ANALYSIS OF THE EFFICIENCY OF COMPANIES IN SERBIA BASED ON THE DEA SUPER-RADIAL APPROACH

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The issue of analyzing the company's efficiency factors is very challenging, current, significant, and complex. Based on that, this paper analyzes the efficiency of companies in Serbia based on the DEA Super-Radial approach. According to the results of the Super-Radial (Super-CCR-I and Super-CCR-O) model in 2021, none of the analyzed companies in Serbia was efficient. This means that the input/output elements were poorly managed. According to the results of the Super-Radial (Super-BCC-I) model in the same year in Serbia, two companies were efficient. These are JP EPS and NIS. Other observed companies were inefficient. According to the results of the Super-Radial (Super-BCC-O) model in 2021, three companies in Serbia were efficient. They are MERCATA VT, MY KIOSK GROUP, and KNEZ PETROL COMPANY. Other observed companies were inefficient. According to the projection, to achieve the planned efficiency, for example, at the DMU unit of JP EPS in 2021, it was necessary to reduce the number of employees by 51.93%, business assets by 57.18%, capital by 56.34%, business income by 3.00% and increase the net profit by 235.28 %. According to Slack analysis, for example, in the DMU unit of JP EPS, to increase efficiency, it is necessary to reduce the number of employees by 12469, business assets by 548953, capital by 339215 and increase the net profit by 35984.19 monetary units. The efficiency of companies in Serbia was influenced by numerous macro and micro factors: the economic climate, the efficiency of management of human resources, assets, capital, sales, and profit, etc. Their adequate control can significantly influence the achievement of the company's target profit in Serbia.

Keywords: Efficiency; Companies; Serbia; DEA Super-Radial model.

INTRODUCTION

It is a very challenging problem to evaluate the efficiency of companies based on the DEA model (Alam et al., 2022; Amirteimoori et al., 2022; Fotova Čiković & Lozić, 2022; Park, & Kim, 2022; Sala-Garrido, 2023; Zohreh Moghaddas et al., 2022). In this paper, the financial efficiency of companies in Serbia is investigated using the DEA Supe-Radila model. The goal and purpose of this are to see as fully as possible the efficiency of companies in Serbia in the function of improvement in the future by applying relevant measures, and in this, among other things, the scientific and professional contribution of this work is reflected.

In the world, the literature dedicated to the development and application of the DEA model in economics is very rich (Amini et al., 2019; Andersen, & Petersen, 1993; Banker et al., 1984; Chang et al., 2020; Chen et al., 2021; Fenyves, & Tarnóczi, 2020; Guo, & Cai, 2020;

Lee et al., 2011; Lin et al., 2020; Mandić et al., 2017; Pendharkar et al., 2021; Podinovski et al., 2021; Rostamzadeh et al., 2021; Tone, 2002; Tsai et al., 2021). This is also the case with literature in Serbia (Lukic & Hadrovic Zekic, 2019; Lukic & Kozarevic, 2019; Lukic et al., 2017, 2020; Lukic, 2018, 2021, 2022a,b, 2023a,b,c,d,e; Vojteški Kljenak & Lukić, 2022). All this literature serves as a theoretical-methodological and empirical basis for finding the super financial efficiency of companies in Serbia based on the DEA Super-Radial model.

Continuous monitoring of the company's efficiency, in the specific case of Serbia, is a basic assumption for improvement in the future by applying relevant measures. This reflects the primary research hypothesis in this paper. The research methodology of the given hypothesis is based on the application of the DEA Super-Radial model. In principle, DEA models concerning ratio analysis provide more realistic information about the financial efficiency of companies. Because it uses several input/output elements integrated. The application of the DEA Super-Radial model has a significant role in understanding the real situation regarding the efficiency of companies in Serbia. Their application clearly indicates which companies are efficient and which are not, and which measures should be taken in order to transform inefficient into efficient companies in Serbia (Amin, & Hajjami, 2021; Chen et al., 2018, 2020, 2021a,b; Cooper et al., 1999; Đurić et al., 2020; Lukić 2022a,b,c; Martić, & Savić, 2001; Radonjić, 2020; Rasoulzadeh et al., 2021; Stević et al., 2022; Stojanović et al., 2022).

