

Analysis Of The Efficiency Of Insurance Companies In Serbia

DOI: <https://doi.org/10.55707/eb.v10i2.128>

Original Scientific article

UDK 368.03:005.336.1(497.11)

KEYWORDS : efficiency, insurance companies, Serbia, DEA Super-Radial models

ABSTRACT - It is very challenging to investigate the efficiency of insurance companies in all countries based on the DEA (Data Envelopment Analysis) model. This is also the case with Serbia. This paper analyzes the efficiency of insurance companies in Serbia based on the DEA Super-Radial model. According to the results of Super-Radial (Super-CCR-I and Super-CCR-O) in 2021, no insurance company in Serbia was efficient. In the same year, according to the Super-Radial (Super-BCC-I) results, only two insurance companies in Serbia were efficient: DUNAV OSIGURANJE and ĐENERALI OSIGURANJE SERBIA. According to the results of Super-Radial (Super-BCC-O) in 2021 in Serbia, only two insurance companies were efficient: DDOR RE and SAVA ŽIVOTNO. Other insurance companies were ineffective. In order to improve the efficiency of insurance companies in Serbia, it is necessary, in addition to efficient adapting to a dynamic business environment, managing assets, capital, human resources, sales of insurance products and profits as efficiently as possible. Digitalization of the entire business plays a significant role in this. It significantly mitigated the impact of the Covid-19 pandemic on the efficiency of insurance companies in Serbia.

Izvirni znanstveni članek

UDK 368.03:005.336.1(497.11)

KLJUČNE BESEDE: učinkovitost, zavarovalnice, Srbija, DEA Super-Radial modeli

POVZETEK: Raziskovanje učinkovitosti zavarovalnic v državah po modelu DEA (Data Envelopment Analysis) je zelo zahtevno, enako velja tudi za Srbijo. Prispevek analizira učinkovitost zavarovalnic v Srbiji na podlagi modela DEA Super-Radial. Glede na rezultate Super-Radial (Super-CCR-I in Super-CCR-O) v letu 2021 nobena zavarovalnica v Srbiji ni bila učinkovita. Istega leta sta bili po rezultatih Super-Radiala (Super-BCC-I) v Srbiji uspešni le dve zavarovalnici: DUNAV OSIGURANJE in ĐENERALI OSIGURANJE SERBIA. Po rezultatih Super-Radiala (Super-BCC-O) sta bili leta 2021 v Srbiji učinkoviti le dve zavarovalnici: DDOR RE in SAVA ŽIVOTNO. Ostale zavarovalnice so bile neučinkovite. Za izboljšanje učinkovitosti zavarovalnic v Srbiji je potrebno poleg učinkovitega prilagajanja dinamičnemu poslovnemu okolju čim bolj učinkovito upravljati s sredstvi, kapitalom, človeškimi viri, prodajo zavarovalnih produktov in dobičkom, pri čemer ima pomembno vlogo digitalizacija celotnega poslovanja, ki je bistveno omilila vpliv pandemije Covid-19 na učinkovitost zavarovalnic v Srbiji.

1 Introduction

It is a very challenging problem to evaluate the efficiency of insurance companies based on the DEA (data envelopment analysis) model. Considering that, the subject of research in this paper is the analysis of the efficiency of insurance companies in Serbia based on the DEA Super-Radial method. The aim and purpose of this is to see as fully as possible the efficiency of insurance companies in Serbia with the aim of future im-

provement by applying relevant measures. This reflects the scientific and professional contribution of the paper.

The literature devoted to the development and application of DEA models is very rich (Andersen & Petersen, 1993; Banker idr., 1984; Chen idr., 2021; Chang & Wang, 2020; Guo & Cai, 2020; Lee idr., 2011; Lin, 2020; Pendharkar, 2021; Tone, 2002; Dobrovič idr., 2021; Podinovski & Bouzdine-Chameeva, 2021; Rostamzadeh idr., 2021; Fenyves & Tarnóczy, 2020; Amini idr., 2019; Tsai idr., 2021; Sicakyuz, 2023). Likewise, an increasing number of works are devoted to the specifics of the analysis of the efficiency of insurance companies based on the DEA model (Kočović idr., 2010; Lukić, 2010, 2016, 2018a, 2018b, 2021a, 2021b, 2021c, 2021d, 2021e, 2022a, 2022b, 2023; Lukic & Hadrovic Zekic, 2019; Lukic idr., 2017, 2020; Mandić idr., 2017; Rakonjac-Antić, 2018). In this paper, it serves as a theoretical-methodological and empirical basis for evaluating the efficiency of insurance companies in Serbia using the DEA Super-Radial model.

Continuous monitoring of the efficiency of insurance companies, in this specific case in Serbia, is the 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.

The application of the DEA Super-Radial model has a significant role in understanding the real situation regarding the efficiency of insurance companies in Serbia. Its application clearly indicates which insurance companies are efficient and which are not, and which measures should be taken in order to transform inefficient ones into efficient insurance companies.

The necessary empirical data for the research of the problem treated in this work were collected from the National Bank of Serbia. They have been generated in accordance with the relevant international standards. In terms of international comparison, there are no restrictions.

2 Methodology

The investigation of the efficiency of insurance companies in Serbia in this paper is based on the application of the DEA Super-Radial model. Considering that, we will briefly point out its methodological characteristics.

Suppose we have n DMUs $\{DMU_j (j = 1, 2, \dots, n)\}$. Each consumes a set of m inputs, x_{ij} ($i = 1, 2, \dots, m$), in the production of a set of s outputs, Y_{rj} ($r = 1, \dots, s$). Based on the VRS (variable return to scale) model (Banker idr., 1984), the input-oriented VRS super-efficient efficiency measurement model can be expressed as:

$$\begin{aligned}
 & \min \quad \theta \\
 & \text{s. t} \quad \sum_{j=1}^n \lambda_j x_{ij} \leq \theta x_{ik}, \quad i = 1, \dots, m \\
 & \quad \quad \quad j \neq k \\
 & \quad \quad \quad \sum_{j=1}^n \lambda_j y_{rj} \geq y_{rk}, \quad r = 1, \dots, s \quad (1) \\
 & \quad \quad \quad j \neq k \\
 & \quad \quad \quad \sum_{j=1}^n \lambda_j = 1 \\
 & \quad \quad \quad j \neq k \\
 & \quad \quad \quad \lambda \geq 0, \quad j \neq k
 \end{aligned}$$

3 Results and discussion

When analyzing the efficiency of insurance 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: total assets, capital and salary costs, salary compensation and other personal expenses; and as output elements: business (functional) income and net profit. DMU units are the observed insurance companies in Serbia that operated in 2021. Table 1 shows the input/output elements for 2021.

