision-maker. In order to calculate the performance score about inputs, the following equation is used.

$$i^k = \sum_{m=1}^{M} a_m \frac{max_{n=1,\dots K}(X_m^n) - (X_m^k)}{min_{n=1,\dots K}(X_m^n)}, \forall n = 1, \dots, K; \;\; X_m^k > 0; \;\; \forall k = 1, \dots, K \qquad (16)$$

Step-7: Computation of preference ratings with respect to output criteria

By considering the values of the output factors the performance value of each output factor is computed. In order to calculate these values, Eqs 17 can be used.

$$o^k = \sum_{m=1}^{M} b_h \frac{(Y_h^n) - min_{n=1,\dots K}(X_m^n)}{min_{n=1,\dots K}(Y_h^n)}, \forall n = 1, \dots, K; \;\; Y_h^n > 0; \;\; \forall k = 1, \dots, K \qquad (17)$$

While non-measured preference scores of input factors are computed by using Eqs 16, with the help of Eqs 17, non-measured preference scores of output factors are calculated.

Step-8: Calculation of the Linear Preference Rating for the Input and Output Criteria

In the third step, the distance of obtained non-preference score of each input factors from likely the best score of each factor is computed. Eqs 18 is used to calculate linear preference rating for the input factors.

$$I^k = i^k - min_{n=1,\dots K} \; i^n, \forall k = 1, \dots, K \qquad (18)$$

I^k represents the aggregate preference rating for alternative k with respect to the input criteria (Ozbek, 2015; 24). Afterward, measured preference scores of output factors are computed using by Eq 19.

$$O^k = o^k - min_{n=1,\dots K} \; o^n, \forall k = 1, \dots, K \qquad (19)$$

O^k represents the measured preference rating of output factors.

Step-9: Computation of overall preference ratings

By using Eqs 20, General preference score of each decision alternative is computed and all options are ranked considering these values.

$$E^k = I^k + O^k - min_{n=1,\dots K} \; (I^n + O^n), \forall k = 1, \dots, K \qquad (20)$$

4. NUMERICAL ANALYSIS FOR BANKING SECTOR OF THE BALKAN COUNTIES

First of all, input and output matrices were constructed considering the obtained statistical data from the database of the international stock markets and obtained original data have been shown in Table-3.

2018		Input Factors			Output Factors				
C	**Banks**	**I1**	**I2**	**I3**	**O1**	**O2**	**O3**	**O4**	**O5**
P_1	KIBB.SJ	0,2695	0,7047	0,7130	0,4926	0,0152	0,0565	1,3800	0,7529
P_2	NBLB.BJ	0,1315	0,8026	0,5630	0,5639	0,0167	0,1273	0,4900	0,8508
P_3	NOVB.BJ	0,0792	0,7788	0,8730	0,6071	0,0055	0,0693	1,0900	0,6880
P_4	PBSB.SJ	0,1127	0,8768	0,7580	0,4734	0,0073	0,0647	1,3800	0,7005
P_5	UPIB.SJ	0,1330	0,8147	0,7960	0,5806	0,0176	0,1320	2,6100	0,8360
P_6	VBBB.BJ	0,1224	0,8034	0,5260	0,5324	0,0229	0,1869	0,7500	0,8508
P_7	ZGBMP.SJ	0,1333	0,8345	0,7470	0,5763	0,0163	0,1223	2,0300	0,8810

P_8	ZPKB.BJ	0,1432	0,7794	0,6840	0,6626	0,0043	0,0301	1,7000	0,8278
P_9	5BN.BB	0,1296	0,8307	0,7310	0,6344	0,0088	0,0676	0,5700	0,8208
P_{10}	5CP.BB	0,1218	0,8711	0,9950	0,4819	0,0006	0,0053	8,0300	0,9287
P_{11}	HPBZ.ZA	0,0873	0,8992	0,7120	0,7601	0,0067	0,0772	1,8500	0,8376
P_{12}	IKBA.ZA	0,0877	0,9088	0,6570	0,5222	0,0068	0,0770	1,2600	0,8694
P_{13}	KABA.ZA	0,0691	0,9184	0,8560	0,5834	0,0058	0,0844	1,2500	0,8139
P_{14}	KBZA.ZA	0,1025	0,8637	0,7760	0,5456	0,0077	0,0748	0,7700	0,7375
P_{15}	PBZ.ZA	0,1431	0,7837	0,5340	0,5954	0,0150	0,1048	0,9500	0,8704
P_{16}	SNBA.ZA	0,1052	0,8802	0,9010	0,5727	0,0030	0,0288	0,9300	0,7724
P_{17}	ACBr.AT	0,1330	0,7010	0,4730	0,6594	0,0009	0,0065	4,2100	0,7708
P_{18}	BOAr.AT	0,1465	0,8078	0,7640	0,4752	-0,0007	-0,0049	1,3300	0,6000
P_{19}	BOPr.AT	0,1194	0,7795	0,6950	0,6438	-0,0026	-0,0214	1,1000	0,7521
P_{20}	EURBr.AT	0,0868	0,8626	0,0247	0,6249	0,0016	0,0181	0,0400	0,6478
P_{21}	NBGr.AT	0,0762	0,7156	0,7990	0,4629	-0,0013	-0,0169	1,7300	0,8182
P_{22}	OHB.MKE	0,1085	0,7541	0,4800	0,7218	0,0146	0,1348	0,7800	0,7648
P_{23}	STB.MKE	0,1428	0,8412	0,3560	0,7032	0,0304	0,2129	0,4700	0,8486
P_{24}	TNB.MKE	0,1356	0,8170	0,4410	0,6290	0,0260	0,1915	0,8300	0,8420
P_{25}	FFBN.MOT	0,0356	0,9183	0,8340	0,3418	0,0039	0,1095	1,6800	0,6624
P_{26}	HIBP.MOT	0,0900	0,8623	0,8460	0,4544	0,0085	0,0945	2,0400	0,7872
P_{27}	NKBA.MOT	0,0874	0,8657	0,9750	0,5274	0,0009	0,0098	1,6200	0,6762
P_{28}	OBPG.MOT	0,1455	0,6592	0,6380	0,6166	0,0197	0,1351	0,7300	0,8977
P_{29}	ROBRD.BX	0,1366	0,8168	0,4780	0,5449	0,0279	0,2045	0,5600	0,9214
P_{30}	ROPBK.BX	0,0920	0,8894	1,0180	0,4468	-0,0012	-0,0126	1,6100	0,7458
P_{31}	ROTLV.BX	0,0974	0,8390	0,5430	0,4855	0,0161	0,1648	0,8000	0,8641
P_{32}	KMBN.BEL	0,1620	0,7917	0,6700	0,4345	0,0190	0,1174	1,2000	0,9242
P_{33}	JBMN.BEL	0,2489	0,7269	0,5550	0,6036	0,0298	0,1198	0,7900	0,8079
P_{34}	NLBR.LJ	0,1268	0,8486	0,6240	0,6807	0,0160	0,1260	1,0700	0,8718
P_{35}	AKBNK.IS	0,1234	0,6285	0,4660	0,6030	0,0176	0,0176	0,3900	0,4391
P_{36}	DENIZ.IS	0,0785	0,7164	0,5440	0,6940	0,0122	0,1550	0,3900	0,3935
P_{37}	GARAN.IS	0,1170	0,6204	0,4070	0,6367	0,0182	0,1553	0,4200	0,5062
P_{38}	HALKB.IS	0,0755	0,7439	0,6040	0,6663	0,0075	0,0990	0,2300	0,2377
P_{39}	ICBCT.IS	0,0732	0,5281	0,6600	0,4828	0,0057	0,0784	0,4500	0,3835
P_{40}	ISCTR.IS	0,0992	0,5220	0,6100	0,6075	0,0075	0,1468	0,4700	0,4444
P_{41}	QNBFB.IS	0,0893	0,5310	0,5220	0,6075	0,0172	0,1924	0,2900	0,4584
P_{42}	SKBNK.IS	0,0732	0,7017	0,7970	0,6536	0,0030	0,0405	0,5600	0,3419
P_{43}	VAKBN.IS	0,0823	0,6140	0,4470	0,6633	0,0144	0,1749	0,2700	0,3269
P_{44}	YKBNK.IS	0,1045	0,5727	0,6020	0,6196	0,0136	0,1306	0,2700	0,4083