The necessary empirical data for the research of the treated problem in this paper were collected from the Agency for Economic Registers of the Republic of Serbia. The data is "produced" following relevant international standards. This facilitates and enables an international comparison of the results obtained in this paper.

METHODOLOGY

In this paper, the financial efficiency of companies in Serbia is investigated using the DEA Super-Radial model. Suppose we have n DMUs {DMU $_j$ ($j = 1,2,..., n$)}. Each consumes a set of m inputs, x_{ij} ($i =1,2,..., m$), in the production of a set *of* s outputs, Y_{rj} ($r =1,..., s$). Based on VRS (variable return to scale) model (Banker et al., 1984), the input-oriented VRS super-efficient efficiency measurement model can be expressed as:

$$\min \quad \theta$$
$$s.t \sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{ik}, \qquad i = 1, ..., m$$
$$j \neq k$$
$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{rk}, \qquad r = 1, ..., s \qquad (1)$$
$$j \neq k$$

$$\sum_{j=1}^{n} \lambda_j = 1$$
$$j \neq k$$
$$\lambda \geq 0, \quad j \neq k$$

RESULTS AND DISCUSSION

When analyzing the efficiency of companies in Serbia based on the DEA Super-Radial model of input and output orientation, with constant and variable returns, the following elements were used as input elements: a number of employees, business assets and capital, and as output elements: business income and net profit / net loss. The selected input/ output data fully show the financial efficiency of companies. That is why they are used when analyzing the super financial efficiency of the most important companies in Serbia. DMU units are considered the largest companies in Serbia according to business income that operated in 2021. Table 1 shows the input/output elements for 2021.

The input/output data statistics show a high correlation between the given variables. In further presentations of the treated issues in this paper, we will present the results of the DEA Super-Radial model. (All calculations and results in this paper are the author's own.) Table 2 shows the results of the Super-Radial (Super-CCR-I and Super-CCR-O) model.

The company is super-efficient if the score is equal to 1. In the case of inefficient companies, the score is different from 1.

According to the results of the Super-Radial (Super-CCR-I and Super-CCR-O) model, none of the analyzed companies in Serbia was efficient in 2021. Their scores are different from 1. This means that the input/output elements were poorly managed. The target efficiency of companies in Serbia can be achieved by their adequate control... An important role in this is the application of modern concepts of cost management, sales revenue, profit, and customers. Digitization of the entire business is also one of the critical factors for the business success of modern companies. Table 3 shows the results of the Super-Radial (Super-BCC-I and Super-BCC-O) model.