Table 1*Input / Output data*

DMU	(I) Total assets	(I) Capital	(I) Salary expenses, salary compensation and other personal expenses	(O) Business (functional) income	(O) Net profit
AMS	8164	2921	105	4255	522
DDOR NEW USA	23713	7825	269	12376	703
DDOR RE	1293	667	16	14	3
DUNAV INSURANCE	60772	18501	1017	27833	2519
DANUBE-RE	10053	2520	77	2325	351
GENERALI INSURANCE OF SERBIA	74708	17243	493	19495	3393
GENERALI RE-OSIGURANJE SERBIA	5167	773	32	187	132
GLOBOS INSURANCE	4750	1165	53	3077	382
GRAVES	37212	10171	143	4447	751
MERKUR INSURANCE	5340	686	43	773	48
MILLENNIUM	6740	2048	66	3310	284
OTP INSURANCE	1860	677	684	100	99
SAVA LIFELESS	4617	1435	1664	155	65
ALL LIFE	1545	535	545	31	3
SOGAZ	1679	947	169	61	43
THREE-HEADED	11642	3106	5276	271	481
UNIQA NON-LIFE INSURANCE	6754	1368	2725	254	19
UNIQA LIFE INSURANCE	11643	1024	in 1823	95	59
WINER RE	8041	880	1021	55	62
WINER STADTSCH	48338	6580	9401	322	1178
IN TOTAL	334043	81084	101409	3669	11108

Note: Data are expressed in millions of dinars. I - input, O - output

Source: National Bank of Serbia

Table 2 shows the statistics of input / output elements. (In this paper, all calculations and results are the author's.)

Table 2

Statistics of Input / Output elements

Statistics		Total assets	Capital	Salary expenses, salary compensation and other personal expenses	Business (functional) income	Net gain
N	Valid	20	20	20	20	20
	Missing	0	0	0	0	0
Mean		16701.5500	4053.6000	1281.1000	3971.8000	554.8500
Median		7397.5000	1401.5000	381.0000	296.5000	208.0000
Std. Deviation		21377.83981	5418.97381	2295.78288	7458.75665	889.80975
The minimum		1293.00	535.00	16.00	14.00	3.00
Maximum		74708.00	18501.00	9401.00	27833.00	3393.00
Correlations		Total assets	Capital	Salary expenses, salary compensation and other personal expenses	Business (functional) income	Net gain
Total assets	Pearson Correlation	1	.951 **	.278	.793 **	.948 **
	Sig. (2-tailed)		.000	.236	.000	.000
	N	20	20	20	20	20
Capital	Pearson Correlation	.951 **	1	.067	.917 **	.943 **
	Sig. (2-tailed)	.000		.779	.000	.000
	N	20	20	20	20	20
Salary expenses, salary compensation and other personal expenses	Pearson Correlation	.278	.067	1	-.163	.115
	Sig. (2-tailed)	.236	.779		.492	.629
	N	20	20	20	20	20
Business (functional) income	Pearson Correlation	.793 **	.917 **	-.163	1	.872 **
	Sig. (2-tailed)	.000	.000	.492		.000
	N	20	20	20	20	20
Net gain	Pearson Correlation	.948 **	.943 **	.115	.872 **	1
	Sig. (2-tailed)	.000	.000	.629	.000	
	N	20	20	20	20	20

** . Correlation is significant at the 0.01 level (2-tailed).

In this case, there is therefore a strong correlation between the observed variables at the level of statistical significance, except for salary expenses, salary allowances and other personal expenses.

Table 3 and figures 1 and 2 show the results of the application of the DEA Super-Radial model of input and output orientation with constant return in the assessment of the efficiency of insurance companies in Serbia.

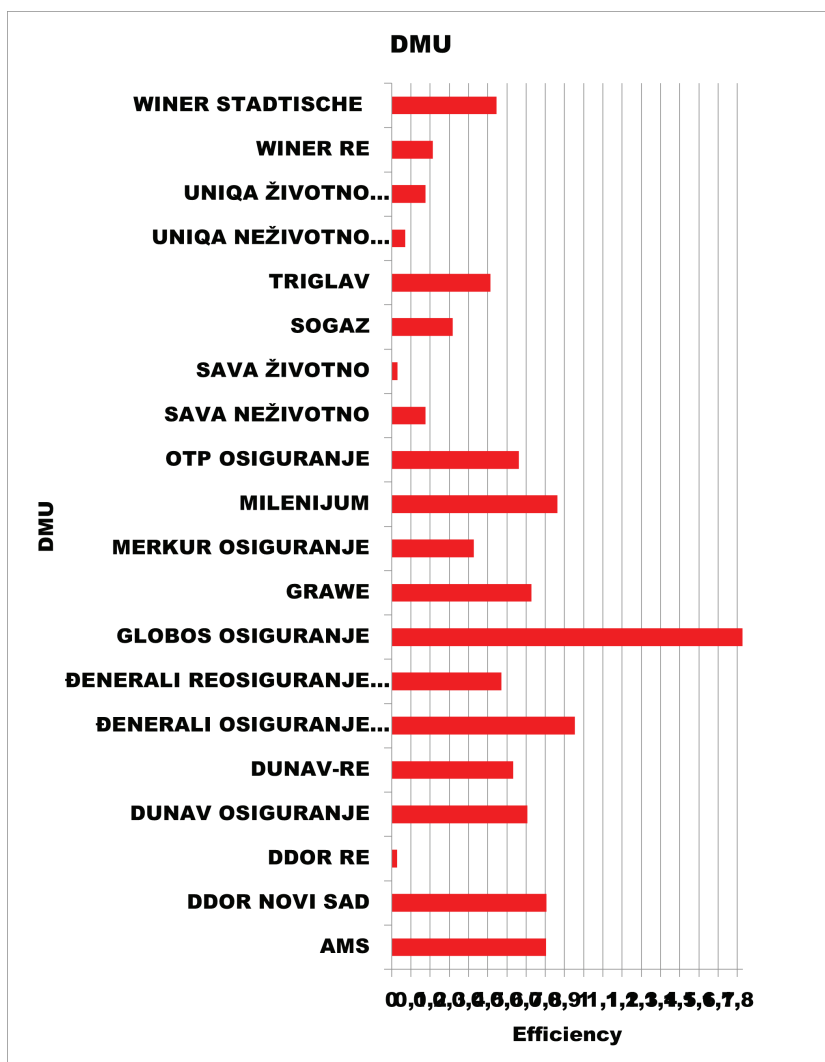
Table 3

Efficiency of insurance companies in Serbia: Super-Radial (Super-CCR-I)

