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An Approach to the Evaluation of the Overall Performance with Efficiency Measurements by Means of an Efficiency Evaluation Chain Using DEA and Fuzzy DEA

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Abstract In this paper, we will give an approach to the performance evaluation and efficiency value measurements where the gathered real data form a "time series" along a certain period of time (t). Along with the use of the basic models of DEA (Data Envelopment Analysis) method in joint cooperation with Fuzzy DEA models, the impact of the variable factors on DMU's (Decision Making Units) inefficiencies, performance evaluation and ranking is studied by accepting the t period of time as a discreet variable and as a unique "moment". This is determined by the objectives given by the CSAM (Connoisseur-study-analysis model) viewpoint in order to form the most real tableau of the DMUs' performance evaluation by means of an efficiency evaluation chain. For the evaluation of performance as a competitive process, 17 countries from the macroeconomic and financial environment are included (countries from the Western Balkans, the EU, and other countries). The study – a knowledge analysis – is also developed as issues of economic optimization portfolio by going through two steps: First step – (time as a discreet variable) evaluation of DMU's performance by measuring and analysing the efficiency value in the economic environment, with defined goals and criteria, where the concept of differences "deviation" elasticity coefficient (differences between Ef-VRS and Ef-CRS) is also included at the efficiency levels for the inefficient DMUs during the period of time 't'; Second step – (the period of time as a unique "moment") where is operated using the Fuzzy DEA model approach (α-cut) and the coordination of both steps with the DMUs' performance ranking. In addition, the study investigates the impact of the correlative relations between the variables to the DMUs' efficiency values during the evaluation of their performance. The gained results through the methodology followed in this study will give a more real tableau in the study of the performance evaluation and the connoisseur analysis of the DMUs' efficiency value, based on the real data gathered during the period of time (t) ϵ (2015-2019).

Keywords Efficiency Value Connoisseur- Analysis, "Time Series", Correlation, DEA, Fuzzy DEA

1. Introduction

Performance evaluation and definition of the relative technical efficiency value over a competition racing process during a period of time "t" calls for an appropriate instrument that can serve as a key to a connoisseur-analysis study such as the DEA method application.

Different methods and ways are used by different authors under the perspective of CSAM (Connoisseur-study-analysis model) in order to form the most real tableau of the DMUs' performance evaluation by means of the efficiency value.

Analysis that have been conditioned by the impact of the fundamental financial factors, using the DEA method models are used by Edirisinghe et al. [9a,9b], Luptacik, M [26], Bowlin, W. F [10], Yeh [50], Ray [51]. The DEA methodology has been often used in combination with other methodologies and techniques, developing further DEA, and bringing with applications and many other new approaches. This trend is particularly noticed in the last decade. Thus, DEA Window in combination with Fuzzy TOPSIS model (TOPSIS-technique for ordering preference by similarity to ideal solution), has been used by the authors of [56] to evaluate the capabilities of 42 countries in terms of renewable energy production potential. The efficiency measurement model with imprecise data to assess the circular economy system of EU countries is given in [58]. The performance evaluation of DMUs is given by developing the FMOO (fuzzy multi-objective optimistic) and FMOP (fuzzy multi-objective pessimistic) models [60]. The application of two-stage DEA to evaluate the production and investment efficiency in the food industry is noted in [57]. In [61] the intuitionistic fuzzy set theory is used in the application of two-stage DEA based on efficiency decomposition. The utilization of the Fuzzy DEA method to evaluate the Cost Efficiency of DMUs with α-level approach is given in [59].

In order to evaluate productivity by means of the DEA method between two periods of time (t-1) and t, the Malmquist index is used in [30a,30b].

Malmquist productivity index can be given as the product of the two respective components according to [43.b] in order to make the productivity evaluation tableau clearer. The Malmquist-Luenberger index [44] is used when it is dealt with desirable and undesirable variables. DEA is a non-parametric method where many selected criteria, evaluated as inputs or outputs, may be intertwined. From a homogeneous set of DMUs "peer", DEA will identify decision making units that may be evaluated as efficient or inefficient. Selection of inputs and outputs is a fundamental requirement of DEA. It may preliminarily be made by using statistical analysis [21,22] in order to define the relation between them. In the DEA method, the number of DMUs is related to the general number of the inputs and outputs. [23] suggests $n \geq 2(m+s)$; [24] suggests $n \geq 3(m+s)$ (where 'n' is the number of DMUs, 'm+s' is the number of input-output criteria). In certain cases, the DEA method requires the normalization of the data [55] which can very clearly be noted that have big differences in the values of the variable factors between DMUs (such as when the population number of the countries clearly differs of many times), so the data to be used are unified on a 'per capita' bases. This normalization of data will increase the credibility of defining the efficiency value. The joint use of DEA method with the statistical analysis methods is quite frequently found in studies and applications. So, the DEA method is used in coordination with the statistical analysis methods, regress methods [25,43a,45,46].

In this study, statistical tests for the evaluation of the hypothesis set forth in the evaluation of performances based on defined goals are used.

Wilcoxon statistical test is used with the results of the DEA model (CCR and Fuzzy DEA) in the evaluation of the impact the correlative relations may have on the DMUs' performances.

The application of the DEA methodology related to real life problems of performance evaluation is a very powerful instrument for analysis of the processes of DMUs development in many areas of business management. "The DEA methodology is not a new concept, the increase in its usage is evident in a number of different industries and different fields of business operations through the years..." is emphasized in the study [62] regarding the ever-increasing trend nowadays of applying the DEA methodology. Our study presents an approach to the evaluation of the overall performance with efficiency measurements by means of an efficiency evaluation "chain" with the application of DEA and Fuzzy DEA (α cut) models. This study is based on the conceptual aim: To obtain a better monitoring CSAM analysis with a more direct visualization for the progress of the macroeconomic development of DMUs. The study contains two steps related to the evaluation of period t, period t as discrete variable and as a unique "moment". This study enables the creation of wider interpretation spaces in the managerial aspect to devise the growth of the optimization portfolio of DMUs. The results of this study emphasize also the possibility of designing and defining new strategies to obtain and develop a growing progress for each DMU. The obtained results lead to the respect of economic concepts to better maintain the "balances" of management and economic activity in itself related to the size and dimensionality of the variables. The study emphasizes the evaluation of variable generative and developmental metrics in the dynamic process of macroeconomic development of DMUs. In the study, the tracking coefficient of the progress rate (ef $\cdot ef_t = (\ln(Ef^t)\text{-}\ln(Ef^{t-1}))\cdot 100$ (in %)) associated with the elasticity "deviation" coefficient is used as monitoring aspects. The study presents the impact that can be felt of the correlation coefficient between the variables (input-output) for each DMU as well as the impact of EU membership for the countries of the region on the efficiency values. The summary tables have also been built with the grouping of DMUs according to their geographical positioning as well as related to EU membership to broaden the perspective of the relevant analyses. Performance evaluation rankings are given according to the application of the DEA model compared to the rankings of the Fuzzy DEA model using statistical tests.