Table 1: Input / Output data

DMU	Sector	(I) Number of employees	(I) Business assets	(I) Capital	(O) Business income	(O) Net profit / Net loss
JP EPS BELGRADE	D-supply of electricity, gas, steam, and air conditioning	24.013	959.978.120	602.051.809	319.834.327	- 15.492.467
NIS AD NOVI SAD	B-mining	11.544	411.025.157	262.836.211	310.238.277	20.957.03
TELEKOM SRBIJA AD, BELGRADE	J-information and communications	12.333	490.964.452	185.581.329	144.701.134	6.709.246
JP SRBIJAGAS NOVI SAD	D-supply of electricity, gas, steam, and air conditioning	2.471	287.578.349	129.753.548	122.489.585	5.802.970
DELHAIZE S	G-wholesale and retail trade; repair of motor vehicles and motorcycles	11.637	83.293.447	42.881.583	118.912.715	2.989.461
NELT CO. DOO BELGRADE	G-wholesale and retail trade; repair of motor vehicles and motorcycles	3.121	37.637.630	18.721.522	87.126.267	248.331
DELTA HOLDING DOO BELGRADE	M-professional, scientific, innovative, and technical activities	3.311	149.188.208	83.718.203	76.424.081	2.497.651
MERCATA VT DOO	G-wholesale and retail trade; repair of motor vehicles and motorcycles	1.078	12.763.274	1.093.035	75.391.561	958.452
PHOENIX PHARMA DOO BELGRADE	G-wholesale and retail trade; repair of motor vehicles and motorcycles	2.749	39.024.302	10.837.865	74.941.130	1.772.275
COCA-COLA HBC - SERBIA DOO ZEMUN	C-processing industry	1.623	56.832.256	43.084.091	64.769.803	6.783.008
MY KIOSK GROUP DOO	K-financial activities and insurance activities	3.589	12.247.043	2.622.462	64.365.537	596.487
TARKETT DOO BACA PALANKA	C-processing industry	3.215	38.174.721	19.813.533	58.565.776	2.493.835
MK GROUP DOO BELGRADE	K-financial activities and insurance activities	2.151	94.429.880	46.830.681	57.675.525	17.461.388
KNEZ PETROL COMPANY DOO BELGRADE	M-professional, scientific, innovative, and technical activities	1.183	11.849.900	3.417.319	52.652.064	3.447.603
HEMOFARM AD VRŠAC	C-processing industry	3.922	68.380.107	47.524.813	49.284.002	5.091.653
MILŠPED DOO BELGRADE	H-transport and storage	2.758	27.749.201	3.547.447	45.553.539	1.084.644
FCA SERBIA DOO KRAGUJEVAC	C-processing industry	2.072	49.521.815	31.195.733	41.512.762	- 3.866.438
EMSAD BELGRADE	D-supply of electricity, gas, steam, and air conditioning	1.656	105.336.795	69.530.738	39.043.259	2.362.403
KOEFIK DOO BELGRADE	G-wholesale and retail trade; repair of motor vehicles and motorcycles	2.983	34.703.094	8.502.607	38.062.233	152.317
YURA CORPORATION DOO RACA	C-processing industry	6.913	27.713.854	4.458.143	37.188.438	- 1.092.021

Note: Data are expressed in thousands of dinars. The number of employees is expressed in whole numbers
Source: Annual report on the operations of economic units in the economy in 2021. Serbian Business Registers Agency

Table 2: Super-Radial (Super-CCR-I and Super-CCR-O) model results

No.	DMU	Super-Radial(Super-CCR-I) Returns to Scale = Constant (0 =< Sum of Lambda < Infinity)		Super-Radial(Super-CCR-O) Returns to Scale = Constant (0 =< Sum of Lambda < Infinity)	
		Score	Rank	Score	Rank
1	JP EPS	6.12E-02	20	6.12E-02	20
2	NIS	0.31115	11	0.31115	11
3	TELEKOM SERBIA	9.46E-02	19	0.094582	19
4	JP SRBIJAGAS	0.20389	14	0.20389	14
5	DELHAIZE S	0.260436	12	0.260436	12
6	NELT CO.	0.392684	6	0.392684	6
7	DELTA HOLDING	0.13402	18	0.13402	18
8	MERCATA VT	2.912059	2	2.912059	2
9	PHOENIX PHARMA	0.35726	7	0.35726	7
10	COCA-COLA HBC - SERBIA	0.669829	5	0.669829	5
11	MY KIOSK GROUP	256.434	1	256.434	1
12	TARKETT	0.312934	10	0.312934	10
13	MK GROUP	1.772034	4	1.772034	4
14	KNEZ PETROL COMPANY	2.249153	3	2.249153	3
15	HEMOPHARM	0.320259	9	0.320259	9
16	MILŠPED	0.322236	8	0.322236	8
17	FCA SERBIA	0.150305	17	0.150305	17
18	EMSAD	0.16225	16	0.16225	16
19	COEFFICIENT	0.185677	15	0.185677	15
20	YURA CORPORATION	0.227171	13	0.227171	13
	Average	13.37665		13.37665	
	SD	55.76638		55.76638	
	Maximum	256.434		256.434	
	The minimum	0.061167		0.061167	
	No. of efficient DMUs =	0		0	
	No. of inefficient DMUs =	20		20	
	No. of over-iteration DMUs =	0		0	