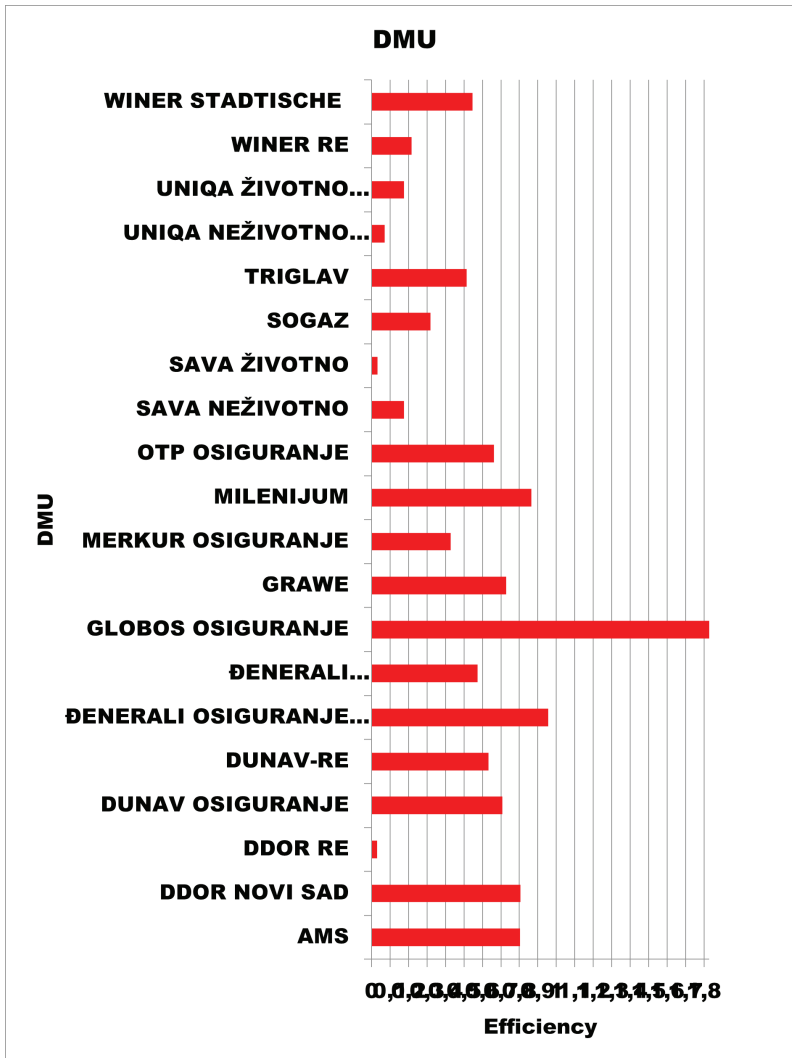
Returns to Scale = Constant and Super-Radial (Super-CCR-O) Returns to Scale = Constant

No.	DMU	Model Name = DEA-Solver LV(V7)/ Super-Ra- dial(Super-CCR-I) Returns to Scale = Constant (0 =< Sum of Lambda < Infinity)	Rank	Model Name = DEA-Solver LV(V7)/ Super-Ra- dial(Super-CCR -O) Returns to Sca- le = Constant (0 =< Sum of Lambda < Infinity)	Rank
1	AMS	0.804568	5	0.804568	5
2	DDOR NEW USA	0.805675	4	0.805675	4
3	DDOR RE	2.89E-02	20	2.89E-02	20
4	DUNAV INSURANCE	0.707005	7	0.707005	7
5	DANUBE-RE	0.632454	9	0.632454	9
6	GENERALI OSIGURANJE SERBIA	0.954881	2	0.954881	2
7	GENERALI REOSIGURANJE SERBIA	0.572317	10	0.572317	10
8	GLOBOS INSURANCE	1.828092	1	1.828092	1
9	GRAVES	0.728646	6	0.728646	6
10	MERKUR INSURANCE	0.426632	13	0.426632	13
11	MILLENNIUM	0.863838	3	0.863838	3
12	OTP INSURANCE	0.661839	8	0.661839	8
13	SAVA LIFELESS	0.175059	17	0.175059	17
14	ALL LIFE	3.10E-02	19	3.10E-02	19
15	SOGAZ	0.318455	14	0.318455	14
16	THREE-HEADED	0.513745	12	0.513745	12
17	UNIQA NON-LIFE INSURANCE	7.03E-02	18	7.03E-02	18
18	UNIQA LIFE INSURANCE	0.175717	16	0.175717	16
19	WINER RE	0.214868	15	0.214868	15
20	WINER STADTSCH	0.545987	11	0.545987	11
	SD	0.408445		0.408445	
	Maximum	1.828092		1.828092	
	The minimum	0.02885		0.02885	
	Average of scores =	0.552995		0.552995	
	No. of efficient DMUs =	0		0	
	No. of inefficient DMUs =	20		20	
	No. of over iteration DMUs =	0		0	

Figure 1
Super-Radial (Super-CCR-I)



Source: Author's picture

Figure 2*Super-Radial (Super-CCR-O)*

Source: Author's picture

A DMU unit is considered efficient if the score value is equal to one. If, however, the score value is greater or less than one, the DMU unit is inefficient. The score value of the DMU unit – AMS in both input and output orientation models with constant yield (CCR-I and CCR-O) – is 0.804568. The given DMU unit is 80% efficient and 20% inefficient. The analysis of results is similar for other DMU units.