The following is an outline of this work's contributions:

1. Use of the (basic) DEA and Fuzzy DEA models on an economic application in order to detect the best the impact of the variable factors and interpret the DMUs' inefficiencies. This work will give an approach to the evaluation of the overall performance with efficiency measurements by means of an efficiency evaluation chain using DEA and Fuzzy DEA;
2. Coordination of the gained results using basic DEA and fuzzy DEA models will have a deeper understanding of the CSAM study. Use of the "deviation" elasticity coefficient concept $d^{ef}(x_t, y_t)$ during the period of time 't' may serve to a better investigation of the DMUs' inefficiencies;
3. Cooperation of the methods and models for a CSAM analysis study may be evaluated as a useful instrument when aiming at performance evaluation where the real data can be considered as a time "series".
4. How to develop the application of DEA and Fuzzy DEA methodology as an effective approach to optimize the operating processes of DMUs.

2. Background (Basic Concepts)

In the context of performance and relative efficiency evaluation for the decision making units DMUs, DEA evaluates the production process based on the conjunction between inputs and outputs.

To evaluate and measure the relative technical efficiency of a homogeneous DMUs set, in the DEA method, the DEA-CCR model is used (constant returns to scale (CRS)) [1]. The DEA method is further expanded by Banker et al. in 1984 [12] with the so called model, BCC model (variable returns to scale (VRS)). Both models, CCR and BCC, are presented as models of a linear programming.

DEA method, presently, is also used in the operational research [34,35].

For the inefficient DMUs, DEA evaluates their "virtual" target projection in the limit of the efficient production, so that an inefficient DMU becomes efficient.

In a homogeneous set of DMUs {DMU_j; j=1,2,…,n}, the relative technical efficiency of each DMU_p from this set is evaluated using the CCR model of linear programming (LP) [1,26,33], with the multipliers (the row vectors υ_i and μ_r are the weights for inputs and outputs respectively), but also with its dual model.

(LP) max $w_p = \sum_{r=1}^{s} \mu_r y_{rp}$

subject to

$$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} \upsilon_i x_{ij} \leq 0, \ \forall \ j \qquad (1)$$

$$\sum_{i=1}^{m} \upsilon_i x_{ip} = 1$$

$$\mu_r, \upsilon_i \geq 0 \qquad \forall \ r, i$$

(DLP) The dual problem is expressed by a real variable θ and a non-negative vector $\lambda_j = (\lambda_1, \ldots, \lambda_n)^T$ (weights on DMUs).

(DLP) min $\theta_p = \theta_p^*$

subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta_p x_{ip}; \qquad i= 1,2,\ldots,m \qquad (2)$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{rp}; \qquad r=1,2,\ldots,s; \ j=1,2,\ldots,n$$

$$\lambda_j \geq 0$$

In the DEA method applications are required that the data is accurately defined for the DMUs' inputs and outputs values. However, in real life, the data with which the DMUs will operate, may be data obtained from perceptions taken in different ways from specialists' judgments, and questionnaires, or they may be vague data (not completely defined) expressed as such, so the DEA method may be related with models where the Fuzzy numbers can be used. The Fuzzy set related to the evaluation of impressions is given by Zadeh [15,36]. The application of Fuzzy set theory is found in many fields of study by authors like Zimmerman [48], Saber Saati et al. [6], Izadikhah and Khoshroo [49], Peykani et al. [54], Lio and Liu [29], Wen [31] etc.

Sengupta [2] applied an alternative approach to measure the technical relative efficiencies by using the Fuzzy sets. It is known as the approach with tolerance levels.

Clarification of Fuzzy sets theory is related to the membership function which measures the degree to which element is a member of a set [15,39].

A Fuzzy set is symbolically written by $\tilde{A}$ (Fuzzy set A), where the membership function $\mu_{\tilde{A}}(x) \rightarrow [0,1]$ is given $\tilde{A}$ = {(x,$\mu_{\tilde{A}}$(x)|$x \epsilon$ X}. A triangular Fuzzy number can be defined as $\tilde{A} = (x_m, x_1, x_2)$, where x_m is the central value, x_1 is the left width (spread) and x_2 is the right width (spread) [38,39]. The membership function may symbolically be described by the two functions f^L(left) and f^R (right):

$$\mu_{\tilde{X}}(x) = \begin{cases} f^L\left(\frac{x_m - x}{x_1}\right) & x \leq x_m, \quad x_1 > 0 \\ f^R\left(\frac{x - x_m}{x_2}\right) & x > x_m, \quad x_2 > 0 \end{cases}$$

Symbolically, $\tilde{X} = (x^m, x^l, x^u)$ expresses a triangular fuzzy number. Applications used in Fuzzy DEA can be grouped as follows (see Izadikhah and Khoshroo [49]).

The tolerance approach, Sengupta [2], Kahraman and Tolga [11];

α cut approach, O.Girod [4], Kao and Liu [5], Saati et al. [6]; Fuzzy ranking approach, Guo and Tanaka [7]; Possibility approach [8]; Fuzzy arithmetic approach [19].

Fuzzy efficiency evaluated for each DMU_p is given by the CCR model as follows [32]:

min W_p=θ

subject to

$$\sum_{j=1}^{n} \lambda_j \widetilde{x_{ij}} \leq \theta \widetilde{x_{ip}} \qquad (3)$$

$$\sum_{j=1}^{n} \lambda_j \widetilde{y_{rj}} \geq \widetilde{y_{rp}}$$

$$\lambda_j \geq 0$$

Considering that $\widetilde{x_{ij}} = (x_{ij}^l, x_{ij}^m, x_{ij}^u)$ and $\widetilde{y_{rj}} = (y_{rj}^l, y_{rj}^m, y_{rj}^u)$, where 'l' is the lowest value of data, 'm' the middle of data in the increase series and 'u' is the upper value of data [27].(*)

Model (3) can be written [37,41,27]:

min w = θ

subject to

$$(\sum_{j=1}^{n} \lambda_j x_{ij}^m, \sum_{j=1}^{n} \lambda_j x_{ij}^l, \sum_{j=1}^{n} \lambda_j x_{ij}^u) \leq (\theta x_{ip}^m, \theta x_{ip}^l, \theta x_{ip}^u)$$

$$(\sum_{j=1}^{n} \lambda_j y_{rj}^m, \sum_{j=1}^{n} \lambda_j y_{rj}^l, \sum_{j=1}^{n} \lambda_j y_{rj}^u) \geq (y_{rp}^m, y_{rp}^l, y_{rp}^u),$$

$$\lambda_j \geq 0$$

According to the α -cut concept approach [2], in the triangular Fuzzy numbers, the DMUs ranking model is suggested as follows:

min $W_p = \theta$

subject to

$$\sum_{j=1}^{n} \lambda_j (\alpha x_{ij}^m + (1-\alpha) x_{ij}^u) \leq \theta(\alpha x_{ip} + (1-\alpha) x_{ip}^l)$$

$$\sum_{j=1}^{n} \lambda_j (\alpha y_{rj}^m + (1-\alpha) y_{rj}^l) \geq \alpha y_{rp}^m + (1-\alpha) y_{rp}^u$$

$$\lambda_j \geq 0$$

For each α –cut, an optimal solution is obtained.