Table 4. Original Values of Input and Output Factors for 2018

2017		Input Factors			Output Factors				
C	**Banks**	**I1**	**I2**	**I3**	**O1**	**O2**	**O3**	**O4**	**O5**
P_1	KIBB.SJ	0,2687	0,7036	0,7370	0,4873	0,0143	0,0534	1,3700	0,7135
P_2	NBLB.BJ	0,1359	0,7758	0,4950	0,6050	0,0175	0,1287	0,4400	0,8218
P_3	NOVB.BJ	0,0836	0,7858	0,8800	0,6615	0,0052	0,0625	1,0200	0,6278
P_4	PBSB.SJ	0,1559	0,8312	0,7500	0,5895	0,0010	0,0062	2,1200	0,6766
P_5	UPIB.SJ	0,1435	0,8041	0,8100	0,5764	0,0134	0,0932	2,0600	0,8042
P_6	VBBB.BJ	0,1271	0,7946	0,5490	0,5203	0,0346	0,2719	0,4800	0,8160
P_7	ZGBMP.SJ	0,1464	0,8137	0,5190	0,5696	0,0172	0,1175	0,6200	0,8506
P_8	ZPKB.BJ	0,1527	0,7660	0,6740	0,6694	0,0064	0,0421	1,1600	0,7724
P_9	5BN.BB	0,1438	0,8230	0,7990	0,6177	0,0064	0,0442	0,5900	0,7408
P_{10}	5CP.BB	0,1634	0,8215	0,9240	0,4609	0,0007	0,0043	9,3800	0,7473
P_{11}	HPBZ.ZA	0,0873	0,8713	0,6700	0,4973	0,0004	0,0040	3,6700	0,7941
P_{12}	IKBA.ZA	0,0882	0,9058	0,5990	0,5410	0,0078	0,0880	0,9700	0,8148
P_{13}	KABA.ZA	0,0647	0,8846	0,9200	0,5077	0,0035	0,0542	1,4100	0,7410
P_{14}	KBZA.ZA	0,0995	0,8696	0,8020	0,5267	0,0061	0,0614	0,6500	0,6174
P_{15}	PBZ.ZA	0,1511	0,7707	0,5140	0,6263	0,0123	0,0811	0,9900	0,8491
P_{16}	SNBA.ZA	0,1037	0,8822	0,9820	0,5612	0,0004	0,0041	1,3300	0,6941
P_{17}	ACBr.AT	0,1578	0,7520	0,5600	0,7124	0,0003	0,0022	0,9700	0,7726
P_{18}	BOAr.AT	0,1777	0,8054	0,5830	0,6157	0,0001	0,0006	1,7900	0,6336
P_{19}	BOPr.AT	0,1397	0,7828	0,6410	0,6633	-0,0030	-0,0213	-0,8938	0,7449
P_{20}	EURBr.AT	0,1191	0,8051	0,0241	0,6182	0,0017	0,0146	0,1000	0,6765
P_{21}	NBGr.AT	0,1034	0,6823	0,6560	0,5858	-0,0068	-0,0662	3,1700	0,8607
P_{22}	OHB.MKE	0,0945	0,7598	0,5150	0,7344	0,0100	0,1055	0,8600	0,7773
P_{23}	STB.MKE	0,1579	0,8218	0,4010	0,7024	0,0237	0,1499	0,5600	0,8300
P_{24}	TNB.MKE	0,1257	0,8187	0,4230	0,6431	0,0281	0,2232	0,6800	0,8196
P_{25}	FFBN.MOT	0,0415	0,9069	0,8350	0,2707	0,0016	0,0379	1,8600	0,7302
P_{26}	HIBP.MOT	0,0906	0,7982	0,8410	0,4356	0,0080	0,0879	1,6000	0,7328
P_{27}	NKBA.MOT	0,0773	0,8734	0,9860	0,4651	0,0006	0,0074	1,6400	0,6931
P_{28}	OBPG.MOT	0,1368	0,7334	0,6150	0,6115	0,0161	0,1177	0,6900	0,8521
P_{29}	ROBRD.BX	0,1332	0,8212	0,5460	0,5523	0,0261	0,1962	0,6400	0,9242
P_{30}	ROPBK.BX	0,0635	0,9196	1,2740	0,3635	-0,0119	-0,1875	-5,1000	0,7620
P_{31}	ROTLV.BX	0,1191	0,8203	0,5110	0,5058	0,0212	0,1776	0,8200	0,8993
P_{32}	KMBN.BEL	0,1677	0,7837	0,8040	0,4365	0,0202	0,1202	2,6100	0,8801
P_{33}	JBMN.BEL	0,2977	0,6609	1,0640	0,5802	0,0052	0,0176	0,8500	0,8000
P_{37}	NLBR.LJ	0,1380	0,8354	0,6620	0,7130	0,0183	0,1326	0,9300	0,8504
P_{38}	AKBNK.IS	0,1189	0,5912	0,4010	0,6140	0,0195	0,0195	0,2700	0,4630
P_{39}	DENIZ.IS	0,0801	0,6947	0,5170	0,7043	0,0131	0,1638	0,3200	0,4898
P_{40}	GARAN.IS	0,1159	0,6108	0,5090	0,6524	0,0197	0,1698	0,4200	0,5531
P_{41}	HALKB.IS	0,0811	0,7160	0,5000	0,6708	0,0143	0,1766	0,2400	0,3531

P_{42}	ICBCT.IS	0,0835	0,2991	0,6380	0,5768	0,0040	0,0482	0,2600	0,4934
P_{43}	ISCTR.IS	0,0978	0,4898	0,6120	0,6310	0,0143	0,1428	0,5000	0,4768
P_{44}	QNBFB.IS	0,0947	0,5148	0,5710	0,6623	0,0150	0,1579	0,3000	0,5099
P_{45}	SKBNK.IS	0,0830	0,6814	0,6910	0,6450	0,0038	0,0458	0,3700	0,4425
P_{46}	VAKBN.IS	0,0817	0,6107	0,4490	0,6787	0,0155	0,1898	0,2900	0,4070
P_{47}	YKBNK.IS	0,0941	0,5624	0,4940	0,6550	0,0125	0,1329	0,2900	0,4235

Table 5. Original Values of Input and Output Factors for 2017

2016		Input Factors			Output Factors				
C	**Banks**	**I1**	**I2**	**I3**	**O1**	**O2**	**O3**	**O4**	**O5**
P_1	KIBB.SJ	0,2740	0,6974	0,7540	0,3807	0,0155	0,0564	1,5500	0,6821
P_2	NBLB.BJ	0,1333	0,8482	0,5030	0,6105	0,0185	0,1388	0,4200	0,8279
P_3	NOVB.BJ	0,0869	0,8720	0,8690	0,7516	0,0077	0,0886	1,2800	0,5795
P_4	PBSB.SJ	0,1618	0,8202	1,0030	0,5817	0,0067	0,0415	0,4700	0,6861
P_5	UPIB.SJ	0,1459	0,8402	0,5760	0,6691	0,0153	0,1049	0,5700	0,7875
P_6	VBBB.BJ	0,1196	0,7824	0,5370	0,5150	0,0365	0,3053	0,6100	0,8173
P_7	ZGBMP.SJ	0,1469	0,7757	0,5180	0,5740	0,0157	0,1071	0,6400	0,8172
P_8	ZPKB.BJ	0,1487	0,7606	0,6780	0,7207	0,0050	0,0336	0,8700	0,6942
P_9	5BN.BB	0,1586	0,7969	0,8460	0,6319	0,0056	0,0351	0,7700	0,6997
P_{10}	5CP.BB	0,1786	0,8126	0,9180	0,4318	0,0039	0,0220	6,3400	0,6784
P_{11}	HPBZ.ZA	0,0953	0,8563	0,6790	0,5533	0,0090	0,0949	1,6100	0,7084
P_{12}	IKBA.ZA	0,0882	0,8738	0,6130	0,4647	0,0078	0,0880	0,8100	0,7466
P_{13}	KABA.ZA	0,0606	0,8759	0,6340	0,4989	0,0036	0,0599	1,1700	0,6738
P_{14}	KBZA.ZA	0,0995	0,6836	0,8590	0,4771	0,0040	0,0397	0,6100	0,4327
P_{15}	PBZ.ZA	0,1511	0,7710	0,4800	0,6306	0,0129	0,0853	0,8200	0,8498
P_{16}	SNBA.ZA	0,1037	0,7893	0,7860	0,4832	0,0004	0,0041	0,6500	0,6443
P_{17}	ACBr.AT	0,1578	0,7511	0,5580	0,7123	0,0007	0,0044	0,9500	0,7210
P_{18}	BOAr.AT	0,1755	0,8094	1,0210	0,7703	-0,0138	-0,0786	1,6200	0,6059
P_{19}	BOPr.AT	0,1186	0,7791	0,6280	0,6099	-0,0025	-0,0207	0,9400	0,7433
P_{20}	EURBr.AT	0,1017	0,8394	0,0225	0,5879	0,0035	0,0348	0,1000	0,6434
P_{21}	NBGr.AT	0,0880	0,6865	0,6610	0,5303	-0,0056	-0,0641	1,4300	0,8583
P_{22}	OHB.MKE	0,0844	0,7464	0,5110	0,6861	0,0121	0,1435	0,6300	0,7485
P_{23}	STB.MKE	0,1587	0,8129	0,4240	0,6808	0,0259	0,1634	0,4600	0,8035
P_{24}	TNB.MKE	0,1151	0,8183	0,5310	0,6433	0,0220	0,1911	0,6800	0,7694
P_{25}	FFBN.MOT	0,0775	0,8451	0,8490	0,5361	0,0028	0,0356	1,9300	0,6727
P_{26}	HIBP.MOT	0,0905	0,7782	0,8380	0,5037	0,0084	0,0933	1,3200	0,7000
P_{27}	NKBA.MOT	0,0877	0,8439	0,8770	0,5049	0,0007	0,0076	1,3300	0,6411
P_{28}	OBPG.MOT	0,1313	0,7304	0,6060	0,5591	0,0178	0,1356	0,5700	0,8283
P_{29}	ROBRD.BX	0,1320	0,8248	0,5000	0,5508	0,0144	0,1090	1,0600	0,8776
P_{30}	ROPBK.BX	0,0599	0,8984	0,8970	0,3655	-0,0119	-0,1981	-7,0900	0,7724

P_{31}	ROTLV.BX	0,1181	0,8072	0,4340	0,5243	0,0247	0,2095	1,2400	0,8701
P_{32}	KMBN.BEL	0,1383	0,7893	0,7740	0,3889	-0,0146	-0,1054	-4,7200	0,8060
P_{33}	JBMN.BEL	0,3668	0,5910	0,8670	0,5000	0,0069	0,0187	2,1600	0,7953
P_{37}	NLBR.LJ	0,1352	0,8394	0,7110	0,6133	0,0090	0,0665	1,2900	0,8167
P_{38}	AKBNK.IS	0,1103	0,5951	0,3830	0,6089	0,0183	0,0183	0,3100	0,4478
P_{39}	DENIZ.IS	0,0781	0,6802	0,5220	0,6919	0,0115	0,1470	0,3700	0,5058
P_{40}	GARAN.IS	0,1138	0,5834	0,4830	0,6568	0,0182	0,1597	0,4100	0,5419
P_{41}	HALKB.IS	0,0890	0,6621	0,5020	0,6847	0,0118	0,1331	0,2800	0,4232
P_{42}	ICBCT.IS	0,0730	0,3977	0,7720	0,6136	0,0025	0,0342	0,3200	0,4845
P_{43}	ISCTR.IS	0,0983	0,4979	0,5940	0,6208	0,0118	0,1515	0,5500	0,4957
P_{44}	QNBFB.IS	0,0987	0,5163	0,5770	0,6259	0,0132	0,1334	0,3800	0,5176
P_{45}	SKBNK.IS	0,1021	0,6420	0,6330	0,7243	0,0055	0,0534	0,4500	0,4366
P_{46}	VAKBN.IS	0,0865	0,5847	0,4820	0,6911	0,0140	0,1625	0,3100	0,4266
P_{47}	YKBNK.IS	0,0963	0,5902	0,4780	0,6800	0,0120	0,1248	0,3100	0,4302

Table 6. Original Values of Input and Output Factors for 2016

After the computation of Z-score standardization, new matrices that consist of obtained values constructed. These matrices consisted of the new values of elements of both matrices were used as decision matrices when applying the entropy method.