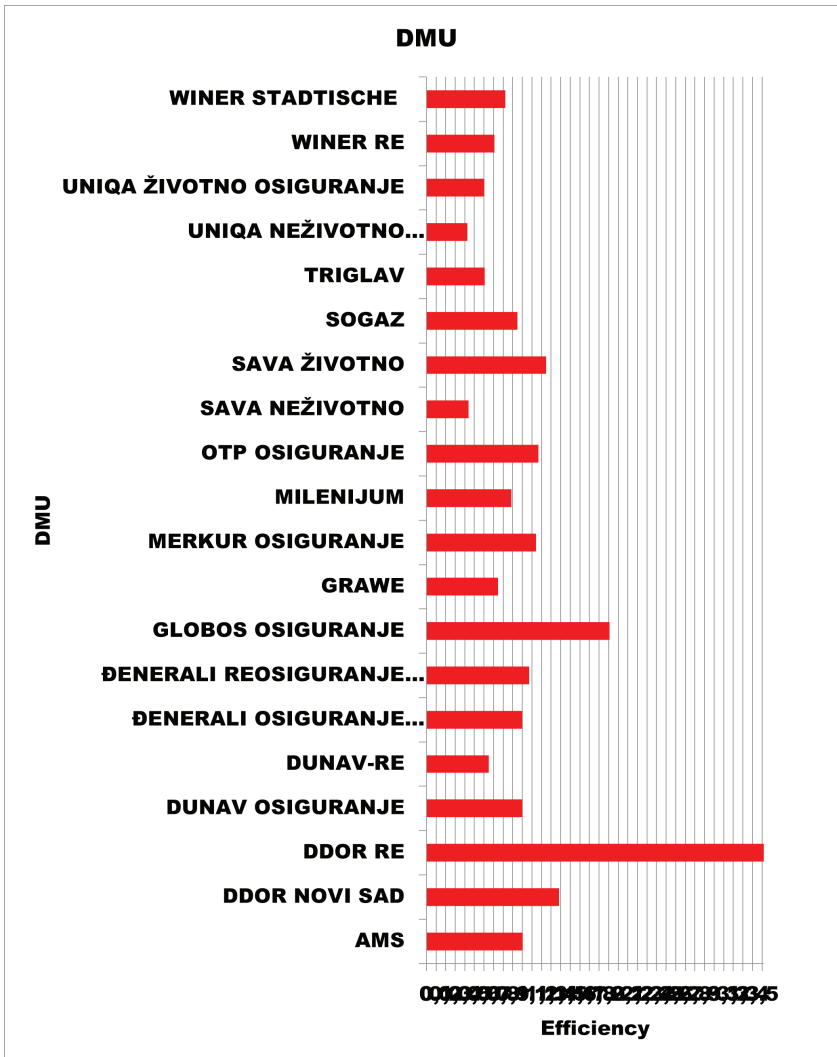
According to the results of the Super-Radial (Super-CCR-I and Super-CCR-O) model in 2021, no insurance company in Serbia was efficient.

Table 4 and figures 3 and 4 show the results of applying the DEA Super-Radial model of input and output orientation with variable yield in the evaluation of the efficiency of insurance companies in Serbia.

Table 4

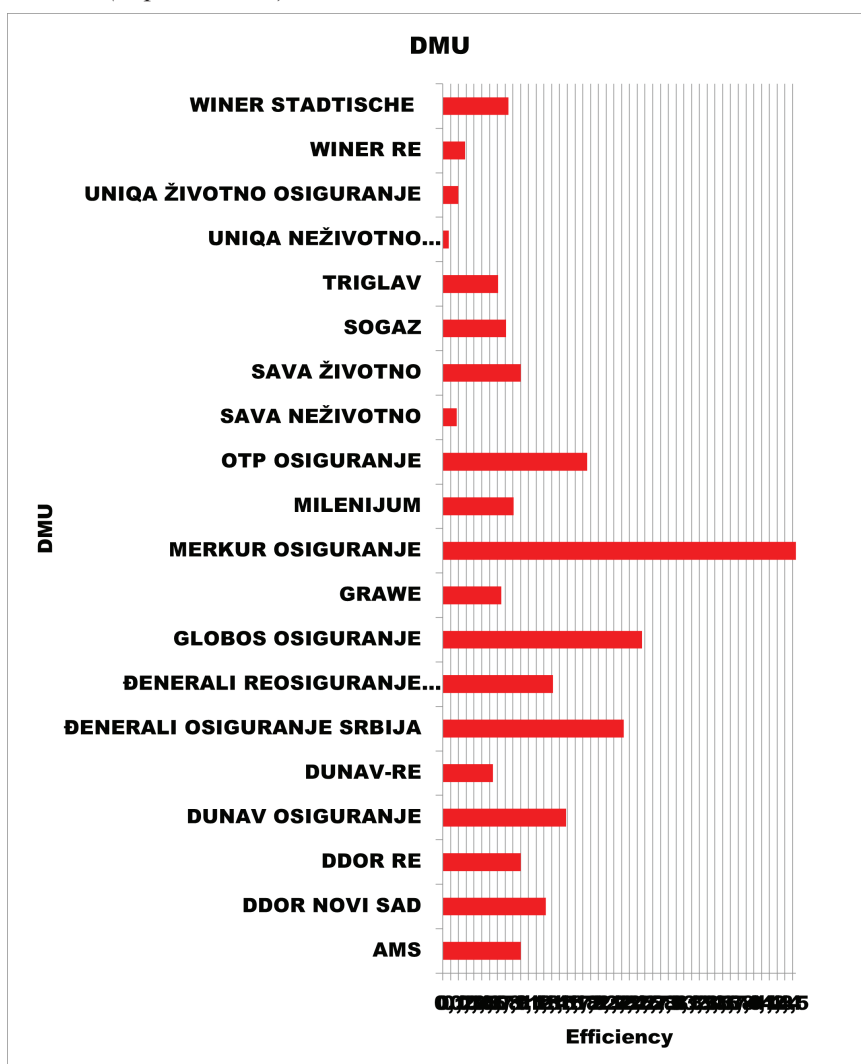
Efficiency of insurance companies in Serbia: Super-Radial(Super-BCC-I) Returns to Scale = Variable and Super-Radial(Super-BCC-O) Returns to Scale = Variable

No.	DMU	Model Name = DEA-Solver LV(V7)/ Super-Radial(Super-BCC-I) Returns to Scale = Variable (Sum of Lambda = 1)	Rank	Model Name = DEA-Solver LV(V7)/ Super-Radial(Super-BCC-O) Returns to Scale = Variable (Sum of Lambda = 1)	Rank
1	AMS	1.004944	8	1.00316	8
2	DDOR NEW USA	1.384294	3	1.321771	7
3	DDOR RE	3.517881	1	1	9
4	DUNAV INSURANCE	1	9	1.58597	5
5	DANUBE-RE	0.649006	16	0.642579	16
6	GENERALI OSIGURANJE SERBIA	1	9	2.325551	3
7	GENERALI REOSIGURANJE SERBIA	1.069234	7	1.413699	6
8	GLOBOS INSURANCE	1.907679	2	2.562415	2
9	GRAVES	0.747708	14	0.752591	14
10	MERKUR INSURANCE	1.143267	6	4.539957	1
11	MILLENNIUM	0.885033	12	0.910175	11
12	OTP INSURANCE	1.168235	5	1.854022	4
13	SAVA LIFELESS	0.438112	19	0.176163	19
14	ALL LIFE	1.247512	4	1	9
15	SOGAZ	0.948227	11	0.812396	13
16	THREE-HEADED	0.605582	17	0.708778	15
17	UNIQA NON-LIFE INSURANCE	0.424346	20	7.54E-02	20
18	UNIQA LIFE INSURANCE	0.603928	18	0.196513	18
19	WINER RE	0.70712	15	0.286075	17
20	WINER STADTSCH	0.823016	13	0.843784	12
	SD	0.656669		1.00754	
	Maximum	3.517881		4.539957	
	The minimum	0.424346		0.075441	
	Average of scores =	1.063756		1.200552	
	No. of efficient DMUs =	2		2	
	No. of inefficient DMUs =	18		18	
	No. of over iteration DMUs =	0		0	