The Guo and Tanaka approach [7] uses the input-oriented CCR multiplier model to measure the DMUs' Fuzzy efficiency and ranking with the inputs and outputs data in triangular Fuzzy numbers.

The Fuzzy numbers set for the inputs and outputs data that are used by the DMUs for a progressive period of time (based on years) are developed by presenting the real data values in a series with increasing values where the lowest value, the biggest value, and the middle value in this series can be defined. So, the variables data are presented in triangular Fuzzy numbers as set forth above (*).

The fuzzy DEA approach [2] is used to rank the performance evaluation based on the definition of the efficiency values ($\alpha -$cut) by accepting the period of time (t) in the time progress as a unique "moment".

Once the two obtained ranks (based on the CCR -DEA model and the Fuzzy DEA model) are defined as two alternatives, the Spearman statistical test is used to test the correlative relation between the two ranks.

3. Application Methodology Framework

The application of DEA method (of its basic models) using the $\alpha -$cut approach is applied using real data in order to study the progress of the DMUs' macroeconomic and financial development dynamics. This study–a competitiveness analysis – is made in an economic environment for the period of time t ϵ(2015-2019). Years 2020 and 2021 are not included in this work (the Covid-19 period). 17 Decision Making Units (DMUs) are taken into consideration in this study (5 Western Balkan countries, 6 EU member countries, and 6 non EU member countries) and they are: 1. Albania (ALB), 2. North Macedonia (MKD), 3. Serbia (SRB), 4. Montenegro (MNE), 5. Croatia (HRV), 6. Bosnia and Herzegovina (BIH), 7. Romania (ROU), 8. Bulgaria (BGR), 9. Turkey (TUR), 10. Hungary (HUN), 11. Poland (POL), 12. Czech Republic (CZE), 13. Armenia (ARM), 14. Kazakhstan (KAZ), 15. Moldova (MDA), 16. Russian Federation (RUS), 17. Ukraine (UKR).

The variable data (input-output) are taken from the Databases of the World Development Indicators (Last Updated: 12/16/2021) such as: Gross national expenditure (current US$) (GNE), GDP per capita (constant 2015 US$), GNI per capita, Atlas method (current US$), Imports of goods and services (current US$) (IGS), Exports of goods and services (BoP, current US$) (EGS). Revenue, excluding grants (% of GDP) and for Montenegro, the Revenue data are taken from the International Monetary Fund (here also, it is taken as percentage of the GDP and afterwards it is likewise calculated in US$ per capita as for any other country); Population, total; and the Foreign Direct Investment (FDI) is taken from the UNCTADSTAT databases (Inward, US dollars at current prices per capita, Stock).

In order to have normalization of data, the data is calculated per capita (in US$).

Using the DEA basic models (CRS and VRS) and the Fuzzy DEA ranking (α -cut) the relative technical efficiency is defined where the evaluation of each DMU performance is done. Along with the inefficiencies of the Decision Making Units during the period of time 't' (time as a discreet variable), we make evident the evaluation of the ratio of the change of efficiency values, the definition of the "deviation" elasticity coefficient, and their target "virtual" projections.

The following formula is used to calculate the ratio of the change of efficiency values as the time progresses along the period of time 't': ef $\cdot ef_t$ = (ln(Ef^t)-ln(Ef^{t-1}))·100 (in %)(where $Ef^t and\ Ef^{t-1}$ are the efficiency values according to the CCR model for the period of time 't') (**) and the average relative technical efficiency for the period of time 't' (of the DMU_p) is evaluated as: $\overline{Ef_p^t} = \frac{1}{t}\sum_{t=1}^{t} Ef_p^t$.

The coefficient of "deviation" elasticity (along the period of time "t") is given by the formula $d^{ef}(x_t, y_t) = \sqrt{\frac{\sum_{t=1}^{t}(x_t - y_t)^2}{t-1}}$, where x_t and y_t are respectively the efficiencies values of Ef_VRS and Ef_CRS for each DMU, where 't' is the number of years. This coefficient together with the coefficient of the ratio of change of efficiency values (**), presents to us a better perception for the CSAM analysis over each Decision-Making Unit, for their performance and their operation.

The coefficient of "deviation" elasticity is a real number that describes the "space" between two levels of the efficiency values (Ef_VRS and Ef_CRS) as an instrument where the inefficiency of any DMU may be studied as compared to the group as a whole. The $d^{ef}(x_t, y_t)$ value of a DMU_p may be bigger or smaller than the average value of the $d^{ef}(x_t, y_t)$ of the entire group, comparing, at the same time, the respective efficiency values of the DMU_p with the value of the group's average efficiencies. The scale efficiency that is given for the DMU_p may mostly be seen as of 'local' character, while the $d^{ef}(x_t, y_t)$ analyzed with the others, allows for and creates a broader space of knowledge for the inefficiency resources. If this value of $d_p^{ef}(x_t, y_t) > d_m^{ef}(x_t, y_t)$ where the $\mathrm{E}\,f_p < \mathrm{E}\,f_m$ may suggest: to better investigate its own inefficiency resources as compared to the other inefficient DMUs by defining better strategies to increase production effectiveness, to better investigate its "raw" resources, and to enable the enhancement of its activity aiming that each input unit may further increase the value of each output unit, and then the coefficients of the support relations (output-input) should be known and evaluated either to its self or compared to the others.

If $d_p^{ef}(x_t, y_t) < d_m^{ef}(x_t, y_t)$ where $\mathrm{E}\,f_p < \mathrm{E}\,f_m$ may suggest: the inefficient DMU_p should know and decrease the "strongest" obstacles that inhibit lessening its inefficiency as compared to the others, and then reduction of those inputs (or keeping them constant) and the increase of those specific outputs that have the highest weight value in DEA should lay out a specific goals, particularly when multiple dimensions that characterize its production and performance exist.

