PRIMENA EDAS METODE U EVALUACIJI EFIKASNOSTI BANAKA U SRBIJI

Radojko Lukić, prof. u penziji, Ekonomski fakultet Univerziteta u Beogradu

Rezime

U poslednje vreme, kao što je poznato, sve se više vrši evaluacija performansi (efikasnosti) banaka na bazi višekriterijumske analize. Imajući to u vidu, u ovom radu se analizira efikasnost banaka u Srbiji na bazi EDAS metode. U kontekstu toga predložene su adekvatne mere za unapređenje efikasnosti banaka u Srbiji u budućnosti. Dobijeni rezultati empirijskog istraživanja primenom date metode pokazuju da se u poslednje vreme znatno poboljšala efikasnost banaka u Srbiji. Najbolja je bila u 2019. godini. Na to su pozitivno uticali brojni makro i mikro faktori (ekonomska klima, životni standard, politička stabilnost, digitalizacija poslovanja).

Ključne reči: efikasnost, banke, Srbija, determinante, EDAS metoda

JEL klasifikacija: C02, C44, C61, G21.

Uvod

Vrlo je aktuelna, kompleksna, složena i značajna problematika merenja efikasnosti banaka na bazi višekriterijumske analize (Mandic, 2014; Eraković, 2017; Lukić, 2010; Lukić, 2016; Lukic, 2017; Lukić, 2018; Lukic, 2018; Bukvić, 2020). S obzirom na to, predmet istraživanja u ovom radu je analiza efikasnosti banaka u Srbiji na bazi EDAS metode. Cilj i svrha toga je da se data problematika što kompleksnije obradi i predlože adekvatne mere za poboljšanje efikasnosti banaka u Srbiji u budućnosti (Lukic, 2020 a, b, c). U tome se, pored ostalog, ogleda naučno-stručni doprinos ovog rada. U poslednje vreme, kao što je poznato, sve je bogatija literatura posvećena analizi efikasnosti preduzeća iz različitih privrednih sektora na bazi EDAS metode (Alinezhad, 2019; Keshavarz Ghorabae, 2015, 2016, 2018; Ren, 2020; Stevic, 2019; Torkayesh, 2020; Ersoy, 2017; Lukic, 2019, 2020a,b,s; Gaur, 2020). Za razliku od primene AHP i TOPSIS metoda, „vrlo je malo, međutim, radova ove vrste iz uslužnog, odnosno finansijskog sektora. U literaturi u Srbiji ne postoji, koliko je nama poznato, ni jedan celoviti rad posvećen analizi efikasnosti banaka u Srbiji na bazi EDAS metode“ (Lukic, 2020 a, b, c). U ovom radu se, po ugledu na savremenu stranu literaturu, po prvi put vrši analiza efikasnosti banaka u Srbiji pomoću EDAS metode. i u tome se, pored ostalog, ogleda naučno-stručni doprinos ovog rada.

Istraživanje kroz literaturu u ovom radu služi kao teorijsko-metodološka i empirijska osnova za pravilnu analizu efikasnosti banaka u Srbiji na bazi EDAS metode. To je svakako u funkciji poboljšanja njihove efikasnosti u budućnosti preduzimanjem adekvatnih mera (Lukic, 2020 a, b, c).

Osnovna hipoteza istraživanja u ovom radu je da je kontinuirano praćenje efikasnosti banaka pretpostavka za unapređenje u budućnosti: u našem slučaju u Srbiji. To olakšava i ukazuje na to koje adekvatne mere treba preduzeti za ostvarenje ciljne efikasnosti banaka u Srbiji (Lukic, 2020 a, b, c).

U tome, u metodološkom smislu te reči, značajnu ulogu ima primena EDAS metode.

Potrebni empirijski podaci su prikupljeni od Agencije za privredne registre Republike Srbije. Oni su „proizvedeni“ u skladu sa relevantnim međunarodnim standardima. U pogledu međunarodne uporedivosti ne postoje s obzirom na to nikakva ograničenja (Lukic, 2020 a, b, c).

EDAS metoda

EDAS (*Evaluation based on Distance from Average Solution*) metoda je nova metoda višekriterijumskog odlučivanja (Keshavarz Ghorabae, 2015). Ona je vrlo korisna kada imamo neke oprečne (konfliktne) kriterijume. Izbor najbolje alternative vrši se prema udaljenosti od prosečnog rešenja (AV). Postoje dve mere poželjnosti: (1) pozitivna udaljenost od proseka (PDA), i (2) negativna udaljenost od proseka (NDA). One pokazuju razliku između svakog (alternativnog) i prosečnog rešenja. Procena poželjnosti alternativa se vrši prema većim vrednostima PDA i nižim vrednostima NDA. Visoka vrednost PDA ili niža vrednost NDA pokazuje da je izbor (alternative) bolji od prosečnog rešenja.