Figure 3*Super-radial (Super-BCC-1)*

Source: Author's picture

Figure 4
Super-Radial (Super-BCC-O)



Source: Author's picture

According to the results of Super-Radial (Super-BCC-I) in Serbia in 2021, only two insurance companies were efficient: DUNAV OSIGURANJE and ĐENERALI OSIGURANJE SRBIJA. Other insurance companies were ineffective. The same is the case with the results of applying Super-Radial (Super-BCC-O). In the specific case, according to this method in Serbia in 2021, only two insurance companies were effective: DDOR RE and SAVA ŽIVOTNO. Other insurance companies were ineffective.

The projection of the input / output element shows the percentage deviation of the realized values from the projected values. Table 5 shows, for the sake of illustration, the projection of input / output elements only for Super-Radial (Super-BCC-O). The same is true for other Super-Radial models.

Table 5*Projection of Input / Output elements: Super-Radial (Super-BCC-O)*

Model Name = DEA-Solver LV(V7) Super-Radial(Super-BCC-O) Returns to Scale = Variable (Sum of Lambda = 1)												
No.	DMU	Score	(I) Total assets		((I) Capital		I) Salary expenses, salary compensation and other personal expenses		(O) Business (functional) income		(O)Net profit	
			Projection	Change(%)	Projection	Change(%)	Projection	Change(%)	Projection	Change(%)	Projection	Change(%)
1	AMS	1.00316	8164	0.00%	2089.257	-28.47%	93.61905	-10.84%	4241.597	-0.31%	520.3558	-0.31%
2	DDOR NEW USA	1.321771	23713	0.00%	6228.624	-20.40%	269	0.00%	9363.198	-24.34%	1154.806	64.27%
3	DDOR RE	1	1293	0.00%	667	0.00%	16	0.00%	14	0.00%	3.000321	0.01%
4	DUNAV INSURANCE	1.58597	60772	0.00%	14669.23	-20.71%	431.7849	-57.54%	17549.51	-36.95%	2657.872	5.51%
5	DANUBE-RE	0.642579	8565.891	-14.79%	2041.982	-18.97%	77	0.00%	3972.527	70.86%	546.2364	55.62%
6	GENERALI OSIGURANJE SERBIA	2.325551	46646.78	-37.56%	13506.81	-21.67%	493	0.00%	13812.1	-29.15%	1459.009	-57.00%
7	GENERALI REOSIGURANJE SERBIA	1.413699	3271.886	-36.68%	773	0.00%	32	0.00%	869.8802	365.18%	93.37206	-29.26%
8	GLOBOS INSURANCE	2.562415	4750	0.00%	1165	0.00%	53	0.00%	1200.82	-60.97%	149.0781	-60.97%
9	GRAVES	0.752591	19059.59	-48.78%	4453.682	-56.21%	143	0.00%	6435.227	44.71%	997.8864	32.87%
10	MERKUR INSURANCE	4.539957	1480.41	-72.28%	686	0.00%	43	0.00%	170.2659	-77.97%	22.23564	-53.68%
11	MILLENNIUM	0.910175	5891.292	-12.59%	1565.833	-23.54%	66	0.00%	3636.662	9.87%	401.3194	41.31%
12	OTP INSURANCE	1.854022	1860	0.00%	677	0.00%	246.2049	-64.01%	428.5414	328.54%	53.39741	-46.06%
13	SAVA LIFELESS	0.176163	4617	0.00%	1142.538	-20.38%	82.0282	-95.07%	2940.014	999.90%	368.977	467.66%
14	ALL LIFE	1	1544.974	0.00%	535	0.00%	544.9731	0.00%	31	0.00%	3.000067	0.00%
15	SOGAZ	0.812396	1679	0.00%	706.4799	-25.40%	169	0.00%	262.3746	330.12%	52.92983	23.09%
16	THREE-HEADED	0.708778	11642	0.00%	2748.944	-11.50%	96.34715	-98.17%	4694.44	999.90%	678.6324	41.09%
17	UNIQA NON-LIFE INSURANCE	7.54E-02	5406.003	-19.96%	1368	0.00%	64.28819	-97.64%	3366.886	999.90%	407.0237	999.90%
18	UNIQA LIFE INSURANCE	0.196513	3915.001	-66.37%	1024	0.00%	235.302	-87.09%	2216.883	999.90%	300.2345	408.87%
19	WINER RE	0.286075	3062.214	-61.92%	880	0.00%	421.4988	-58.72%	1338.423	999.90%	216.7263	249.56%
20	WINER STADTSCHIE	0.843784	28311.55	-41.43%	6580	0.00%	201.1901	-97.86%	8606.511	999.90%	1396.092	18.51%

In the specific case, in order to improve efficiency (i.e., equalize the realized values of input/output elements with the projected ones) it is necessary, for example, for the DMU unit DUNAV OSIGURANJE to reduce capital by 20.71%; salary expenses, salary compensation and other personal expenses by 57.54%; business (functional) revenues by 36.95%; and increase net profit by 5.51%. The analysis of the projection of input/output elements is similar for the other DMU units observed.

Slack shows how to transform inefficient DMU units into efficient ones. In Table 6, for the sake of illustration, slack is shown only for the Super-Radial (Super-BCC-O) model. The analysis is similar for the other Super-Radial models.