With the Input – Oriented CRS Model Target, the target projections are defined to perceive the "virtual" units in the efficient frontier for each inefficient DMU. Knowing the inputs' "contraction" (reduction) and outputs' "enlargement" (increase) to obtain an optimal solution for the efficient frontier, we also know the influences of each variable factor.

In order to study better the progress of the DMUs' macroeconomic and financial development with a sensitive analysis in DEA three groupings are developed with distinguished relations respectively between the inputs and outputs (1x2),(2x2),(2x4). The (1x2) grouping has as input the foreign direct investment and as output the GNI and Trada (Imports of goods and services and Export of goods and services), the (2x2) grouping has in relation 2 inputs (Foreign direct investment and Gross national expenditure) and two outputs (GDP and Revenue), while the (2x4) grouping has in relation 2 inputs (Foreign direct investment and Gross national expenditure) and 4 outputs (GDP, Revenue, GNI, and Trada).

The three groupings altogether enable the best performance evaluation and the best evaluation of the variable factors impact in the efficiency value, for a wider and deeper expansion of the study.

4. Numerical Applications and Results

The abbreviations WB (Western Balkans) and EU (European Union) in this work stand respectively only for those Western Balkans countries and the 6 European Union countries that are included in the study. This is the same throughout this work.

Table 1 gives the data for the input-output variables that are used (where Min is the smallest value and Max is the biggest value for each variable during the period of time 't', while for the Western European countries as a group, European Union countries as a group, and for the 17 countries as a group, the values are their respective averages).

Selection of those variable factors is made based on the opinion of the specialists of economy who follow the macroeconomic developments. The specialists suggest that the GDP and the GNI should be taken in joint consideration (Central Statistics Office), because GDP alone is not the true measure of wellbeing as it does not show the quality of development. GDP refers to the total market value of all the goods and services produced by a country, whereas the GNI calculates the total revenue generated by the citizens of that country. They both reflect how effectively a country is economically functioning year by year. The foreign direct investments have their role in economy to transform it into a much competitive economy with impact in trade, specifically in export.

Table 2 shows the correlative relation between the values of the variables included in the study as inputs and outputs. For a better credibility, these correlative relations are evaluated for the period of time 2007–2019, as they are considered in a longer period of time. The study of the correlative relations impact to the efficient values for each grouping (1x2, 2x2 and 2x4) will be performed once the results based on the CCR and α −cut model are obtained.

Table 1. Variable values per capita in US$ during the period 2015-2019

Country	Indicator	FDI	GNE	GDP	Revenue	GNI	Trada
ALB	Min	1500.247	4649.462	3952.801	977.850	4290	2837.856
	Max	2909.8	6195.865	4549.457	1143.915	5230	4116.525
	Average	2226.657	5399.284	4255.232	1067.611	4618	3531.278
	Dev.ST	600.550	696.325	243.470	63.039	412.759	570.709
MKD	Min	2303.799	5650.208	4843.492	1305.669	4940	5527.615
	Max	3075.668	6905.681	5334.237	1511.399	5890	8379.845
	Average	2672.446	6309.19	5071.213	1370.149	5292	6958.417
	Dev.ST	338.224	563.741	188.107	78.642	398.836	1261.564
SRB	Min	3674.257	5982.511	5588.981	2180.170	5570	5376.820
	Max	5504.298	8153.928	6562.671	2696.178	7040	8282.206
	Average	4565.869	6952.94	6035.720	2425.410	6136	6804.429
	Dev.ST	788.646	1015.820	383.036	155.142	598.690	1260.128
MNE	Min	7288.743	7716.341	6517.164	2634.238	7090	6699.818
	Max	8666.769	10956.49	7684.151	3230.417	9130	9688.934
	Average	8171.248	9537.131	7062.864	2898.054	7860	8327.719
	Dev.ST	606.987	1394.689	477.782	191.455	882.383	1357.770
BIH	Min.	2088.108	5870.14	4727.276	1824.202	5120	4224.370
	Max	2603.398	7230.053	5575.420	2123.044	6180	6060.673
	Average	2382.464	6598.258	5154.620	1983.526	5478	5180.777
	Dev.ST	260.240	628.448	338.902	102.299	471.137	818.664
WB	Min.	3371.031	5973.732	5125.943	1784.426	5402	4933.296
	Max	4551.987	7888.403	5941.187	2140.99	6694	7305.636
	Average	4003.737	6959.361	5515.93	1948.95	5876.8	6160.524
	Dev.ST	518.929	859.805	326.259	118.115	552.761	1053.767
EU	Min.	6610.839	11407.916	11820.317	4070.546	12173.333	14719.379
	Max	8628.182	15322.696	13929.904	4838.911	15238.333	19529.168
	Average	7698.310	13328.170	12845.640	4448.767	13276.333	17170.402
	Dev.ST	921.343	1805.615	857.404	252.588	1313.119	2220.659
17 countries	Min.	4167.520	7777.096	8150.135	2549.835	8017.059	7887.893
	Max	5457.241	10456.900	9401.436	3030.204	10155.29	10782.614
	Average	4858.297	9117.376	8748.558	2781.257	8817.412	9369.971
	Dev.ST	535.101	1012.592	508.312	159.341	679.728	1282.874

Table 2. Correlative relations between the variable values (2007 – 2019)

DMU	FDI and GDP	FDI and Revenue	FDI and GNI	FDI and Trada	GNE and GDP	GNE and Revenue	IGS and EGS
ALB	0.945	0.920	0.774	0.803	0.556	0.608	0.707
MKD	0.879	0.521	0.878	0.879	0.774	0.504	0.978
SRB	0.952	0.924	0.269	0.914	0.209	0.116	0.873
MNE	0.742	0.751	0.685	0.673	0.598	0.723	0.560
BIH	0.857	0.872	0.860	0.843	0.550	0.548	0.871
WB	0.875	0.798	0.693	0.822	0.537	0.500	0.798
EU	0.519	0.460	0.535	0.479	0.546	0.482	0.929
17 countries	0.565	0.419	0.590	0.551	0.429	0.354	0.878