Step-1: Construct the Input and Output Matrices

2018		Input Factors			Output Factors				
C	**Banks**	**I1**	**I2**	**I3**	**O1**	**O2**	**O3**	**O4**	**O5**
P_1	KIBB.SJ	7,166	2,801	3,759	2,451	3,916	2,871	3,566	3,670
P_2	NBLB.BJ	3,836	3,706	2,962	3,264	4,092	3,967	2,871	4,190
P_3	NOVB.BJ	2,573	3,486	4,610	3,756	2,793	3,070	3,340	3,326
P_4	PBSB.SJ	3,381	4,392	3,998	2,234	3,002	2,999	3,566	3,393
P_5	UPIB.SJ	3,872	3,818	4,200	3,454	4,187	4,041	4,526	4,111
P_6	VBBB.BJ	3,615	3,714	2,765	2,905	4,800	4,890	3,074	4,189
P_7	ZGBMP.SJ	3,880	4,002	3,940	3,405	4,043	3,891	4,073	4,349
P_8	ZPKB.BJ	4,118	3,492	3,605	4,388	2,658	2,463	3,816	4,068
P_9	5BN.BB	3,790	3,966	3,855	4,067	3,171	3,044	2,934	4,030
P_{10}	5CP.BB	3,600	4,340	5,258	2,329	2,234	2,079	8,756	4,603
P_{11}	HPBZ.ZA	2,767	4,600	3,754	5,499	2,937	3,192	3,933	4,119
P_{12}	IKBA.ZA	2,777	4,688	3,461	2,789	2,939	3,190	3,472	4,288
P_{13}	KABA.ZA	2,329	4,777	4,519	3,486	2,833	3,303	3,465	3,994
P_{14}	KBZA.ZA	3,136	4,271	4,094	3,055	3,045	3,156	3,090	3,589
P_{15}	PBZ.ZA	4,116	3,532	2,808	3,622	3,891	3,620	3,230	4,293
P_{16}	SNBA.ZA	3,199	4,423	4,759	3,364	2,509	2,443	3,215	3,774
P_{17}	ACBr.AT	3,871	2,767	2,483	4,352	2,260	2,098	5,775	3,765

P_{18}	BOAr.AT	4,198	3,754	4,030	2,253	2,077	1,921	3,527	2,859
P_{19}	BOPr.AT	3,543	3,493	3,663	4,174	1,865	1,666	3,348	3,666
P_{20}	EURBr.AT	2,755	4,261	0,100	3,958	2,341	2,277	2,520	3,113
P_{21}	NBGr.AT	2,501	2,902	4,216	2,114	2,010	1,735	3,839	4,017
P_{22}	OHB.MKE	3,279	3,258	2,520	5,062	3,847	4,083	3,098	3,733
P_{23}	STB.MKE	4,107	4,063	1,861	4,850	5,669	5,293	2,856	4,178
P_{24}	TNB.MKE	3,935	3,839	2,313	4,005	5,158	4,961	3,137	4,143
P_{25}	FFBN.MOT	1,520	4,776	4,402	0,734	2,609	3,692	3,800	3,191
P_{26}	HIBP.MOT	2,833	4,258	4,466	2,017	3,141	3,460	4,081	3,852
P_{27}	NKBA.MOT	2,769	4,290	5,152	2,848	2,259	2,149	3,753	3,264
P_{28}	OBPG.MOT	4,173	2,381	3,360	3,864	4,429	4,089	3,059	4,438
P_{29}	ROBRD.BX	3,958	3,838	2,510	3,048	5,384	5,163	2,926	4,564
P_{30}	ROPBK.BX	2,881	4,509	5,381	1,930	2,026	1,802	3,746	3,633
P_{31}	ROTLV.BX	3,012	4,043	2,855	2,370	4,013	4,548	3,113	4,260
P_{32}	KMBN.BEL	4,570	3,606	3,531	1,790	4,354	3,814	3,426	4,578
P_{33}	JBMN.BEL	6,668	3,007	2,919	3,716	5,600	3,851	3,106	3,962
P_{34}	NLBR.LJ	3,723	4,132	3,286	4,594	4,004	3,947	3,324	4,301
P_{35}	AKBNK.IS	3,641	2,096	2,446	3,710	4,188	2,269	2,793	2,006
P_{36}	DENIZ.IS	2,555	2,909	2,861	4,746	3,564	4,397	2,793	1,764
P_{37}	GARAN.IS	3,484	2,022	2,132	4,093	4,256	4,401	2,817	2,362
P_{38}	HALKB.IS	2,482	3,164	3,180	4,431	3,022	3,529	2,669	0,938
P_{39}	ICBCT.IS	2,429	1,168	3,477	2,340	2,822	3,210	2,840	1,711
P_{40}	ISCTR.IS	3,055	1,112	3,212	3,761	3,022	4,270	2,856	2,034
P_{41}	QNBFB.IS	2,816	1,195	2,744	3,761	4,142	4,975	2,715	2,109
P_{42}	SKBNK.IS	2,427	2,774	4,206	4,285	2,501	2,624	2,926	1,491
P_{43}	VAKBN.IS	2,647	1,962	2,345	4,397	3,821	4,704	2,700	1,411
P_{44}	YKBNK.IS	3,182	1,580	3,169	3,898	3,735	4,019	2,700	1,843

Table 7. Standardized Values of Input and Output Factors for 2018

2017		Input Factors			Output Factors				
C	**Banks**	**I1**	**I2**	**I3**	**O1**	**O2**	**O3**	**O4**	**O5**
P_1	KIBB.SJ	6,869	3,373	4,167	2,792	4,252	3,489	3,989	3,866
P_2	NBLB.BJ	4,078	3,957	3,032	4,008	4,579	4,387	3,462	4,589
P_3	NOVB.BJ	2,979	4,038	4,837	4,591	3,303	3,598	3,790	3,294
P_4	PBSB.SJ	4,498	4,406	4,228	3,848	2,860	2,926	4,413	3,620
P_5	UPIB.SJ	4,239	4,187	4,509	3,712	4,152	3,964	4,379	4,471
P_6	VBBB.BJ	3,894	4,110	3,285	3,133	6,357	6,096	3,485	4,550
P_7	ZGBMP.SJ	4,300	4,264	3,145	3,642	4,550	4,253	3,564	4,780
P_8	ZPKB.BJ	4,432	3,879	3,871	4,672	3,429	3,355	3,870	4,259
P_9	5BN.BB	4,244	4,339	4,457	4,139	3,421	3,379	3,547	4,048
P_{10}	5CP.BB	4,657	4,327	5,043	2,520	2,833	2,904	8,521	4,091
P_{11}	HPBZ.ZA	3,058	4,730	3,853	2,896	2,796	2,900	5,290	4,403
P_{12}	IKBA.ZA	3,077	5,010	3,520	3,347	3,567	3,902	3,762	4,542
P_{13}	KABA.ZA	2,582	4,838	5,025	3,002	3,124	3,499	4,011	4,049
P_{14}	KBZA.ZA	3,313	4,717	4,471	3,199	3,395	3,584	3,581	3,225
P_{15}	PBZ.ZA	4,399	3,916	3,121	4,227	4,034	3,819	3,774	4,770
P_{16}	SNBA.ZA	3,403	4,819	5,315	3,555	2,803	2,901	3,966	3,736
P_{17}	ACBr.AT	4,540	3,765	3,337	5,117	2,796	2,878	3,762	4,260
P_{18}	BOAr.AT	4,957	4,197	3,445	4,118	2,771	2,860	4,226	3,333
P_{19}	BOPr.AT	4,158	4,014	3,717	4,610	2,449	2,598	2,707	4,075
P_{20}	EURBr.AT	3,725	4,195	0,825	4,144	2,940	3,026	3,270	3,619
P_{21}	NBGr.AT	3,395	3,201	3,787	3,809	2,048	2,063	5,007	4,848
P_{22}	OHB.MKE	3,209	3,828	3,126	5,344	3,797	4,111	3,700	4,291
P_{23}	STB.MKE	4,540	4,330	2,592	5,014	5,223	4,641	3,530	4,643
P_{24}	TNB.MKE	3,864	4,304	2,695	4,401	5,679	5,515	3,598	4,574
P_{25}	FFBN.MOT	2,096	5,018	4,626	0,555	2,923	3,304	4,266	3,977
P_{26}	HIBP.MOT	3,127	4,139	4,654	2,258	3,589	3,901	4,119	3,994
P_{27}	NKBA.MOT	2,847	4,748	5,334	2,563	2,819	2,940	4,141	3,730
P_{28}	OBPG.MOT	4,097	3,614	3,595	4,075	4,435	4,257	3,604	4,791
P_{29}	ROBRD.BX	4,022	4,325	3,271	3,463	5,480	5,193	3,575	5,272
P_{30}	ROPBK.BX	2,558	5,121	6,684	1,514	1,519	0,615	0,327	4,189
P_{31}	ROTLV.BX	3,726	4,318	3,107	2,983	4,961	4,971	3,677	5,105
P_{32}	KMBN.BEL	4,747	4,021	4,481	2,268	4,858	4,287	4,690	4,978
P_{33}	JBMN.BEL	7,478	3,028	5,700	3,752	3,306	3,062	3,694	4,443
P_{37}	NLBR.LJ	3,721	2,464	2,592	4,100	4,790	3,085	3,366	2,194
P_{38}	AKBNK.IS	4,123	4,440	3,815	5,123	4,665	4,435	3,740	4,779
P_{39}	DENIZ.IS	2,905	3,301	3,135	5,033	4,125	4,807	3,394	2,373
P_{40}	GARAN.IS	3,657	2,623	3,098	4,497	4,807	4,878	3,451	2,796
P_{41}	HALKB.IS	2,927	3,474	3,056	4,687	4,250	4,959	3,349	1,461