Table 6

Slack: Super-Radial(Super-BCC-O) Returns to Scale = Variable

Model Name = DEA-Solver LV(V7)/ Super-Radial(Super-BCC-O) Returns to Scale = Variable (Sum of Lambda = 1)							
No.	DMU	Score	Excess Total assets	Excess Capital	Excess salary expenses, wage compensation and other personal expenses	Shortage Business (functional) income	Shortage Net gain
			S-(1)	S-(2)	S-(3)	S+(1)	S+(2)
1	AMS	1.00316	0	831.7433	11.38095	0	0
2	DDOR NEW USA	1.321771	0	1596.376	0	0	622.9437
3	DDOR RE	1	0	0	0	0	3.21E-04
4	DUNAV INSURANCE	1.58597	0	3831.767	585.2151	0	1069.57
5	DANUBE-RE	0.642579	1487.109	478.0182	0	354.2949	0
6	GENERALI OSIGURANJE SERBIA	2.325551	28061.22	3736.188	0	5429.143	0
7	GENERALI REOSIGURANJE SERBIA	1.413699	1895.114	0	0	737.6031	0
8	GLOBOS INSURANCE	2.562415	0	0	0	0	0
9	GRAVES	0.752591	18152.41	5717.318	0	526.305	0
10	MERKUR INSURANCE	4.539957	3859.59	0	0	0	11.66285
11	MILLENNIUM	0.910175	848.7083	482.1667	0	0	89.29164
12	OTP INSURANCE	1.854022	0	0	437.7951	374.6046	0
13	SAVA LIFELESS	0.176163	0	292.4618	1581.972	2060.146	0
14	ALL LIFE	1	2.57E-02	0	2.69E-02	0	6.67E-05
15	SOGAZ	0.812396	0	240.5201	0	187.2881	0
16	THREE-HEADED	0.708778	0	357.0557	5179.653	4312.092	0
17	UNIQA NON-LIFE INSURANCE	7.54E-02	1347.997	0	2660.712	0	155.17
18	UNIQA LIFE INSURANCE	0.196513	7727.999	0	1587.698	1733.454	0
19	WINER RE	0.286075	4978.786	0	599.5012	1146.166	0
20	WINER STADTSCH	0.843784	20026.45	0	9199.81	8224.896	0

Slack: Super-Radial (Super-BCC-O) Returns to Scale = Variable

So, for example, in order to transform the inefficient DMU unit DUNAV OSIGURANJE into an efficient DMU unit, the capital and salary costs should be reduced by 3,831.767 monetary units, salary compensation and other personal expenses by 585.2151 monetary units, and the net profit increased by 1,069.57 monetary units. The analysis is similar for the other DMU units observed.

All in all, in order to improve the efficiency of insurance companies in Serbia, it is necessary, in addition to efficiently adapting to the business environment, to manage assets, capital, human resources, sales of insurance products, and profits as efficiently as possible. The digitalization of the entire business plays a significant role in this. The increased digitalization of business significantly mitigated the impact of the COVID-19 pandemic on the efficiency of insurance companies in Serbia.

4 Conclusion

Based on the results obtained from the application of the DEA Super-Radial model in the evaluation of the efficiency of insurance companies in Serbia, the following can be concluded: According to the results of the Super-Radial (Super-CCR-I and Super-CCR-O) model, no insurance company was efficient in Serbia in 2021. According to the results of the Super-Radial (Super-BCC-I) model in Serbia in 2021, only two insurance companies were efficient: DUNAV OSIGURANJE and ĐENERALI OSIGURANJE SERBIA. According to the results of the Super-Radial (Super-BCC-O) model in Serbia in 2021, only two insurance companies were efficient: DDOR RE and SAVA ŽIVOTNO. Other insurance companies were inefficient.

In the specific case, in order to improve the efficiency of insurance companies in Serbia, it is necessary, in addition to efficiently adapting to the business environment, to manage assets, capital, human resources, sales of insurance products, and profits as efficiently as possible. The digitalization of the entire business plays a significant role in this. It significantly mitigated the impact of the COVID-19 pandemic on the efficiency of insurance companies in Serbia.

Dr. Radojko Lukic

Analiza učinkovitosti zavarovalnic v Srbiji

Raziskovanje učinkovitosti zavarovalnic v državah po modelu DEA je zelo zahtevno, enako velja tudi za Srbijo. Prispevek analizira učinkovitost zavarovalnic v Srbiji na podlagi modela DEA Super-Radial. Glede na rezultate Super-Radial (Super-CCR-I in Super-CCR-O) v letu 2021 nobena zavarovalnica v Srbiji ni bila učinkovita. Istega leta sta bili po rezultatih Super-Radiala (Super-BCC-I) v Srbiji uspešni le dve zavarovalnici: DUNAV OSIGURANJE in ĐENERALI OSIGURANJE SRBIJA. Po rezultatih Super-Radiala (Super-BCC-O) sta bili leta 2021 v Srbiji učinkoviti le dve zavarovalnici: DDOR RE in SAVA ŽIVOTNO, medtem ko so bile ostale zavarovalnice neučinkovite. Za izboljšanje učinkovitosti zavarovalnic v Srbiji je potrebno poleg učinkovitega prilagajanja dinamičnemu poslovnemu okolju čim bolj učinkovito upravljati s sredstvi, kapitalom, človeškimi viri, prodajo zavarovalnih produktov in dobičkom, pri čemer ima pomembno

vlogo digitalizacija celotnega poslovanja, ki je bistveno omilila vpliv pandemije Covid-19 na učinkovitost zavarovalnic v Srbiji.

Ocenjevanje učinkovitosti zavarovalnic po modelu DEA je zelo zahteven problem. Glede na to je predmet raziskave v tem prispevku analiza učinkovitosti zavarovalnic v Srbiji na podlagi metode DEA Super-Radial. Cilj in namen te raziskave je čim bolj celovit pregled nad učinkovitostjo zavarovalnic v Srbiji z namenom izboljšanja v prihodnosti z uporabo ustreznih ukrepov, kar odraža znanstveni in strokovni prispevek tega prispevka.

Na razpolago je številna literatura, posvečena razvoju in uporabi modelov DEA, poleg tega pa je vse več del posvečenih posebnostim analize učinkovitosti zavarovalnic po modelu DEA. V tem prispevku služi kot teoretično-metodološka in empirična podlaga za oceno učinkovitosti zavarovalnic v Srbiji z uporabo modela DEA Super-Radial.

Stalno spremljanje učinkovitosti zavarovalnic, v konkretnem primeru v Srbiji, je osnovna predpostavka za izboljšanje v prihodnosti z uporabo ustreznih ukrepov. To odraža primarno raziskovalno hipotezo v tem dokumentu. Raziskovalna metodologija podane hipoteze temelji na uporabi modela DEA Super-Radial.