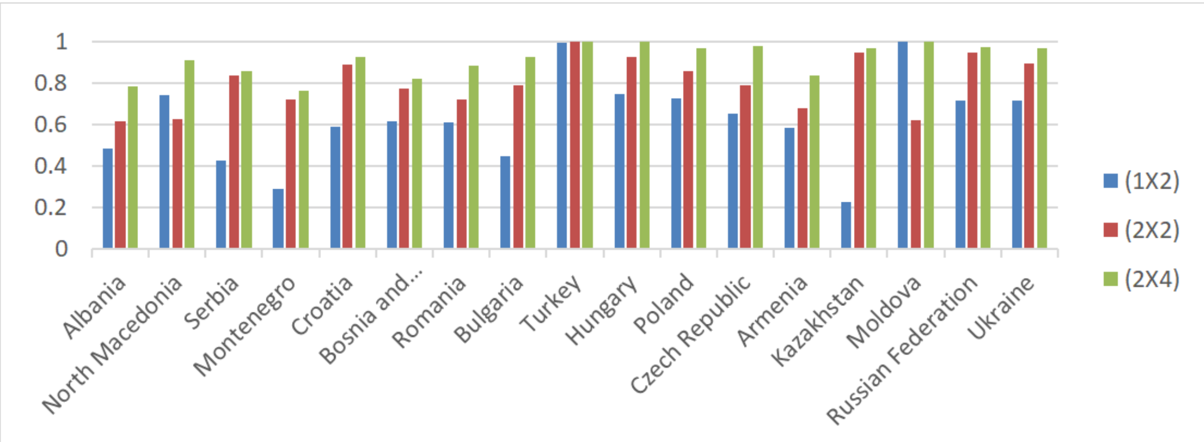

Figure 1. Column Chart of average efficiency results of DMU (DEA – CCR)

Table 3. Average results of relative technical efficiency based on the DMU groupings (2015 – 2019)

DMU	2X4			2X2			1X2		
	a	*b*	c	a	*b*	c	a	*b*	c
ALB	0.78324	0.05458	>	0.61713	0.11326	>	0.48495	0.01466	>
MKD	0.91415	0.01630	>	0.62695	0.08463	>	0.74071	0.16964	<
SRB	0.86133	0.05225	>	0.83558	0.05523	>	0.42562	0.09934	>
MNE	0.76285	0.03741	>	0.72347	0.03608	>	0.29047	0.07929	>
BIH	0.82355	0.03370	>	0.77634	0.06650	>	0.61943	0.11114	>
WB	0.82902	0.03885	>	0.71589	0.07114	>	0.51224	0.09481	>
EU	0.94844	0.03601	<	0.82861	0.13644	<	0.63003	0.26079	<
17 Countries	0.91715	0.03273	>	0.80281	0.11604	>	0.62278	0.13928	>

The relative technical efficiency of each DMU for each respective year from the period of time 't' for any grouping (1x2),(2x2) and (2x4) is evaluated by applying the DEA-CCR model having time as the discreet variable. Based on the gained results, the average efficiency of each DMU is calculated. Figure 1 shows the column Chart of average efficiency results of DMU is given for the 17 countries based on the three groupings.

The Table 3 shows the average results of the values for:

a) the relative technical efficiencies;
b) the "deviation" elasticity coefficient $d^{ef}(x_t, y_t)$;
c) the scale efficiency (SE_m) in relation to the efficiency values $E_f VRS$, if it is bigger or smaller ($SE_m \binom{>}{<} Ef_m^{VRS}$)

Based on the above table for the relative average technical efficiencies, it is noted that the efficiency value of the (1x2) grouping with the unique input the foreign investments and the output the GNI and Trada is smaller than the efficiency value of the other two groupings (2x2) and (2x4).

The effectiveness of the efficient value for the DMUs from the Western Balkans countries is 51.22% for the (1x2) grouping. This is smaller than the effectiveness value of the efficiency for the DMUs from the EU grouping countries which is 63% and also smaller than the effectiveness of the whole efficiency value grouping which is 62.3%. Of the Western Balkans countries in study, the highest effectiveness for the efficiency value pertains to the North Republic of Macedonia with 74%, which is the highest value not only compared to the average of the 17 countries, but also compared to the EU countries grouping. For the North Republic of Macedonia, the returns to scale (RTS) shows that its efficiency is related more to other factors than to its managerial values. In addition, the average "deviation" elasticity coefficient for the North Republic of Macedonia is 0.16964, an indicator that not only is the highest of any of the Western Balkans countries taken into consideration in this study, but also is the highest of the average coefficient for the 17 countries altogether. This shows that the possibilities for the improvement of the North Republic of Macedonia inefficiency of 26% against the DMUs average inefficiency of 37.7% have a higher sensitivity potential for improvement. This coefficient for Albania is smaller, which shows for fewer possibilities in lessening the inefficiency as compared to the other countries. For the Western Balkans countries in the study, the returns to scale for each year from the period of time is decreasing in the (1x2) grouping.

For the (2x2) grouping, the inefficiency value for the Western Balkans countries (as a grouping) in study is 28.4%, but higher than the general average of the inefficiency value for the 17 countries altogether (which is 19.7%). Here also, the value of the "deviation" elasticity coefficient is smaller than the average value of this coefficient for the 17 countries altogether, which shows that the operational actions for inefficiency lessening in the Western Balkans are weaker in improvement sensitivity than the average of all countries altogether. For the Western Balkans countries in the study, the role of the foreign investments as inputs in cooperation with the other input, that is the expenditure, where the output is the GDP and the revenues, are presented by an effectiveness level that is not high.

For the (2x4) grouping, the inefficiency value for the Western Balkans countries (as a grouping) is 17.1%, which is higher than the average value of the inefficiency of the 17 DMUs (8.3%) and higher than that of the EU countries grouping (5.2%). The "deviation" elasticity coefficient in general as a grouping has low values, which shows that the improvement sensibility of the inefficiencies in this grouping is not high. Of the three groupings, the coefficient of change ratio of the technical efficiency values (given in Table 4) based on years has increasing tendencies (positive) only for Serbia and Montenegro from the Western Balkans. It shows that Albania is the weakest, with high negative values of the efficiency value change ratio (-7.5% for the (1x2) grouping and -4% for the (2x2) grouping). The coefficient of change ratio of the efficiency values is an indicator of the DMUs performance evaluation for the macroeconomic and financial development dynamics during the period of time 't'. For this, it is sufficient to see the average value of this coefficient.

In order to define the inputs reduction and the outputs increase so that an inefficient DMU can become efficient in the efficient frontier of production, and the Input-Oriented CRS Model Target is used, where the following results are obtained. These results present the average values for any grouping of inputs reduction (in %) and outputs increase (in%) against their real values for the period of time t $\epsilon\,(2015-2019)$. These projections are shown in Table 5.

The "reduction" values as inputs expressed in percentage in the target projections show that the effectiveness of the foreign investments is weak in the Western Balkans countries. The reduction values in percentage are higher than the average in percentage of the reduction for the 17 countries in the three groupings (1x2), (2x2), and (2x4).

The relative technical efficiencies of the DMUs for each year is evaluated using the CCR and BCC model by accepting the time as discreet variable for the three groupings (1x2, 2x2, 2x4) separately.