P_{42}	ICBCT.IS	2,978	0,100	3,703	3,717	3,179	3,427	3,360	2,397
P_{43}	ISCTR.IS	3,279	1,643	3,581	4,277	4,250	4,556	3,496	2,286
P_{44}	QNBFB.IS	3,213	1,846	3,389	4,600	4,316	4,736	3,383	2,507
P_{45}	SKBNK.IS	2,967	3,194	3,951	4,421	3,155	3,398	3,423	2,057
P_{46}	VAKBN.IS	2,940	2,622	2,817	4,769	4,373	5,116	3,377	1,820
P_{47}	YKBNK.IS	3,199	2,231	3,028	4,524	4,061	4,438	3,377	1,931

Table 8. Standardized Values of Input and Output Factors for 2017

2016		Input Factors			Output Factors				
C	**Banks**	**I1**	**I2**	**I3**	**O1**	**O2**	**O3**	**O4**	**O5**
P_1	KIBB.SJ	7,377	4,146	5,132	2,489	5,232	4,386	5,081	4,613
P_2	NBLB.BJ	4,746	5,462	3,821	4,797	5,537	5,325	4,429	5,657
P_3	NOVB.BJ	3,879	5,670	5,733	6,214	4,453	4,753	4,925	3,879
P_4	PBSB.SJ	5,279	5,217	6,433	4,508	4,353	4,216	4,458	4,642
P_5	UPIB.SJ	4,982	5,392	4,203	5,386	5,216	4,939	4,516	5,368
P_6	VBBB.BJ	4,490	4,888	3,999	3,838	7,345	7,223	4,539	5,581
P_7	ZGBMP.SJ	5,001	4,829	3,900	4,431	5,260	4,964	4,556	5,581
P_8	ZPKB.BJ	5,034	4,697	4,736	5,905	4,182	4,126	4,689	4,700
P_9	5BN.BB	5,220	5,014	5,613	5,013	4,239	4,144	4,631	4,740
P_{10}	5CP.BB	5,594	5,151	5,989	3,002	4,074	3,994	7,842	4,587
P_{11}	HPBZ.ZA	4,036	5,533	4,741	4,222	4,588	4,825	5,115	4,802
P_{12}	IKBA.ZA	3,904	5,686	4,396	3,333	4,459	4,746	4,654	5,075
P_{13}	KABA.ZA	3,388	5,704	4,506	3,677	4,045	4,426	4,862	4,554
P_{14}	KBZA.ZA	4,114	4,025	5,681	3,457	4,077	4,196	4,539	2,829
P_{15}	PBZ.ZA	5,079	4,788	3,701	5,000	4,973	4,715	4,660	5,814
P_{16}	SNBA.ZA	4,194	4,947	5,300	3,519	3,722	3,789	4,562	4,343
P_{17}	ACBr.AT	5,205	4,614	4,109	5,820	3,749	3,793	4,735	4,892
P_{18}	BOAr.AT	5,535	5,123	6,527	6,402	2,296	2,847	5,121	4,068
P_{19}	BOPr.AT	4,471	4,858	4,474	4,791	3,433	3,507	4,729	5,051
P_{20}	EURBr.AT	4,155	5,385	1,312	4,571	4,035	4,140	4,245	4,336
P_{21}	NBGr.AT	3,899	4,050	4,647	3,992	3,114	3,012	5,011	5,875
P_{22}	OHB.MKE	3,832	4,573	3,863	5,556	4,896	5,379	4,550	5,089
P_{23}	STB.MKE	5,222	5,154	3,409	5,504	6,284	5,606	4,452	5,482
P_{24}	TNB.MKE	4,406	5,201	3,968	5,127	5,888	5,922	4,579	5,239
P_{25}	FFBN.MOT	3,702	5,435	5,629	4,051	3,956	4,148	5,300	4,546
P_{26}	HIBP.MOT	3,946	4,851	5,571	3,725	4,527	4,807	4,948	4,742
P_{27}	NKBA.MOT	3,895	5,425	5,775	3,737	3,747	3,829	4,954	4,320
P_{28}	OBPG.MOT	4,709	4,433	4,359	4,281	5,467	5,289	4,516	5,660
P_{29}	ROBRD.BX	4,722	5,258	3,806	4,198	5,124	4,985	4,798	6,013
P_{30}	ROPBK.BX	3,375	5,900	5,879	2,337	2,488	1,484	0,100	5,260

P_{31}	ROTLV.BX	4,463	5,104	3,461	3,932	6,164	6,131	4,902	5,959
P_{32}	KMBN.BEL	4,839	4,947	5,237	2,572	2,216	2,541	1,466	5,501
P_{33}	JBMN.BEL	9,112	3,216	5,723	3,688	4,369	3,956	5,432	5,424
P_{37}	NLBR.LJ	4,781	5,385	4,908	4,825	4,582	4,501	4,931	5,577
P_{38}	AKBNK.IS	4,317	3,252	3,195	4,781	5,519	3,952	4,366	2,936
P_{39}	DENIZ.IS	3,714	3,995	3,921	5,615	4,832	5,419	4,400	3,352
P_{40}	GARAN.IS	4,382	3,150	3,717	5,262	5,505	5,564	4,423	3,610
P_{41}	HALKB.IS	3,918	3,837	3,816	5,543	4,869	5,260	4,349	2,761
P_{42}	ICBCT.IS	3,620	1,529	5,226	4,828	3,931	4,133	4,372	3,200
P_{43}	ISCTR.IS	4,092	2,403	4,297	4,901	4,869	5,471	4,504	3,279
P_{44}	QNBFB.IS	4,100	2,564	4,208	4,952	5,002	5,264	4,406	3,436
P_{45}	SKBNK.IS	4,164	3,662	4,500	5,940	4,228	4,352	4,447	2,857
P_{46}	VAKBN.IS	3,871	3,162	3,712	5,607	5,090	5,596	4,366	2,785
P_{47}	YKBNK.IS	4,055	3,209	3,691	5,495	4,887	5,166	4,366	2,810

Table 9. Standardized Values of Input and Output Factors for 2016

Step-2: Normalization of the Matrices

By using Eqs 5a and 5b, elements of both matrices were normalized. Afterward, normalized matrices were constructed.