Uporaba modela DEA Super-Radial ima pomembno vlogo pri razumevanju dejanskega stanja glede učinkovitosti zavarovalnic v Srbiji. Njegova uporaba jasno kaže, katere zavarovalnice so učinkovite in katere ne ter katere ukrepe je treba sprejeti, da se neučinkovite preoblikujejo v učinkovite zavarovalnice.

Potrebne empirične podatke za raziskavo obravnavanega problema v tem delu smo zbrali pri Narodni banki Srbije. Pripravljeni so v skladu z ustreznimi mednarodnimi standardi. Z vidika mednarodne primerjave ni nobenih omejitev.

Pri analizi učinkovitosti zavarovalnic v Srbiji na podlagi modela DEA Super-Radial input and output orientation, s stalnimi in variabilnimi donosi, so bili kot vhodni uporabljeni naslednji elementi: bilančna vsota, stroški kapitala in plač, nadomestila plače in drugi osebni odhodki, kot output elementi pa poslovni (funkcionalni) dohodek in čisti dobiček. Enote DMU so opazovane zavarovalnice v Srbiji, ki so poslovale v letu 2021.

V tem primeru gre torej za močno korelacijo med opazovanimi spremenljivkami na ravni statistične pomembnosti, razen pri odhodkih za plače, nadomestilih plač in drugih osebnih stroških. Enota DMU velja za učinkovito, če je vrednost rezultata enaka ena. Če pa je vrednost rezultata večja ali manjša od enote, je enota DMU neučinkovita. Vrednost ocene enote DMU – AMS v modelih vhodne in izhodne orientacije s stalnim donosom (CCR-I in CCR-O) je 0,804568. Določena enota DMU je 80 % učinkovita in 20 % neučinkovita. Analiza rezultatov je podobna tudi za druge enote DMU.

Po rezultatih Super-Radiala (Super-BCC-I) sta bili v Srbiji v letu 2021 uspešni samo dve zavarovalnici: DUNAV OSIGURANJE in ĐENERALI OSIGURANJE SRBIJA. Ostale zavarovalnice so bile neučinkovite. Enako je z rezultati Super-Radial (Super-BCC-O). V konkretnem primeru sta bili po tej metodi v Srbiji v letu 2021 učinkoviti le dve zavarovalnici: DDOR RE in SAVA ŽIVOTNO. Ostale zavarovalnice so bile neučinkovite.

Projekcija vhodno/izhodnega elementa prikazuje odstotek odstopanja realiziranih vrednosti od predvidenih vrednosti.

V konkretnem primeru je potrebno zaradi izboljšanja učinkovitosti (tj. izenačitve realiziranih vrednosti vhodnih/izhodnih elementov s predvidenimi) na primer DMU enoto DUNAV OSIGURANJE dokapitalizirati za 20,71 %, stroške plač, nadomestil plač oz. druge osebne odhodke za 57,54 %, poslovne (funkcionalne) prihodke za 36,95 % in čisti dobiček povečati za 5,51 %. Analiza projekcije vhodno/izhodnih elementov je podobna tudi za ostale opazovane enote DMU.

Slack pokaže, kako pretvoriti neučinkovite enote DMU v učinkovite. Tako je na primer za preoblikovanje neučinkovite enote DMU DUNAV OSIGURANJE v učinkovito enoto DMU treba zmanjšati kapital za 3831.767, stroške plač, nadomestil in drugih osebnih stroškov za 585.2151 ter povečati čisti dobiček za 1069,57 denarnih enot. Analiza je podobna za ostale opazovane enote DMU.

Tako je na primer za preoblikovanje neučinkovite enote DMU DUNAV OSIGURANJE v učinkovito enoto DMU treba zmanjšati kapital za 3831.767, stroške plač, nadomestil in drugih osebnih stroškov za 585.2151 ter povečati čisti dobiček za 1069,57 denarnih enot. Analiza je podobna za ostale opazovane enote DMU.

Zaključek - Na podlagi rezultatov, pridobljenih z uporabo modela DEA Super-Radial glede ocene učinkovitosti zavarovalnic v Srbiji je mogoče ugotoviti naslednje: Glede na rezultate Super-Radial (Super-CCR-I in Super-CCR -O) ni bila leta 2021 v Srbiji učinkovita nobena zavarovalnica. Po rezultatih Super-Radiala (Super-BCC-I) sta bili v Srbiji v letu 2021 uspešni samo dve zavarovalnici: DUNAV OSIGURANJE in ĐENERALI OSIGURANJE SRBIJA. Po rezultatih Super-Radiala (Super-BCC-O) sta bili v Srbiji v letu 2021 uspešni le dve zavarovalnici: DDOR RE in SAVA ŽIVOTNO. Ostale zavarovalnice so bile neučinkovite.

V konkretnem primeru je za izboljšanje učinkovitosti zavarovalnic v Srbiji poleg učinkovitega prilagajanja poslovnemu okolju potrebno čim bolj učinkovito upravljanje sredstev, kapitala, človeških virov, prodaje zavarovalnih produktov in dobička. Pri tem ima pomembno vlogo digitalizacija celotnega poslovanja, ki je bistveno omilila vpliv pandemije Covid-19 na učinkovitost zavarovalnic v Srbiji.

LITERATURE

1. Amini, A., Alinezhad, A., & Yazdipoor, F. (2019). A TOPSIS, VIKOR and DEA integrated evaluation method with belief structure under uncertainty to rank alternatives. *International Journal of Advanced Operations Management*, 11(3), 171–188. <https://doi.org/10.1504/IJAOM.2019.100708>
2. Andersen, P., & Petersen, N.C. (1993). A procedure for ranking efficient units in data envelopment analysis. *Management Science*, 39, 1261–1264. <https://doi.org/10.1287/mnsc.39.10.1261>
3. Banker, R.D., Charnes, A., & Cooper, W.W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, 30(9), 1078–1092. <https://doi.org/10.1287/mnsc.30.9.1078>
4. Chang, X., & Wang, X. (2020). Research Performance Evaluation of University Based on Super DEA Model. 2020 IEEE 9th Joint International Information Technology and Artificial Intelligence Conference (ITAIC), 1252–1255. <https://doi.org/10.1109/ITAIC49862.2020.9339131>
5. Chen, Chunhua, Liu, Haohua, Tang, Lijun & Ren, Jianwei. (2021). A Range Adjusted Measure of Super-Efficiency in Integer-Valued Data Envelopment Analysis with Undesirable Outputs. *Journal of Systems Science and Information*, 9(4), 378–398. <https://doi.org/10.21078/JSSI-2021-378-21>