Based on the (α-cut) approach of the Fuzzy DEA model use, we accept time as one unique "moment" and evaluate the DMUs ranking for each given grouping. The tables (Table 6, Table 7, Table 8) give the efficiency values in relation to different values of α according to (α-cut) approach with the respective rankings according the DEA-CCR and Fuzzy DEA models. The Rank column gives the ranking position for each DMU based on the DEA-CCR (E_f^C) and Fuzzy DEA (E_f^f).

Table 4. The coefficient of change ratio of the efficiency values during the period of time 't' efef^{t}=[ln(Ef^{t})-lnEf^{t-1}] 100 (%)

DMU	I x O	2016/2015	2017/2016	2018/2017	2019/2018	Average	Frequency of RTS		
							I	D	C
ALB	2x4	9.69910	0.77719	-8.91054	4.39542	1.49029	5	-	-
	2x2	-2.70526	12.13952	-20.7109	-4.73692	-4.00339	5	-	-
	1x2	-8.83027	-11.7792	-9.34142	0.00021	-7.48768	-	5	-
MKD	2x4	2.47348	1.66019	1.912291	0.95819	1.75104	3	2	-
	2x2	-1.08881	12.16434	-18.6075	-2.52313	-2.51377	4	1	-
	1x2	4.27637	0.80105	5.265283	0.00071	2.58585	-	5	-
SRB	2x4	15.38500	3.32871	-5.17503	0.56147	3.52504	3	2	-
	2x2	17.31248	3.32871	-10.0857	-3.19013	1.84133	3	2	-
	1x2	1.77197	-4.64416	4.405291	0.00060	0.38343	-	5	-
MNE	2x4	4.25423	5.147908	-4.93329	6.63766	2.77663	4	1	-
	2x2	4.70067	2.144561	-4.61112	1.67794	0.97801	4	1	-
	1x2	13.6567	-1.42346	10.91534	0.00078	5.78734	-	5	-
BIH	2x4	4.78496	-0.41293	-7.04773	1.55228	-0.28086	3	2	-
	2x2	10.23845	0.70221	-11.101	-5.07546	-1.30896	2	3	-
	1x2	2.97464	0.50195	7.7684	0.00042	2.81135	-	5	-
EU	2x4	4.44151	1.99303	-4.73869	2.51415	1.0525			
	2x2	11.06892	5.20035	-13.8091	-4.18577	-0.4314			
	1x2	0.87615	-2.96312	6.61026	0.00053	1.13096			
17 Countries	2x4	5.46665	1.72078	-4.5287	1.789622	1.11209			
	2x2	7.86934	4.12076	-13.8284	-4.50481	-1.58578			
	1x2	-3.95752	2.31327	2.44492	0.00058	0.20031			

Table 5. Target projections (in %) as an average value during the period of time t

DMU	2x4						2x2				1x2		
	I_1	I_2	O_1	O_2	O_3	O_4	I_1	I_2	O_1	O_2	I_1	O_3	O_4
ALB	39.7	21.7	17.2	41.5	0.0	0.0	46.6	38.7	0.0	8.5	52.8	0.0	0.0
MKD	8.3	8.4	0.0	21.6	2.7	0.0	45.6	37.5	0.0	6.2	25.5	55.3	0.0
SRB	31.5	13.6	12.0	0.0	5.2	19.8	45.6	16.5	17.4	0.0	57.3	31.0	0.0
MNE	55.3	23.4	16.2	0.6	0.1	14.5	62.9	27.6	18.4	0.0	70.8	25.2	0.0
BIH	18.1	17.8	18.3	1.4	3.7	0.0	36.2	22.6	23.4	0.0	37.8	11.7	0.0
WB	30.6	17.0	12.7	13.0	2.3	6.9	47.4	28.6	11.8	2.9	48.8	24.6	0.0
EU	14.2	5.1	6.7	8.3	0.2	0.2	45.7	17.4	8.0	0.7	36.9	48.7	0.0
17 Countries	17.5	8.3	7.2	13.8	0.9	3.0	38.2	20.4	6.5	5.9	37.8	25.4	0.3

Note: I_1- investment; I_2- expenditure; O_1- GDP; O_2- revenue; O_3- GNI; O_4 -trada

Table 6. The efficiency of DMU_s with respect to different value of α for (2x4) grouping

DMU	α=0	α =0.2	α =0.4	α =0.6	α =0.8	α =1	Average	Rank	
								E_f^f	E_f^c
ALB	1.32076	1.20354	1.09932	1.00339	0.91306	0.82921	1.06155	16	16
MKD	1.64892	1.47608	1.30848	1.15823	1.02940	0.91729	1.25640	10	11
SRB	1.44673	1.32608	1.21360	1.10870	1.01074	0.91918	1.17084	13	13
MNE	1.41217	1.25509	1.11776	0.99823	0.88823	0.78575	1.07620	15	17
HRV	1.53200	1.40402	1.29232	1.18829	1.09383	0.99079	1.25021	11	9
BIH	1.32375	1.18678	1.06651	0.98723	0.92407	0.81726	1.05093	17	15
ROU	1.63990	1.45973	1.29954	1.15653	1.02779	0.91238	1.24931	12	12
BGR	1.63819	1.47948	1.33414	1.20101	1.07729	0.95985	1.28166	8	10
TUR	1.70375	1.53542	1.38228	1.24284	1.11580	1.00000	1.33002	5	2
HUN	1.76665	1.57689	1.40767	1.25695	1.12264	1.00000	1.35513	4	2
POL	1.55308	1.41337	1.29839	1.19157	1.09229	1.00000	1.25812	9	8
CZE	1.62460	1.47601	1.33923	1.21331	1.09684	0.98809	1.28968	6	4
ARM	1.42809	1.30938	1.19975	1.09880	1.00831	0.92455	1.16148	14	14
KAZ	1.81977	1.63292	1.46386	1.30620	1.14467	1.00000	1.39457	3	7
MDA	2.52229	2.15671	1.78345	1.47360	1.21552	1.00000	1.69193	1	2
RUS	1.62937	1.47016	1.33029	1.20550	1.09183	1.00000	1.28786	7	5
UKR	1.91950	1.67755	1.46793	1.29214	1.16105	1.00000	1.41969	2	6

Table 7. The efficiency of DMU_s with respect to different value of α for (2x2) grouping