		2018								2017								2016							
		I1	**I2**	**I3**	**O1**	**O2**	**O3**	**O4**	**O5**	**I1**	**I2**	**I3**	**O1**	**O2**	**O3**	**O4**	**O5**	**I1**	**I2**	**I3**	**O1**	**O2**	**O3**	**O4**	**O5**
P1	KIBB.SJ	-0,1445	-0,0739	-0,0919	-0,0668	-0,0946	-0,0753	-0,0884	-0,0903	-0,1312	-0,0788	-0,0921	-0,0684	-0,0934	-0,0808	-0,0892	-0,0872	-0,1214	-0,0801	-0,0937	-0,0544	-0,0950	-0,0835	-0,0930	-0,0867
P2	NBLB.BJ	-0,0932	-0,0909	-0,0770	-0,0828	-0,0977	-0,0955	-0,0753	-0,0994	-0,0907	-0,0887	-0,0728	-0,0895	-0,0986	-0,0956	-0,0804	-0,0988	-0,0885	-0,0980	-0,0754	-0,0892	-0,0990	-0,0963	-0,0841	-0,1005
P3	NOVB.BJ	-0,0693	-0,0869	-0,1064	-0,0918	-0,0737	-0,0791	-0,0842	-0,0840	-0,0718	-0,0900	-0,1026	-0,0988	-0,0776	-0,0827	-0,0859	-0,0774	-0,0762	-0,1007	-0,1015	-0,1075	-0,0845	-0,0886	-0,0909	-0,0762
P4	PBSB.SJ	-0,0850	-0,1028	-0,0961	-0,0623	-0,0778	-0,0778	-0,0884	-0,0852	-0,0973	-0,0959	-0,0931	-0,0869	-0,0697	-0,0709	-0,0960	-0,0830	-0,0957	-0,0948	-0,1102	-0,0852	-0,0831	-0,0811	-0,0845	-0,0871
P5	UPIB.SJ	-0,0939	-0,0929	-0,0996	-0,0863	-0,0993	-0,0968	-0,1050	-0,0980	-0,0932	-0,0924	-0,0975	-0,0846	-0,0918	-0,0888	-0,0955	-0,0969	-0,0917	-0,0971	-0,0809	-0,0970	-0,0948	-0,0911	-0,0853	-0,0968
P6	VBBB.BJ	-0,0893	-0,0911	-0,0732	-0,0759	-0,1095	-0,1110	-0,0792	-0,0994	-0,0876	-0,0912	-0,0773	-0,0746	-0,1244	-0,1208	-0,0807	-0,0981	-0,0850	-0,0904	-0,0780	-0,0756	-0,1210	-0,1196	-0,0857	-0,0996
P7	ZGBMP.SJ	-0,0940	-0,0961	-0,0951	-0,0854	-0,0968	-0,0942	-0,0974	-0,1021	-0,0942	-0,0936	-0,0748	-0,0834	-0,0981	-0,0935	-0,0821	-0,1017	-0,0920	-0,0896	-0,0765	-0,0841	-0,0954	-0,0915	-0,0859	-0,0996
P8	ZPKB.BJ	-0,0982	-0,0870	-0,0891	-0,1027	-0,0710	-0,0671	-0,0929	-0,0973	-0,0963	-0,0874	-0,0873	-0,1001	-0,0798	-0,0785	-0,0872	-0,0936	-0,0924	-0,0878	-0,0884	-0,1037	-0,0806	-0,0798	-0,0877	-0,0879
P9	5BN.BB	-0,0924	-0,0955	-0,0936	-0,0973	-0,0811	-0,0786	-0,0765	-0,0966	-0,0933	-0,0948	-0,0967	-0,0916	-0,0796	-0,0789	-0,0818	-0,0902	-0,0949	-0,0921	-0,1000	-0,0921	-0,0814	-0,0801	-0,0869	-0,0884
P10	5CP.BB	-0,0890	-0,1019	-0,1168	-0,0643	-0,0623	-0,0590	-0,1650	-0,1063	-0,0998	-0,0947	-0,1057	-0,0633	-0,0692	-0,0705	-0,1518	-0,0909	-0,0997	-0,0940	-0,1048	-0,0628	-0,0791	-0,0779	-0,1266	-0,0863
P11	HPBZ.ZA	-0,0732	-0,1063	-0,0918	-0,1205	-0,0766	-0,0815	-0,0949	-0,0982	-0,0732	-0,1009	-0,0869	-0,0703	-0,0685	-0,0704	-0,1093	-0,0959	-0,0785	-0,0990	-0,0884	-0,0812	-0,0863	-0,0896	-0,0935	-0,0893
P12	IKBA.ZA	-0,0734	-0,1077	-0,0865	-0,0737	-0,0766	-0,0814	-0,0867	-0,1011	-0,0736	-0,1052	-0,0813	-0,0784	-0,0822	-0,0878	-0,0854	-0,0980	-0,0766	-0,1009	-0,0837	-0,0680	-0,0845	-0,0885	-0,0872	-0,0930
P13	KABA.ZA	-0,0643	-0,1092	-0,1049	-0,0869	-0,0745	-0,0835	-0,0865	-0,0960	-0,0645	-0,1026	-0,1054	-0,0722	-0,0744	-0,0810	-0,0896	-0,0902	-0,0689	-0,1011	-0,0852	-0,0732	-0,0786	-0,0841	-0,0901	-0,0859
P14	KBZA.ZA	-0,0804	-0,1008	-0,0977	-0,0788	-0,0787	-0,0808	-0,0795	-0,0888	-0,0778	-0,1007	-0,0969	-0,0758	-0,0792	-0,0824	-0,0824	-0,0762	-0,0796	-0,0784	-0,1009	-0,0699	-0,0791	-0,0808	-0,0857	-0,0600
P15	PBZ.ZA	-0,0981	-0,0878	-0,0740	-0,0894	-0,0942	-0,0894	-0,0822	-0,1011	-0,0958	-0,0880	-0,0744	-0,0931	-0,0899	-0,0864	-0,0856	-0,1016	-0,0930	-0,0891	-0,0736	-0,0919	-0,0916	-0,0881	-0,0873	-0,1025
P16	SNBA.ZA	-0,0816	-0,1033	-0,1089	-0,0847	-0,0680	-0,0667	-0,0819	-0,0921	-0,0793	-0,1023	-0,1097	-0,0819	-0,0686	-0,0704	-0,0888	-0,0850	-0,0808	-0,0912	-0,0959	-0,0709	-0,0739	-0,0749	-0,0860	-0,0829
P17	ACBr.AT	-0,0939	-0,0732	-0,0675	-0,1021	-0,0628	-0,0594	-0,1247	-0,0920	-0,0980	-0,0855	-0,0782	-0,1068	-0,0685	-0,0700	-0,0854	-0,0936	-0,0947	-0,0867	-0,0796	-0,1026	-0,0743	-0,0750	-0,0884	-0,0905
P18	BOAr.AT	-0,0995	-0,0918	-0,0966	-0,0627	-0,0589	-0,0555	-0,0877	-0,0751	-0,1044	-0,0926	-0,0801	-0,0913	-0,0680	-0,0696	-0,0930	-0,0781	-0,0990	-0,0936	-0,1114	-0,1099	-0,0511	-0,0603	-0,0936	-0,0790
P19	BOPr.AT	-0,0880	-0,0871	-0,0902	-0,0991	-0,0542	-0,0497	-0,0844	-0,0902	-0,0919	-0,0896	-0,0847	-0,0991	-0,0619	-0,0648	-0,0668	-0,0906	-0,0847	-0,0900	-0,0848	-0,0891	-0,0696	-0,0707	-0,0883	-0,0926
P20	EURBr.AT	-0,0730	-0,1006	-0,0048	-0,0954	-0,0645	-0,0632	-0,0683	-0,0800	-0,0848	-0,0925	-0,0262	-0,0917	-0,0711	-0,0727	-0,0770	-0,0830	-0,0802	-0,0970	-0,0329	-0,0861	-0,0785	-0,0800	-0,0815	-0,0828
P21	NBGr.AT	-0,0679	-0,0759	-0,0998	-0,0597	-0,0575	-0,0513	-0,0933	-0,0964	-0,0792	-0,0758	-0,0859	-0,0862	-0,0540	-0,0543	-0,1051	-0,1027	-0,0765	-0,0787	-0,0871	-0,0779	-0,0646	-0,0630	-0,0921	-0,1033
P22	OHB.MKE	-0,0831	-0,0827	-0,0683	-0,1137	-0,0934	-0,0976	-0,0797	-0,0914	-0,0759	-0,0865	-0,0745	-0,1101	-0,0860	-0,0912	-0,0844	-0,0941	-0,0755	-0,0861	-0,0760	-0,0993	-0,0905	-0,0970	-0,0858	-0,0931
P23	STB.MKE	-0,0980	-0,0972	-0,0541	-0,1104	-0,1231	-0,1174	-0,0750	-0,0992	-0,0980	-0,0947	-0,0646	-0,1052	-0,1084	-0,0996	-0,0815	-0,0996	-0,0949	-0,0940	-0,0692	-0,0986	-0,1084	-0,0999	-0,0844	-0,0983
P24	TNB.MKE	-0,0950	-0,0933	-0,0640	-0,0962	-0,1153	-0,1121	-0,0804	-0,0986	-0,0871	-0,0943	-0,0666	-0,0958	-0,1150	-0,1126	-0,0827	-0,0985	-0,0838	-0,0946	-0,0775	-0,0936	-0,1035	-0,1039	-0,0862	-0,0951
P25	FFBN.MOT	-0,0462	-0,1092	-0,1030	-0,0259	-0,0701	-0,0907	-0,0926	-0,0814	-0,0549	-0,1053	-0,0993	-0,0190	-0,0708	-0,0776	-0,0937	-0,0890	-0,0736	-0,0977	-0,1002	-0,0787	-0,0774	-0,0801	-0,0959	-0,0858
P26	HIBP.MOT	-0,0745	-0,1005	-0,1041	-0,0576	-0,0805	-0,0865	-0,0975	-0,0935	-0,0745	-0,0916	-0,0998	-0,0582	-0,0825	-0,0878	-0,0913	-0,0893	-0,0772	-0,0899	-0,0994	-0,0740	-0,0855	-0,0893	-0,0912	-0,0884
P27	NKBA.MOT	-0,0733	-0,1011	-0,1152	-0,0748	-0,0628	-0,0605	-0,0918	-0,0828	-0,0694	-0,1012	-0,1100	-0,0641	-0,0689	-0,0711	-0,0917	-0,0849	-0,0765	-0,0976	-0,1021	-0,0741	-0,0743	-0,0755	-0,0913	-0,0826
P28	OBPG.MOT	-0,0991	-0,0654	-0,0846	-0,0937	-0,1034	-0,0977	-0,0789	-0,1036	-0,0910	-0,0830	-0,0826	-0,0906	-0,0964	-0,0935	-0,0828	-0,1019	-0,0880	-0,0842	-0,0831	-0,0820	-0,0981	-0,0958	-0,0853	-0,1006