6. Fenyves, V., & Tarnóczy, T. (2020). Data envelopment analysis for measuring performance in a competitive market. *Problems and Perspectives in Management*, 18(1), 315-325. [https://doi.org/10.21511/ppm.18\(1\).2020.27](https://doi.org/10.21511/ppm.18(1).2020.27)
7. Guo, D., & Cai, Z.Q. (2020). Super-Efficiency Infeasibility in the Presence of Nonradial Measurement. *Mathematical Problems in Engineering*, 2020, Article 6264852, 7 pages. <https://doi.org/10.1155/2020/6264852>
8. Kočović, J., Šulejić, P., & Rakonjac-Antić, T. (2010). *Osigurajne*. Beograd: Ekonomski fakultet.
9. Lee, H.S., Chu, C.W., & Zhu, J. (2011). Super-efficiency DEA in the presence of infeasibility. *European Journal of Operational Research*, 212(1), 141–147. <https://doi.org/10.1016/j.ejor.2011.01.022>
10. Lin, R. (2020). Cross-efficiency evaluation capable of dealing with negative data: A directional distance function based approach. *Journal of the Operational Research Society*, 71(3), 505-516. <https://doi.org/10.1080/01605682.2019.1567652>
11. Lukić, R. (2010). *Revizija u bankama*. Beograd: Ekonomski fakultet.
12. Lukić, R. (2016). *Računovodstvo osiguravajućih kompanija*. Beograd: Ekonomski fakultet.
13. Lukic, R., Sokic, M., & Kljenak, D.V. (2017). Efficiency analysis of banking sector in Republic of Serbia. *Business Excellence and Management*, 7, 5–17.
14. Lukić, R. (2018a). *Bankarsko računovodstvo*. Beograd: Ekonomski fakultet.
15. Lukic, R. (2018b). Analysis of the efficiency of insurance companies. In: *Insurance in the post-crisis era*, Belgrade: Faculty of Economics, University of Belgrade.
16. Lukić, R., Hanić, H., & Bugarčić, M. (2020). Analysis of Profitability and Efficiency of Trade in Serbia. *Economic Analysis*, 53(2), 39-50. <https://doi.org/10.28934/ea.20.53.2.pp39-50>
17. Lukic, R. (2021a). Analysis of the efficiency of insurance companies by lines of insurance in Serbia using the COCOSO method. *Insurance Trends*, 2, 24-38. <https://doi.org/10.5937/TokOsig2102009L>
18. Lukic, R. (2021b). Application of MABAC Method in Evaluation of Sector Efficiency in Serbia. *Review of International Comparative Management*, 22(3), 400-417.
19. Lukić, R. (2021c). Analiza efikasnosti finansijskih institucija na bazi OCRA metode. *Tehnika*, 76(1), 103-111. <https://doi.org/10.5937/tehnika2101103L>
20. Lukic, R. (2021d). Application of the EDAS method in the evaluation of bank efficiency in Serbia. *Bankarstvo - Banking*, 50(2), 13-24. <https://doi.org/10.5937/bankarstvo2102064L>
21. Lukic, R. (2021e). Application of ARAS method in assessing efficiency of insurance companies in Serbia. *Insurance Trends*, 3, 23-36. <https://doi.org/10.5937/tokosig2103009F>
22. Lukić, R. (2022a). Evaluation of the efficiency of banks in Serbia using the MABAC method. *Bankarstvo - Banking*, 2, 35-60. <https://doi.org/10.5937/bankarstvo2202010L>
23. Lukić, R. (2022b). Analysis of financial performance and efficiency of banks in Serbia using fuzzy LMAW and MARCOS methods. *Bankarstvo – Banking*, 4, 130-169. <https://doi.org/10.5937/bankarstvo2204130L>
24. Lukic, R., & Hadrovic Zekic, B. (2019). Evaluation of efficiency of trade companies in Serbia using the DEA approach. *Proceedings of the 19 th International Scientific Conference Business Logistics In Modern Management October 10-11, Osijek, Croatia*, Josip Juraj Strossmayer University of Osijek, Faculty of Economics in Osijek, 145-165.
25. Lukic, R. (2023). Application of PROMETHEE method in evaluation of insurance efficiency in Serbia. *Journal of Economic and Business Sciences*, 10(1). <https://doi.org/10.55707/eb.v10i1.121>
26. Mandić, K., Delibašić, B., Knežević, S. & Benković, S. (2017). Analysis of the efficiency of insurance companies in Serbia using the fuzzy AHP and TOPSIS methods. *Economic Research-Ekonomska Istraživanja*, 30(1), 550-565. <https://doi.org/10.1080/1331677X.2017.1305786>
27. Pendharkar, P.C. (2021). Hybrid radial basis function DEA and its applications to regression, segmentation and cluster analysis problems. *Machine Learning with Applications*, 6, 100092. <https://doi.org/10.1016/j.mlwa.2021.100092>

28. Podinovski, V.V., & Bouzdine-Chameeva, T. (2021). Optimal solutions of multiplier DEA models. *J Prod Anal*, 56, 45–68. <https://doi.org/10.1007/s11123-021-00610-3>
29. Rakonjac-Antić, T. (2018). *Penzijsko i zdravstveno osiguranje*. Beograd: Ekonomski fakultet.
30. Rostamzadeh, R., Akbarian, O., Banaitis, A., & Soltani, Z. (2021). Application of DEA in benchmarking: a systematic literature review from 2003–2020. *Technological and Economic Development of Economy*, 27(1), 175-222. <https://doi.org/10.3846/tede.2021.13406>
31. Sıcakyuz, C. (2023). Bibliometric Analysis of Data Envelopment Analysis in Supply Chain Management. *J. Oper. Strateg Anal.*, 1(1), 14-24. <https://doi.org/10.56578/josa010103>
32. Tone, K. (2002). A slacks-based measure of super-efficiency in data envelopment analysis. *European Journal of Operational Research*, 143, 32-41. [https://doi.org/10.1016/S0377-2217\(01\)00324-1](https://doi.org/10.1016/S0377-2217(01)00324-1)
33. Tsai, Chi-Mao, Lee, Hsuan-Shih, & Gan, Guo-Ya (2021). A New Fuzzy DEA Model for Solving the MCDM Problems in Supplier Selection. *Journal of Marine Science and Technology*, 29(1), Article 7. <https://doi.org/10.51400/2709-6998.1006>