DMU	α=0	α =0.2	α =0.4	α =0.6	α =0.8	α =1	Average	Rank	
								E_f^f	E_f^c
ALB	0.93898	0.89194	0.84753	0.80555	0.76047	0.70399	0.82474	17	17
MKD	0.93986	0.89371	0.85029	0.80946	0.76738	0.70906	0.82829	16	15
SRB	1.44200	1.31973	1.20671	1.10220	1.00553	0.91610	1.16538	8	8
MNE	1.33951	1.19160	1.06054	0.94407	0.84028	0.74759	1.02060	12	12
HRV	1.47523	1.36865	1.27081	1.18082	1.09182	0.98221	1.22826	5	6
BIH	1.18885	1.11824	1.05102	0.98723	0.92289	0.81726	1.01425	13	11
ROU	1.25416	1.15725	1.06944	0.98965	0.91606	0.81372	1.03338	11	13
BGR	1.39395	1.27348	1.16640	1.07144	0.98620	0.86078	1.12538	9	10
TUR	1.49680	1.38483	1.27989	1.18101	1.08783	1.00000	1.23839	3	1
HUN	1.55670	1.43381	1.31692	1.20581	1.10014	1.00000	1.26890	2	4
POL	1.41072	1.31217	1.21990	1.13362	1.05180	0.92362	1.17531	7	7
CZE	1.27600	1.20374	1.13483	1.06922	1.00597	0.89302	1.09713	10	9
ARM	1.06693	1.00429	0.94381	0.88521	0.83000	0.77891	0.91819	14	14
KAZ	1.47494	1.36939	1.26971	1.17527	1.08511	1.00000	1.22907	4	2
MDA	1.08251	0.95327	0.85029	0.77581	0.70980	0.65103	0.83712	15	16
RUS	1.47623	1.35069	1.24409	1.15175	1.07106	1.00000	1.21563	6	3
UKR	1.64761	1.51116	1.38542	1.26921	1.15999	1.00000	1.32890	1	5

Table 8. The efficiency of DMU_s with respect to different value of α for 1x2 grouping

DMU	α=0	α=0.2	α=0.4	α=0.6	α=0.8	α=1	Average	Rank	
								E_f^f	E_f^C
ALB	1.25742	1.03130	0.82968	0.67395	0.55115	0.45274	0.79937	13	13
MKD	1.64892	1.45103	1.22242	1.02826	0.86302	0.72217	1.15597	3	4
SRB	1.02473	0.87909	0.72546	0.59882	0.49396	0.40679	0.68814	14	15
MNE	0.60537	0.53585	0.45646	0.38852	0.33023	0.28010	0.43275	16	16
HRV	1.23357	1.09340	0.93345	0.79632	0.67843	0.57685	0.88534	12	11
BIH	1.32375	1.16311	0.98589	0.83577	0.70813	0.59924	0.93598	11	9
ROU	1.41701	1.21658	1.01158	0.84219	0.70143	0.58391	0.96212	10	10
BGR	0.93062	0.82815	0.70733	0.60404	0.51542	0.43917	0.67079	15	14
TUR	1.70375	1.53542	1.38228	1.24284	1.11580	1.00000	1.33002	2	2
HUN	1.44039	1.30727	1.13469	0.98410	0.85235	0.73682	1.07594	6	3
POL	1.55308	1.36210	1.15051	0.97207	0.82098	0.69261	1.09189	5	5
CZE	1.42669	1.24254	1.03876	0.87027	0.73003	0.61263	0.98682	8	8
ARM	1.37083	1.20827	1.02459	0.86605	0.73109	0.62175	0.97043	9	12
KAZ	0.38722	0.35019	0.31354	0.27905	0.24695	0.21727	0.29904	17	17
MDA	2.52229	2.15671	1.78345	1.47360	1.21552	1.00000	1.69193	1	1
RUS	1.62937	1.33824	1.10786	0.92268	0.77192	0.64787	1.06966	7	7
UKR	1.47110	1.32615	1.15175	0.99813	0.86263	0.74298	1.09212	4	6

Table 9. Table of the influence tendencies evaluation for the correlative relations and with the EU membership

Grouping (1x2)				Grouping (2x2)				Grouping (2x4)			
DMU	Rank (CCR)	Direction		DMU	Rank (CCR)	Direction		DMU	Rank (CCR)	Direction	
		C-C	EU			C-C	EU			C-C	EU
KAZ	17	b	b	ALB	17	a	b	MNE	17	b	b
MNE	16	b	b	MDA	16	b	b	ALB	16	a	b
SRB	15	b	b	MKD	15	b	b	BIH	15	a	b
BGR	14	b	a	ARM	14	b	b	ARM	14	b	b
ALB	13	a	b	ROU	13	a	a	SRB	13	b	b
ARM	12	a	b	MNE	12	a	b	ROU	12	a	a
HRV	11	b	a	BIH	11	a	b	MKD	11	a	b
ROU	10	a	a	BGR	10	b	a	BGR	10	a	a
BIH	9	a	b	CZE	9	a	a	HRV	9	b	a
CZE	8	b	a	SRB	8	a	b	POL	8	a	a
RUS	7	b	b	POL	7	a	a	KAZ	7	b	b
UKR	6	a	b	HRV	6	b	a	UKR	6	b	b
POL	5	b	a	UKR	5	b	b	RUS	5	b	b
MKD	4	a	b	HUN	4	b	a	CZE	4	b	a
HUN	3	b	a	RUS	3	b	b	TUR	3	b	b
TUR	2	b	b	KAZ	2	b	b	HUN	2	b	a
MDA	1	a	b	TUR	1	b	b	MDA	1	a	b

Note: Classification of correlation (C-C)

For the Fuzzy DEA (α-cut), the variable values are defined by the triangular Fuzzy numbers for each variable.

Using the Spearman statistical test, a strong correlative relation between the two rankings is evaluated (based on the DEA-CCR model and Fuzzy DEA model). The Spearman rank correlation coefficient is 0.96 for the (1x2) grouping, 0.94 for the (2x2) grouping, and 0.91 for the (2x4) grouping. This shows that in order to rank the DMUs evaluation, both alternatives may be used, based on the DEA-CCR model or the Fuzzy DEA model, but the DEA-CCR model can particularly be used when time is considered as discreet variable and the rank is obtained based on the average values of the efficiencies, and meanwhile, if time is accepted as a unique "moment", ranking may also be performed by using Fuzzy DEA (the α-cut) approach.

In order to show the evaluation of the impact for the correlative relations that exist between the variables for each DMU based on the Wilcoxon test and the ranking results according to the CCR model, the Table 9 is given. In the "a" direction are the countries that have an average correlation coefficient among the variable factors $\rho_{average} \geq 0.7$ and in the "b" direction are the countries that have the average of the correlation coefficients smaller than 0.7. This is how it is operated to evaluate the impact on the performance value in the EU member countries (where in the "a" direction are the EU member countries and in the "b" direction are the EU non-member countries). In order to evaluate the influence tendencies in the DMUs performance based on the above directions, the Wilcoxon test is used and the following table is developed with the results for each grouping (1x2), (2x2), and (2x4) ranks and both directions.