P29	ROBRD.BX	-0,0954	-0,0933	-0,0680	-0,0787	-0,1188	-0,1153	-0,0764	-0,1057	-0,0897	-0,0946	-0,0770	-0,0804	-0,1121	-0,1079	-0,0823	-0,1091	-0,0882	-0,0954	-0,0752	-0,0808	-0,0936	-0,0918	-0,0892	-0,1051
P30	ROPBK.BX	-0,0755	-0,1048	-0,1187	-0,0557	-0,0578	-0,0528	-0,0916	-0,0896	-0,0640	-0,1069	-0,1288	-0,0426	-0,0428	-0,0206	-0,0122	-0,0924	-0,0687	-0,1036	-0,1034	-0,0518	-0,0544	-0,0363	-0,0038	-0,0954
P31	ROTLV.BX	-0,0780	-0,0969	-0,0750	-0,0652	-0,0963	-0,1054	-0,0800	-0,1006	-0,0848	-0,0945	-0,0741	-0,0719	-0,1045	-0,1046	-0,0840	-0,1066	-0,0846	-0,0933	-0,0700	-0,0770	-0,1069	-0,1065	-0,0906	-0,1044
P32	KMBN.BEL	-0,1058	-0,0891	-0,0877	-0,0525	-0,1022	-0,0928	-0,0858	-0,1059	-0,1012	-0,0897	-0,0971	-0,0584	-0,1029	-0,0940	-0,1003	-0,1047	-0,0898	-0,0912	-0,0951	-0,0558	-0,0497	-0,0553	-0,0359	-0,0985
P33	JBMN.BEL	-0,1377	-0,0779	-0,0762	-0,0911	-0,1221	-0,0935	-0,0798	-0,0954	-0,1391	-0,0727	-0,1153	-0,0853	-0,0776	-0,0733	-0,0843	-0,0965	-0,1403	-0,0662	-0,1014	-0,0734	-0,0833	-0,0774	-0,0977	-0,0975
P37	NLBR.LJ	-0,0912	-0,0984	-0,0832	-0,1062	-0,0962	-0,0952	-0,0839	-0,1013	-0,0914	-0,0964	-0,0863	-0,1069	-0,0999	-0,0963	-0,0851	-0,1017	-0,0890	-0,0970	-0,0907	-0,0896	-0,0863	-0,0851	-0,0910	-0,0995
P38	AKBNK.IS	-0,0897	-0,0593	-0,0667	-0,091	-0,0993	-0,063	-0,0738	-0,0574	-0,0848	-0,0622	-0,0646	-0,091	-0,1019	-0,0737	-0,0787	-0,0569	-0,0825	-0,0668	-0,0659	-0,089	-0,0988	-0,0773	-0,0832	-0,0618
P39	DENIZ.IS	-0,069	-0,076	-0,0751	-0,1087	-0,0884	-0,1029	-0,0738	-0,0519	-0,0705	-0,0776	-0,0746	-0,1055	-0,0914	-0,1021	-0,0792	-0,0604	-0,0738	-0,0779	-0,0768	-0,1	-0,0897	-0,0975	-0,0837	-0,0683
P40	GARAN.IS	-0,0869	-0,0577	-0,0601	-0,0977	-0,1005	-0,103	-0,0742	-0,065	-0,0837	-0,0652	-0,074	-0,0973	-0,1021	-0,1032	-0,0802	-0,0685	-0,0835	-0,0652	-0,0738	-0,0954	-0,0986	-0,0994	-0,084	-0,0722
P41	HALKB.IS	-0,0675	-0,0809	-0,0812	-0,1035	-0,0782	-0,0877	-0,0713	-0,0315	-0,0709	-0,0805	-0,0732	-0,1003	-0,0934	-0,1044	-0,0784	-0,0415	-0,0768	-0,0756	-0,0753	-0,0991	-0,0902	-0,0954	-0,083	-0,0589
P42	ICBCT.IS	-0,0664	-0,0376	-0,0868	-0,0645	-0,0743	-0,0818	-0,0747	-0,0507	-0,0718	-0,0044	-0,0844	-0,0847	-0,0754	-0,0798	-0,0786	-0,0609	-0,0724	-0,0371	-0,095	-0,0896	-0,077	-0,0799	-0,0833	-0,066
P43	ISCTR.IS	-0,0789	-0,0361	-0,0818	-0,0919	-0,0782	-0,1008	-0,075	-0,058	-0,0772	-0,0455	-0,0824	-0,0938	-0,0934	-0,0982	-0,0809	-0,0587	-0,0793	-0,053	-0,0823	-0,0906	-0,0902	-0,0982	-0,0852	-0,0672
P44	QNBFB.IS	-0,0742	-0,0383	-0,0728	-0,0919	-0,0986	-0,1124	-0,0722	-0,0596	-0,076	-0,0498	-0,0791	-0,0989	-0,0945	-0,101	-0,079	-0,063	-0,0795	-0,0557	-0,081	-0,0913	-0,092	-0,0955	-0,0838	-0,0696
P45	SKBNK.IS	-0,0663	-0,0734	-0,0997	-0,101	-0,0679	-0,0704	-0,0764	-0,0456	-0,0716	-0,0757	-0,0886	-0,0961	-0,075	-0,0793	-0,0797	-0,0542	-0,0804	-0,073	-0,0851	-0,1041	-0,0813	-0,083	-0,0844	-0,0605
P46	VAKBN.IS	-0,0708	-0,0564	-0,0646	-0,1029	-0,093	-0,108	-0,0719	-0,0436	-0,0711	-0,0652	-0,0689	-0,1015	-0,0954	-0,1068	-0,0789	-0,0493	-0,0761	-0,0654	-0,0738	-0,0999	-0,0932	-0,0998	-0,0832	-0,0593
P47	YKBNK.IS	-0,0813	-0,0477	-0,081	-0,0943	-0,0914	-0,0964	-0,0719	-0,0537	-0,0758	-0,0576	-0,0727	-0,0977	-0,0904	-0,0964	-0,0789	-0,0516	-0,0788	-0,0661	-0,0735	-0,0985	-0,0904	-0,0942	-0,0832	-0,0597

Table 10. Entropy Values of Matrices Elements for Three Years

		Input Factors			Output Factors				
Years	Weight	**I1**	**I2**	**I3**	**O1**	**O2**	**O3**	**O4**	**O5**
2018	Wij	0,311	0,341	0,348	0,206	0,198	0,202	0,183	0,211
2017	Wij	0,314	0,358	0,328	0,206	0,195	0,201	0,197	0,201
2016	Wij	0,320	0,342	0,338	0,196	0,195	0,197	0,215	0,196
Av.	**Wij**	**0,32**	**0,35**	**0,34**	**0,20**	**0,20**	**0,20**	**0,20**	**0,20**

Table 11. Final Entropy Values of Input and Output Factors for Three Years

Step-3: Construction of the Entropy Matrices

As seen in Table 10, entropy values of all elements of matrices were calculated for three years by using Eqs 8a and 8b.

Step-4: Calculation of the Weight Values of the Input&Output Factors

With the help of Eq. 12a and 12b, weight values of all input and output factors can be calculated. By computing arithmatic means of obtained weight values for each year, final weight values of factors were determined.

Step-5: Construction of the initial decision matrices, X and Y:

As seen in Table 4, 5, and 6, obtained original data about input and output factors were used similarly and matrices were constructed.

Step-6: Calculation of Preference Ratings with Respect to The Non-Beneficial Criteria

to calculate the performance score about inputs, Eq 16 was used. Obtained scores have been shown as in Table 12.

Step-7: Computation of preference ratings with respect to output criteria

The performance value of each output factor is computed. In order to calculate these values, Eqs 17 were used. While non-measured preference scores of input factors are computed by using Eqs 16, with the help of eqs 17, non-measured preference scores of output factors are calculated.

		Preference Ratings					
		Input Factors			**Output Factors**		
C	**Banks**	**2016**	**2017**	**2018**	**2016**	**2017**	**2018**
P_1	KIBB.SJ	9,534	9,182	8,887	-0,29	-0,31	-5,36
P_2	NBLB.BJ	12,893	13,907	13,726	-0,22	-0,22	-8,20
P_3	NOVB.BJ	8,729	8,578	8,613	-0,13	-0,13	-10,18
P_4	PBSB.SJ	10,046	9,837	5,998	-0,25	-0,06	-7,86
P_5	UPIB.SJ	9,368	9,077	12,528	-0,30	-0,21	-8,95
P_6	VBBB.BJ	13,529	13,152	13,413	-0,39	-0,67	-7,17
P_7	ZGBMP.SJ	10,077	13,409	13,464	-0,22	-0,22	-7,72
P_8	ZPKB.BJ	11,	11,081	11,064	0,07	0,00	-9,62
P_9	5BN.BB	10,355	9,218	8,411	-0,03	-0,05	-8,49
P_{10}	5CP.BB	6,414	7,169	7,135	-0,09	-0,29	-6,11
P_{11}	HPBZ.ZA	10,936	11,598	11,41	0,06	-0,06	-7,57
P_{12}	IKBA.ZA	11,747	12,616	12,443	-0,07	-0,12	-6,38
P_{13}	KABA.ZA	8,912	8,029	12,369	-0,07	-0,13	-6,86
P_{14}	KBZA.ZA	9,881	9,511	8,871	-0,16	-0,24	-6,75
P_{15}	PBZ.ZA	13,248	13,493	14,003	-0,15	-0,08	-8,40
P_{16}	SNBA.ZA	7,961	6,755	9,806	-0,01	-0,04	-6,61
P_{17}	ACBr.AT	14,35	12,764	12,795	0,01	0,16	-9,47
P_{18}	BOAr.AT	9,737	12,181	5,619	-0,16	-0,05	-10,24
P_{19}	BOPr.AT	11,045	11,673	12,059	0,15	0,22	-8,12
P_{20}	EURBr.AT	21,303	21,093	21,231	-0,02	0,00	-7,96
P_{21}	NBGr.AT	9,94	11,886	11,942	0,03	0,24	-6,98
P_{22}	OHB.MKE	14,4	13,991	14,157	-0,16	-0,05	-9,24
P_{23}	STB.MKE	15,857	15,071	14,728	-0,39	-0,25	-9,14
P_{24}	TNB.MKE	14,672	15,029	13,501	-0,38	-0,44	-8,73