The results of the DEA Super-Radial model can be presented graphically. This is shown by the illustration of the results of the Super BCC-O model in Figure 1. In Figure 1, efficient companies in Serbia are marked with a score 1. The graphic illustration provides a visual insight into the super financial efficiency of the observed companies in Serbia.

In Table 3, efficient companies in Serbia are marked with a score of 1. According to the results of the Super-Radial (Super-BCC-I) model in 2021 in Serbia, two companies were efficient. These are JP EPS and NIS. Other observed companies were inefficient. According to the results of the Super-Radial (Super-BCC-O) model in 2021 in Serbia, three companies were efficient. They are MERCATA VT, MY KIOSK GROUP, and KNEZ PETROL COMPANY. Other observed companies were inefficient. In order to improve the super financial efficiency of companies in Serbia, especially inefficient ones, it is therefore necessary, among other things, to manage the observed input/output elements as efficiently as possible.

The projection of input/output elements shows the deviation of the realized from the planned values of input/output elements. It represents a significant basis for improving the efficiency of the observed DMU units by applying relevant measures. In the specific case, therefore, in order to achieve the planned efficiency in 2021, for example at the DMU unit of JP EPS, it was necessary to reduce the number of employees by 51.93%, business assets by 57.18%, capital by 56.34%, business income by 3.00% and increase the net profit by 235.28%. The projection analysis is similar to the other observed DMU units.

Table 3: Super-Radial (Super-BCC-I and Super-BCC-O) model results

No.	DMU	Super-Radial(Super-BCC-I) Returns to Scale = Variable (Sum of Lambda = 1) Score	Rank	Super-Radial(Super-BCC-O) Returns to Scale = Variable (Sum of Lambda = 1) Score	Rank
1	JP EPS	1	7	1.030931	5
2	NIS	1	7	2.412435	2
3	TELEKOM SERBIA	0.418785	14	0.595383	15
4	JP SRBIJAGAS	1.12797	6	1.065611	3
5	DELHAIZE S	1.156649	5	1.053391	4
6	NELT CO.	0.857021	9	0.964137	9
7	DELTA HOLDING	0.233777	19	0.564693	16
8	MERCATA VT	9.786444	2	1	6
9	PHOENIX PHARMA	0.442959	13	0.902179	10
10	COCA-COLA HBC - SERBIA	0.722427	10	0.870649	11
11	MY KIOSK GROUP	300.3592	1	1	6
12	TARKETT	0.316245	17	0.702323	12
13	MK GROUP	4.455145	3	2.485687	1
14	KNEZ PETROL COMPANY	2.338631	4	1	6
15	HEMOPHARM	0.322785	16	0.595775	14
16	MILŠPED	0.452674	11	0.609504	13
17	FCA SERBIA	0.243888	18	0.427638	19
18	EMSAD	0.185012	20	0.420793	20
19	COEFFICIENT	0.346999	15	0.457986	18
20	YURA CORPORATION	0.447723	12	0.471357	17
	Average	16.31072		0.931524	
	SD	65.20087		0.553994	
	Maximum	300.3592		2.485687	
	The minimum	0.185012		0.420793	
	No. of efficient DMUs =	2		3	
	No. of inefficient DMUs =	18		17	
	No. of over-iteration DMUs =	0		0	

The slack analysis is very important. It shows what measures should be taken to transform an inefficient DMU unit into an efficient one (Zhu, & He, 2023). So, for example, at the DMU unit of JP EPS, to increase efficiency, it is necessary to reduce the number of employees by 12469, business assets by 548953, capital by 339215, and increase the net profit by 35984.19 monetary units. The Slack analysis is similar to the other observed DMU units. Determinants of the efficiency of companies in Serbia are macro and micro in nature. In addition to the economic climate, inflation, interest, exchange rate, foreign direct investments, and competition, the efficiency of companies in Serbia is significantly affected by the adequate management of human capital, assets, capital, sales, and profit. Adequate control of these and other factors can achieve the target efficiency of companies in Serbia.