7 DMUs are in each grouping (1x2), (2x2), and (2x4) where the correlative relations $\rho_{average} \geq 0.7$. Using the Wilcoxon statistical test based on the raking results, it is noted that the statistic W = $\sum_{i=1}^{n} R(X_i)$ (is the sum of the DMUs rankings positioning according to "a" direction, where n is the number of the "a" direction DMUs): for the (1x2) grouping we have $W_a = \sum_{i=1}^{7}(R_i) = (13 + 12 + 10 + 9+6+4+1) = 55$; for the (2x2) grouping we have $W_a = \sum_{i=1}^{7}(R_i) = 77$; for the (2x4) grouping we have $W_a = \sum_{i=1}^{7}(R_i) = 73$. By looking at the Wilcoxon table, the theoretical value for α=0.05 when the DMUs number of the direction is 7 and the general number of the DMUs is 17, this value is 56. By comparing W_a with this theoretical value it is noted that: for the (1x2) grouping we have $W_a = 55 < 56 = t_{7,10,1-\alpha}$, for the (2x2) grouping we have $W_a = 77 > 56 = t_{7,10,1-\alpha}$, and for the (2x4) grouping we have $W_a = 73 > 56 = t_{7,10,1-\alpha}$. These values show that only for the 2x2 and 2x4 groupings, the "a" direction is with a better performance value than the "b" direction.

For the second classification that is related with the impact of the EU membership, by applying the Wilcoxon test is noted that: for the 1x2 grouping, the $W_a = \sum_{i=1}^{6}(R_i) = (14+11+10+8+5+3) = 51 > 43 = t_{6,11,1-\alpha}$; for the (2x2) grouping, the $W_a = \sum_{i=1}^{6}(R_i) = 49 > 43 = t_{6,11,1-\alpha}$; for the (2x4) grouping, the $W_a = \sum_{i=1}^{6}(R_i) = 45 > 43 = t_{6,11,1-\alpha}$. These values show that the "a" direction of the EU membership is with a performance value that is better than the other direction.

These conclusions are obtained even if the Fuzzy DEA ranking results are used.

There are many works that use the DEA method for the performance evaluation with the efficiency measuring where a chain of efficiency evaluation is developed in different modelling [13].

There are approaches with modelling as a multi-phase process and approaches with modelling as a frame network structure, etc.

Here we give a particular approach of the overall performance evaluation with efficiency measurements using an efficiency evaluation chain by the DEA or Fuzzy DEA models. For the study of the sensitive analysis, in this chain are three groupings (1x2), (2x2), (2x4). This approach serves to an analysis from the CSAM viewpoint for the evaluation of the performance progress of the macroeconomic and financial development of the 17 countries.

For the overall evaluation of the performance of DMU_p (Ef_{op}), (following the sensitive analysis of the (1x2), (2x2), and (2x4) grouping efficiencies), we use a simple model of the linear programming that defines the efficiency value as follows:

$Ef_{op} = \sum_{r=1}^{r} W_r Ef_{rp}$, (r = 1,2,3), where $\sum_{r=1}^{r} W_r = 1$.

For each input-output relation, we have:

$$Ef_p(1x2) \rightarrow W_1 = \frac{3}{13};\ Ef_p(2x2) \rightarrow W_2 = \frac{4}{13};\ Ef_p(2x4) \rightarrow W_3 = \frac{6}{13}$$

$$Ef_{op} = W_1\ Ef_{1p} + W_2 Ef_{2p} + W_3 Ef_{3p};\ W_r = \frac{Component\ r\ of\ group\ (input + output)}{total(input + output)\ across\ all\ the\ components}$$

total (input + output) across all the components = (3+4+6) = 13

W_r may be presented as the weigh value of the marginal unit of efficiency Ef_r.

Table 10. Table of the overall efficiency values (following the sensitive analysis of the (1x2), (2x2), and (2x4) grouping efficiencies)

DMU	Ef_CCR	EF_Fuzzy	Rank (CCR)	Rank (Fuzzy)
ALB	0.66329	0.92818	16	16
MKD	0.78576	1.10150	10	10
SRB	0.75286	1.05777	14	13
MNE	0.64172	0.91061	17	17
HRV	0.83826	1.15925	8	8
BIH	0.76192	1.01312	13	15
ROU	0.77191	1.11659	12	9
BGR	0.77499	1.09260	11	11
TUR	0.99929	1.30183	1	3
HUN	0.91984	1.26417	2	4
POL	0.87776	1.19428	6	6
CZE	0.84579	1.16054	7	7
ARM	0.73323	1.04253	15	14
KAZ	0.79323	1.09083	9	12
MDA	0.88333	1.42891	5	1
RUS	0.90555	1.21528	3	5
UKR	0.88990	1.31616	4	2

It is noted from the Table 10 that:

The average efficiency value of the Western Balkans countries according to the CCR model is 0.72111.

The average efficiency value of the EU countries according to the CCR model is 0.83809.

The average efficiency value of the 17 countries according to the CCR model is 0.81404.

The Spearman rank correlation coefficient between the two ranks of the overall sensitive efficiencies according to DEA-CCR model and Fuzzy DEA model is 0.93 (strong correlative relation), which shows that each alternative may be used to rank the performance evaluation. This approach for the performance evaluation and efficiency measuring through an efficiency evaluation chain using DEA and Fuzzy DEA, may be used in other areas as well.

5. General Conclusions

By using the basic DEA and Fuzzy DEA models, particularly in the economic and financial applications, we can discover better the influences of the variable factors and the resources for the interpretation of the DMUs inefficiencies. The approach of the general performance evaluation with the efficiency measuring through an efficiency evaluation chain using DEA and Fuzzy DEA, creates the possibility for a deeper knowledge with the CSAM study. Use of the "deviation" elasticity coefficient for the levels of the efficiency values ($d^{ef}(x_t, y_t)$), specifically when time is presented as a discreet variable, can serve as a useful instrument for the study and evaluation of a DMU's inefficiency sensitivity in relation to the inefficiencies of the group as a whole. The evaluation of ranks based on the efficiency value evaluated during the period of time 't' can be made using the DEA-CCR model and (α-cut) approach (Fuzzy DEA). Based on the correlative influences impact, the Wilcoxon test showed that there cannot be said that those tendencies are dominant (as for the (1x2) grouping, no impact showed up). This shows that, in the DEA application, the ratios of the relations between the input-output variables in a competitive activity between the DMUs are dominant. The evaluation of the efficiency values change ratio during the period of time 't' gave its tableau for the evaluation of the DMUs' performance values. In the end, we can say that by coordinating and comparing the results obtained with the DEA method and the Fuzzy DEA approach, the study connoisseur analysis is deeper and more complete.

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