P_{25}	FFBN.MOT	9,539	9,485	9,028	-0,39	-0,29	-7,33
P_{26}	HIBP.MOT	8,942	9,086	9,156	-0,26	-0,29	-6,93
P_{27}	NKBA.MOT	7,025	6,94	8,518	-0,10	-0,12	-6,91
P_{28}	OBPG.MOT	11,81	12,147	12,334	-0,19	-0,17	-7,55
P_{29}	ROBRD.BX	14,108	13,112	13,81	-0,40	-0,37	-7,39
P_{30}	ROPBK.BX	6,31	2,683	8,401	-0,05	0,41	-4,59
P_{31}	ROTLV.BX	13,453	13,763	14,944	-0,30	-0,34	-7,17
P_{32}	KMBN.BEL	11,03	8,976	9,681	-0,29	-0,39	-5,02
P_{33}	JBMN.BEL	12,063	4,065	6,493	-0,40	0,00	-6,75
P_{37}	NLBR.LJ	11,966	11,312	10,596	-0,12	-0,15	-8,20
P_{38}	AKBNK.IS	14,623	15,683	16,025	-0,44	-0,44	-8,38
P_{39}	DENIZ.IS	13,748	14,165	14,124	-0,48	-0,41	-9,52
P_{40}	GARAN.IS	15,576	14,065	14,506	-0,50	-0,49	-9,06
P_{41}	HALKB.IS	12,842	14,386	14,349	-0,51	-0,57	-9,48
P_{42}	ICBCT.IS	12,271	12,776	10,742	-0,48	-0,26	-8,43
P_{43}	ISCTR.IS	12,799	12,819	13,076	-0,43	-0,47	-8,63
P_{44}	QNBFB.IS	14,198	13,433	13,306	-0,59	-0,44	-8,66
P_{45}	SKBNK.IS	10,013	11,541	12,289	-0,32	-0,25	-9,90
P_{46}	VAKBN.IS	15,29	15,269	14,761	-0,60	-0,55	-9,59
P_{47}	YKBNK.IS	12,814	14,54	14,728	-0,51	-0,46	-9,41

Table 12. Preference Ratings with Respect to Input and Output Factors

Step-8: Calculation of the Linear Preference Rating for the Input and Output Criteria

the distance of obtained non-preference score of each input factors from likely the best score of each factor was computed. Eqs 18 is used to calculate linear preference rating for the input factors as shown is Table 12.

I^k represents the aggregate preference rating for alternative k with respect to the input criteria Afterward, measured preference scores of output factors were computed using by Eq 19. O^k represents the measured preference rating of output factors.

		Linear Preference Rating					
		Input Factors			**Output Factors**		
C	**Banks**	**2016**	**2017**	**2018**	**2016**	**2017**	**2018**
P1	KIBB.SJ	3,22	6,50	3,27	9,24	8,87	3,53
P2	NBLB.BJ	6,58	11,22	8,11	12,67	13,68	5,52
P3	NOVB.BJ	2,42	5,89	2,99	8,60	8,45	-1,57
P4	PBSB.SJ	3,74	7,15	0,38	9,80	9,78	-1,86
P5	UPIB.SJ	3,06	6,39	6,91	9,07	8,86	3,58
P6	VBBB.BJ	7,22	10,47	7,79	13,14	12,48	6,24
P7	ZGBMP.SJ	3,77	10,73	7,84	9,86	13,19	5,74
P8	ZPKB.BJ	4,69	8,40	5,44	11,07	11,08	1,44
P9	5BN.BB	4,04	6,53	2,79	10,33	9,17	-0,08
P10	5CP.BB	0,10	4,49	1,52	6,33	6,87	1,03
P11	HPBZ.ZA	4,63	8,91	5,79	11,00	11,54	3,84
P12	IKBA.ZA	5,44	9,93	6,82	11,68	12,50	6,06
P13	KABA.ZA	2,60	5,35	6,75	8,84	7,90	5,51

P14	KBZA.ZA	3,57	6,83	3,25	9,72	9,27	2,12
P15	PBZ.ZA	6,94	10,81	8,38	13,10	13,41	5,61
P16	SNBA.ZA	1,65	4,07	4,19	7,95	6,72	3,19
P17	ACBr.AT	8,04	10,08	7,18	14,36	12,92	3,33
P18	BOAr.AT	3,43	9,50	0,00	9,58	12,13	-4,62
P19	BOPr.AT	4,73	8,99	6,44	11,19	11,89	3,94
P20	EURBr.AT	14,99	18,41	15,61	21,28	21,09	13,27
P21	NBGr.AT	3,63	9,20	6,32	9,97	12,13	4,96
P22	OHB.MKE	8,09	11,31	8,54	14,24	13,94	4,91
P23	STB.MKE	9,55	12,39	9,11	15,47	14,82	5,58
P24	TNB.MKE	8,36	12,35	7,88	14,29	14,59	4,77
P25	FFBN.MOT	3,23	6,80	3,41	9,15	9,20	1,70
P26	HIBP.MOT	2,63	6,40	3,54	8,69	8,80	2,22
P27	NKBA.MOT	0,71	4,26	2,90	6,93	6,82	1,60
P28	OBPG.MOT	5,50	9,46	6,71	11,62	11,98	4,78
P29	ROBRD.BX	7,80	10,43	8,19	13,70	12,75	6,42
P30	ROPBK.BX	0,00	0,00	2,78	6,26	3,10	3,81
P31	ROTLV.BX	7,14	11,08	9,32	13,15	13,42	7,78
P32	KMBN.BEL	4,72	6,29	4,06	10,74	8,59	4,66
P33	JBMN.BEL	5,75	1,38	0,87	11,66	4,07	-0,26
P37	NLBR.LJ	5,66	8,63	4,98	11,85	11,16	2,40
P38	AKBNK.IS	8,31	13,00	10,41	14,18	15,25	7,64
P39	DENIZ.IS	7,44	11,48	8,50	13,27	13,76	4,61
P40	GARAN.IS	9,27	11,38	8,89	15,07	13,58	5,45
P41	HALKB.IS	6,53	11,70	8,73	12,34	13,81	4,87
P42	ICBCT.IS	5,96	10,09	5,12	11,79	12,52	2,32
P43	ISCTR.IS	6,49	10,14	7,46	12,37	12,35	4,44
P44	QNBFB.IS	7,89	10,75	7,69	13,61	12,99	4,65
P45	SKBNK.IS	3,70	8,86	6,67	9,70	11,29	2,39
P46	VAKBN.IS	8,98	12,59	9,14	14,69	14,72	5,17
P47	YKBNK.IS	6,50	11,86	9,11	12,30	14,08	5,32

Table 13. Preference Ratings with Respect to Input and Output Factors

Step-9: Computation of overall preference ratings

By using Eqs 20, General preference score of each decision alternative is computed and all options are ranked considering these values as shown Table 12. Afterward, all decision options were ranked considering the general preference ratings of options as seen in Table 13.

		Ranking					**Ranking**					**Ranking**		
C	**Banks**	**2016**	**2017**	**2018**	**C**	**Banks**	**2016**	**2017**	**2018**			**2016**	**2017**	**2018**
P1	KIBB.SJ	67	72	115	P17	ACBr.AT	10	31	116	P33	JBMN.BEL	48	110	129
P2	NBLB.BJ	33	19	96	P18	BOAr.AT	65	41	132	P37	NLBR.LJ	45	53	119
P3	NOVB.BJ	77	79	130	P19	BOPr.AT	52	44	111	P38	AKBNK.IS	13	4	83
P4	PBSB.SJ	61	62	131	P20	EURBr.AT	1	2	25	P39	DENIZ.IS	24	17	108
P5	UPIB.SJ	71	73	114	P21	NBGr.AT	59	42	101	P40	GARAN.IS	5	21	98
P6	VBBB.BJ	28	36	91	P22	OHB.MKE	12	15	102	P41	HALKB.IS	39	16	103

P7	ZGBMP.SJ	60	26	93	P23	STB.MKE	3	6	95	P42	ICBCT.IS	46	34	121
P8	ZPKB.BJ	55	54	126	P24	TNB.MKE	11	9	105	P43	ISCTR.IS	37	38	109
P9	5BN.BB	58	69	128	P25	FFBN.MOT	70	68	124	P44	QNBFB.IS	20	30	107
P10	5CP.BB	89	85	127	P26	HIBP.MOT	76	75	122	P45	SKBNK.IS	64	51	120
P11	HPBZ.ZA	56	50	112	P27	NKBA.MOT	84	86	125	P46	VAKBN.IS	8	7	100
P12	IKBA.ZA	47	35	92	P28	OBPG.MOT	49	43	104	P47	YKBNK.IS	40	14	99
P13	KABA.ZA	74	81	97	P29	ROBRD.BX	18	32	88					
P14	KBZA.ZA	63	66	123	P30	ROPBK.BX	90	118	113					
P15	PBZ.ZA	29	23	94	P31	ROTLV.BX	27	22	82					
P16	SNBA.ZA	80	87	117	P32	KMBN.BEL	57	78	106					

Table 14. Ranking the Decision Options

5. DISCUSSION

The discussion will focus on the obtained results of this research and study. In addition to that, the proposed model consists of entropy and ocra method will be discussed whether it can use for similar studies related to performance analysis of banking and finance sectors. It can be seen that there are useful and important conclusions about using this integrated mcdm model and it can contribute to filling the gap, so there are serious requirements a systematic and structural tool for performance analysis.

- Inclusion of the potential many factors, which can affect the results probably, can be accepted as the most important advantages of this model. A decision-maker can add too many inputs or output factors to the evaluation process. Foremost, decision-makers should determine which factors should be kept out.
- Secondly, the ocra method can provide very realistic and applicable results. If evaluated the financial positions of the selected banks, it can be seen clearly that these figures are very similar to the results obtained with this study.
- The ocra method can provide another advantage that data obtained from previous years can be evaluated together, so it can show performance score and ranking position of the selected banks over the last years. Consequently, it provides opportunity evaluation of performance in a wider perspective.

6. CONCLUSIONS

When obtained results are evaluated, the bank, which has higher performance is Eurobank Ergasias SA. This bank ranked as the best and second-best bank over the last three years. Its performance score is very high and it is at least two times more than the performance scores of other competitors. In addition to that, while weight values of input factors are very closer to each other, weight values of output factors are completely same. When it is evaluated in general: it is a known fact that the banking and finance sector should carry out their operations at high performance. It is a very important issue for not only themselves but also for the national economy, other sectors, and the global economy. Continuously monitoring and assessment of the efficiency of the banking and finance sectors is one of the vitally important issues for all parties of the economy. More importantly, it is required an effective tool for performance analysis of these kinds of the sector.