In the literature in Serbia, as far as we know, there is no continuous analysis of the efficiency of companies in Serbia based on the DEA Super–Radial approach. In order to improve the efficiency of companies in Serbia, it is recommended to continuously perform data analysis using different DEA models. It provides a basis for the selection of relevant measures for these purposes.

In order to get a more complete overview of the financial efficiency of companies in Serbia, it is recommended that in addition to the ratio analysis, DEA analysis, and multi-criteria decision-making models are used (TOPSIS, VIKOR, MARCOS, and others).
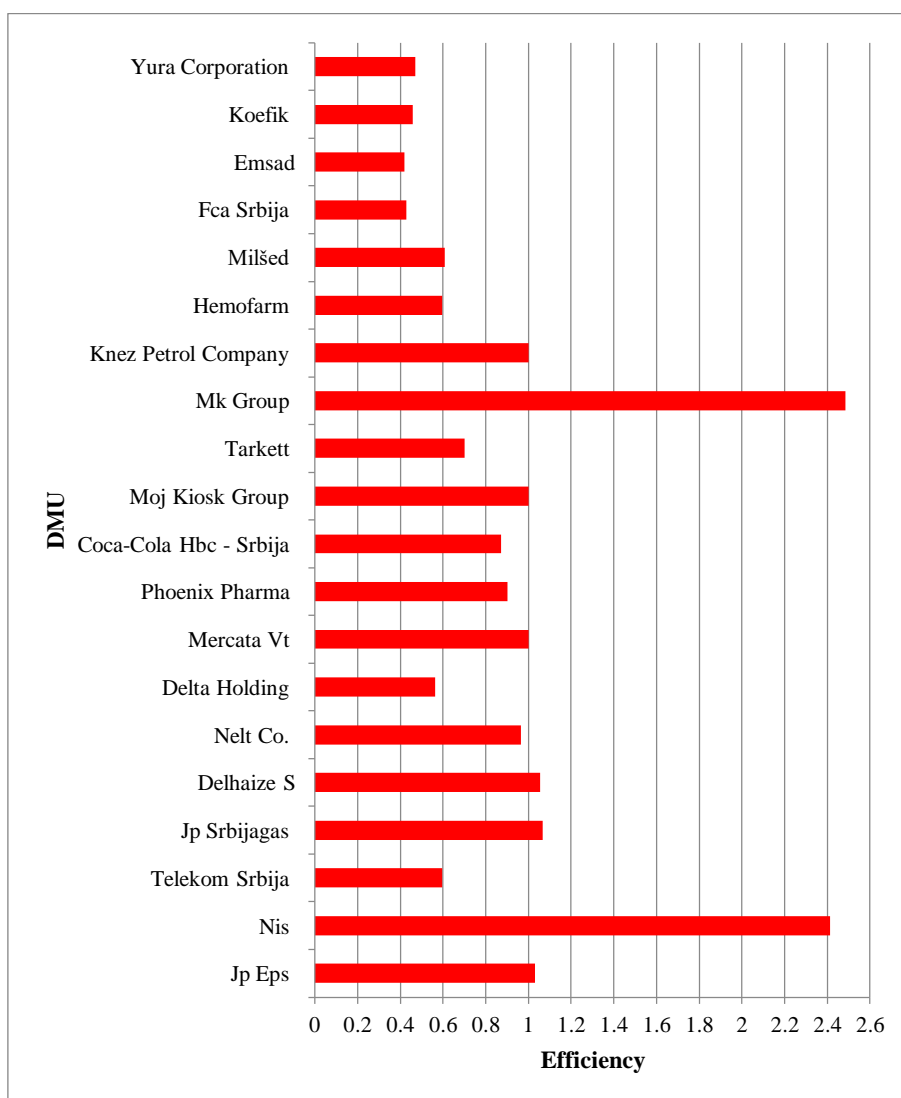
Figure 1: Super-Radial (Super-BCC-O)