This study proposes a useful and very effective decision-making tool to evaluate the performance of the banking sector. It is integrated MCDM approach that consists of entropy technique and OCRA method. It is seen that it can be used for similar decision-making problems because it can provide realistic and applicable results. In addition to that, it is very ergonomic and can be used easily by decision-makers. Moreover, it doesn't require software or program to making performance analysis and it can be applied by a decision-maker manually. As well as banking and finance sectors, it can be applied to various

sectors and fields that needed the performance analysis. Moreover, it can provide a systematic tool that can be used in further studies, which will realize to make performance analysis for various fields.

REFERENCES

Akyüz Y, Yıldız F, Kaya, Z 2013, "Measuring Total Factor Productivity with the Malmquist Index and Data Envelopment Analysis (DEA): An Application in Deposit Banks Listed in BIST", *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi*, vol. 27, no.4, pp. 110-131.

Altunöz U 2017, "The Analysing of the Fınancial Performance of Banks By Usıng Fuzzy AHP and Fuzzy MOORA Approaches: Case Of Turkıih Banks", *Route Educational and Social Science Journal*, vol. 4, no. 4, pp. 116-132.

Antoun R, Coskun A, Georgievski B 2018, "Determinants of Financial Performance of Banks in Central and Eastern Europe", *Business and Economic Horizons*, vol.14, no. 3, pp. 513-529.

Atukalp EM 2018, "Bankaların Finansal Performansının MULTİ-MOORA Yöntemi ile Analizi", *1st International Banking Conference Prceedings*, 4-5 May, Ankara, pp. 67-78.

Caporale Guglielmo Maria vd. (2009), "Financial Development and Economic Growth: Evidence from Ten New EU Members" Discussion Paper of DIW Berlin, 940, pp.1- 39.

Căpraru B, Ihnatov I 2014, "Banks' Profitability in Selected Central and Eastern European Countries", *Procedia Economics and Finance*, vol. 16, pp. 587-591.

Chatterjeea P, Chakraborty S 2014, "Flexible Manufacturing System Selection Using Preference Ranking Methods: A Comparative Study" *International Journal of Industrial Engineering Computations*, vol. 5, pp. 315–338.

Chen JY, Cha QF, Li XL 2006, "The Application of the Information Entropy to the Appraisal of the Urban Sustainable Development Level", *Journal of Jiangsu University*, vol.8, no.3, pp. 88–92.

Çetin MK, Çetin Eİ 2010, "Multi-Criteria Analysis of Banks' Performances", *International Journal of Economics and Finance Studies*, vol. 2, no. 2, pp. 73-78.

Ding SF, Shi Z 2005, "Studies on Incidence Pattern Recognition Based on Information Entropy", *Journal of Information Science*, vol. 31, no. 6, pp. 497–502.

Erjola BS, Orfea D 2015, "Albanian Banking Efficiency Analysis: A Production Dea Approach-Comparision of Crs and Vrs Model", *Regional Science Inquiry, Hellenic Association of Regional Scientists*, vol. 2, pp. 59-68.

Halkos G, Salamouris D 2004, "Efficiency Measurement of The Greek Commercial Banks With The Use Of Financial Ratios: A Data Envelopment Analysis Approach", *Management Accounting Research*. Vol. 2, pp. 201-224.

Hondroyiannis G, Lolos S, Papapetrou E 2005, "Financial Markets and Economic Growth İn Greece, 1986-1999", *Journal of International Financial Markets, Institutions and Money, Elsevier*, vol. 15, no. 2, pp. 173-188.

Horvatova E 2018, "Technical Efficiency of Banks in Central and Eastern Europe", *International Journal of Financial Studies, MDPI, Open Access Journal*, vol. 6, no. 3, pp. 1-25.

Hunjak T, Jakovčević D, 2001, "AHP Based Model for Bank Performance Evaluation and Rating", 6th ISAHP, pp. 1-10.

Ilut B, Chırleşan D 2012, "The European Integratıon Processa and Its Effects on Banks Efficiency: Evıdence From Romania", *International Journal of Economıcs And Finance Studies*, vol. 4, no. 2, pp. 31-40.

Jayanthia S, Kochab B, Sinha KK 1999, "Competitive Analysis of Manufacturing Plants: An Application to the US Processed Food Industry", *European Journal of Operational Research*, vol. 118, no. 2, pp. 217-234.

Kandemir T, Karataş H 2016, "Ticari Bankaların Finansal Performanslarının Çok Kriterli Karar Verme Yöntemleri ile İncelenmesi: Borsa İstanbul'da İşlem Gören Bankalar Üzerine Bir Uygulama (2004-2014)", *İnsan ve Toplum Bilimleri Araştırmaları Dergisi*, vol. 5, no. 7, pp. 1766-1776.

Kosmidou K, Zopounidis C 2008, "Measurement of Bank Performance in Greece," *South-Eastern Europe Journal of Economics, Association of Economic Universities of South and Eastern Europe and the Black Sea Region*, vol. 6, no. 1, pp. 79-95.

Lemonakis C, Garefalakis A, Georgios X, Haritaki H 2018, "A Study of the Banks' Efficiency in Crisis: Empirical Evidence From Eastern Europe, Balkans And Turkey", *Journal of Governance & Regulation*, vol. 7, no. 3, pp. 8-12.

Mandic K, Delibasic B, Knezevic S, Sladjana B 2014, "Analysis of the Financial Parameters of Serbian Banks Through the Application of the Fuzzy AHP And TOPSIS Methods" *Economic Modelling*, vol. 43, pp. 30-37.

Mihai N, Cristi S 2016, "The Relationship Between Bank Efficiency and Risk and Productivity Patterns in the Romanian Banking System", *Journal for Economic Forecasting, Institute for Economic Forecasting*, vol. 1, pp. 39-53.

Munteanu A, Brezeanu P, Badea L 2013, "Productivity Change Patterns in the Romanian Banking System-The Impact of Size And Ownership on Total Factor Productivity" *Theoretical And Applied Economics, Asociatia Generala A Economistilor Din Romania - AGER*, Vol. 20 no. (6(583)), pp. 35-52,

Nenovsky N, Chobanov P, Mihaylova G, Koleva D 2008, "Efficiency of the Bulgarian Banking System: Traditional Approach and Data Envelopment Analysis", *International Centre for Economic Research Working Papers*, vol. 22, pp. 1-33.

Nitoi M 2009, "Efficiency in the Romanian Banking System: An Application of Data Envelopment Analysis", *Romanian Journal of Economics, Institute of National Economy*, vol. 29, no. 2(38)), pp. 162-176.

Onofrei M, Bostan I, Roma A, Firtescu BN 2018, "The Determinants of Commercial Bank Profitability In CEE Countries", *Romanian Statistical Review*, no. 2, pp. 33-46.

Ozbek A 2015a, "Efficiency Analysis of Foreign-Capital Banks in Turkey by OCRA and MOORA", *Research Journal of Finance and Accounting*, vol.6, no.13, pp. 21-30.

Ozbek A 2015b, "Efficiency Analysis of Non-Governmental Organizations Based in Turkey", *International Business Research*, vol. 8, no. 9, pp. 95-104.

Ozbek A 2015c, "Efficiency Analysis of the Turkish Red Crescent Between 2012 and 2014", *International Journal of Economics and Finance*, vol. 7, no. 9; pp. 322-334.

Pancurova D, Lyocsa S 2013, "Determinants of Commercial Banks' Efficiency: Evidence From 11 Cee Countries", *Czech Journal Of Economics And Finance (Finance A Uver), Charles University Prague, Faculty Of Social Sciences*, vol. 63, no. 2, pp. 152-179.

Parkan C, Lam K, Hang G 1997, "Operational Competitiveness Analysis on Software Development", *Journal of the Operational Research Society*, vol. 48, no. 9, pp. 892-905.

Parkan C, Wu ML 1997, "On the Equivalence of Operational Performance Measurement and Multiple Attribute Decision Making", *International Journal of Production Research*, vol. 35, no. 11, pp. 2963-2988.

Sakarya S, Aytekin S 2013, "İMKB'de İşlem Gören Mevduat Bankalarının Performansları ile Hisse Senedi Getirileri Arasındaki İlişkinin Ölçülmesi: PROMETHEE Çok Kriterli Karar Verme Yöntemiyle Bir Uygulama", *Uluslararası Alanya İşletme Fakültesi Dergisi*, vol. 5, no. 2, pp. 99-109.

Somogyi RM 2011, "Review and Systematization of Efficiency Measurement Methods Used in the Transport Sector, *Promet – Traffic&Transportation*, vol. 23, no. 1, pp. 39-47.

Stanujkic D, Kazimieras EZ, Liu S, Karabasevic D, Popovic P 2017, "Improved OCRA Method Based on the Use of Interval Grey Numbers, *The Journal of Grey System*, vol. 29, no.4, pp. 46-60.

Wang S 2006, "Comments on Operational Competitiveness Rating Analysis (OCRA)", *European Journal of Operational Research*, vol. 169, Issue 1, pp. 329-331.

Zhang Y, Zuo TT, Tang, Z, Gao, MC, Dahmen KA, Liaw PK and Lu, ZP 2014, "Microstructures and Properties of High-Entropy Alloys", *Programming Material Science*, vol. 61, pp. 1–93.

Zou Z, Sun J, and Ren G 2005, "Study and Application on the Entropy Method for Determination of Weight of Evaluating Indicators in Fuzzy Synthetic Evaluation for Water Quality Assessment", *ACTA Scientiae Circumstantiae*, vol. 25, no. 4, pp. 552 – 556.