CONCLUSION

We are able to conclude the following based on the conducted empirical research on the problem treated in this paper:

‒ According to the results of the Super-Radial (Super-CCR-I and Super-CCR-O) model in 2021, none of the analyzed companies in 2021 in Serbia was efficient, among other things due to poor management of input/output elements.

‒ According to the results of the Super-Radial (Super-BCC-I) model in 2021 in Serbia, two companies were efficient. These are JP EPS and NIS. Other observed companies were inefficient.

‒ According to the results of the Super-Radial (Super-BCC-O) model in 2021 in Serbia, three companies were efficient. They are MERCATA VT, MY KIOSK GROUP, and

KNEZ PETROL COMPANY. Other observed companies were inefficient.

‒ In the specific case, according to the projection, in order to achieve the planned efficiency in 2021, for example, the DMU unit of JP EPS, it was necessary to reduce the number of employees by 51.93%, business assets by 57.18%, capital by 56.34%, business income by 3.00% and increase the net profit by 235.28%.

‒ According to the Slack analysis, for example, in order to increase the efficiency of the DMU unit of JP EPS, it is necessary to reduce the number of employees by 12469, business assets by 548953, capital by 339215, and increase the net profit by 35984.19 monetary units.

It is recommended to organize effective control of critical factors of business success (asset

management, capital, sales, profit, and human resources) and others in order to achieve the target efficiency of companies in Serbia.

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ANALIZA EFIKASNOSTI KOMPANIJA U SRBIJI NA BAZI DEA SUPER-RADIJALNOG PRISTUPA

Pitanje analize faktora efikasnosti kompanija je veoma izazovno, aktuelno, značajno i kompleksno. Na osnovu toga, ovaj rad analizira efikasnost kompanija u Srbiji na osnovu DEA Super-Radijalnog pristupa. Prema rezultatima Super-Radijalnog (Super-CCR-I i Super-CCR-O) modela u 2021. godini, nijedna od analiziranih kompanija u Srbiji nije bila efikasna. To znači da se ulazno/izlaznim elementima loše upravlja. Prema rezultatima Super-Radijalnog (Super-BCC-I) modela, iste godine u Srbiji dve kompanije su bile efikasne. To su JP EPS i NIS. Ostale posmatrane kompanije bile su neefikasne. Prema rezultatima Super-Radijalnog (Super-BCC-O) modela u 2021. tri kompanije u Srbiji bile su efikasne. To su MERCATA VT, MOJA KIOSK GRUPA i KNEZ PETROL COMPANI. Ostale posmatrane kompanije bile su neefikasne. Prema projekciji, da bi se postigla planirana efikasnost, na primer, u jedinici DMU JP EPS u 2021. godini bilo je potrebno smanjiti broj zaposlenih za 51,93%, poslovnu imovinu za 57,18%, kapital za 56,34%, poslovni prihod za 3,00% i povećanje neto dobiti za 235,28%. Prema Slack analizi, na primer, u DMU jedinici JP EPS, da bi se povećala efikasnost, potrebno je smanjiti broj zaposlenih za 12469, poslovnu imovinu za 548953, kapital za 339215 i povećati neto dobit za 35984,19 novčanih jedinice. Determinante efikasnosti kompanija u Srbiji su ekonomska klima, efikasnost upravljanja ljudskim resursima, imovinom, kapitalom, prodajom i profitom i dr. Njihova adekvatna kontrola može značajno uticati na postizanje ciljnog profita kompanija u Srbiji.

Ključne reči: Efikasnost; Preduzeća; Srbija; DEA Super-Radijalni modeli.