Pretpostavimo da imamo n alternativa i m kriterijuma. Procedura EDAS metode je sledeća (Keshavarz Ghorabae, 2015):

Korak 1: Izbor najvažnijih kriterijuma koji opisuju alternative.

Korak 2: Formiranje matrice odlučivanja (X) na sledeći način:

$$X = [X_{ij}]_{n \times m} = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1m} \\ X_{21} & X_{22} & \cdots & X_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ X_{n1} & X_{n2} & \cdots & X_{nm} \end{bmatrix}, \quad (1)$$

gde: X_{ij} označava performansnu vrednost i -te alternative u odnosu na j -ti kriterijum.

Korak 3: Određivanje prosečnog rešenja prema svim kriterijumima na sledeći način:

$$AV = [AV_j]_{1 \times m}, \quad (2)$$

gde je:

$$AV_j = \frac{\sum_{i=1}^n X_{ij}}{n}. \quad (3)$$

Korak 4: Izračunavanje pozitivne distance od proseka (PDA) i negativne distance od proseka (NDA) matrice prema vrsti kriterijuma (benefit i troškovi) na sledeći način:

$$PDA = [[PDA_{ij}]]_{n \times m}, \quad (4)$$

$$NDA = [[NDA_{ij}]]_{n \times m}. \quad (5)$$

Ako je j -ti kriterijum benefitni:

$$PDA_{ij} = \frac{\max(0, (X_{ij} - AV_j))}{AV_j}, \quad (6)$$

$$NDA_{ij} = \frac{\max(0, (AV_j - X_{ij}))}{AV_j}, \quad (7)$$

i ako je j -ti kriterijum ne-benefitni:

$$PDA_{ij} = \frac{\max(0, (AV_j - X_{ij}))}{AV_j}, \quad (8)$$

$$NDA_{ij} = \frac{\max(0, (X_{ij} - AV_j))}{AV_j}, \quad (9)$$

gde: PDA_{ij} i NDA_{ij} označavaju pozitivne i negativne distance i -te alternative od prosečnog rešenja u terminima j -tog kriterijuma, respektivno.

Korak 5: Determinisanje težinske sume PDA i NDA za sve alternative na sledeći način:

$$SP_i = \sum_{j=1}^m w_j PDA_{ij}; \quad (10)$$

$$SN_i = \sum_{j=1}^m w_j NDA_{ij}. \quad (11)$$

gde je: w_j težina j -tog kriterijuma.

Korak 6: Normalizacija vrednosti SP i SN za sve alternative na sledeći način:

$$NSP_i = \frac{SP_i}{\max_i(SP_i)}; \quad (12)$$

$$NSN_i = 1 - \frac{SN_i}{\max_i(SN_i)}. \quad (13)$$

Korak 7: Izračunavanje srednje vrednosti (AS) za sve alternative na sledeći način:

$$AS_i = \frac{1}{2}(NSP_i + NSN_i), \quad (14)$$

gde je: $0 \leq AS_i \leq 1$.

Korak 8: Rangiranje alternativa prema opadajućoj srednjoj vrednosti (AS). Alternativa sa najvećom vrednošću AS je najbolja.

Procena efikasnosti banaka u Srbiji na bazi EDAS metode: rezultati i diskusija

Prilikom merenja efikasnosti banaka u Srbiji primenom EDAS metode kao kriterijumi su uzeti: C1 – broj zaposlenih, C2 – aktiva, C3 – kapital, C4 – ukupni neto poslovni prihodi i C5 – neto dobitak. Alternative su posmatrane godine: A1 – 2013, A2 – 2014, A3 – 2015, A4 – 2016, A5 – 2017, A6 – 2018. i A7 – 2019 (Lukić, 2020 a, b, c). (Računanje efikasnosti banaka u Srbiji izvršeno je pomoću EDASSoftware-Excel). Dobijeni rezultati su prikazani u niže priloženim tabelama, kao i na grafikonu.

U Tabeli 1. su prikazani inicijalni podaci za merenje efikasnosti banaka u Srbiji za period 2013 – 2019. na bazi EDAS metode.

Tabela 1 - Inicijalni podaci za merenje efikasnosti banaka u Srbiji

Godine	Broj zaposlenih	Aktiva	Kapital	Ukupni neto poslovni prihodi	Neto dobitak
2013	25188	2809333	589559	120705	30808
2014	23983	2968012	612895	126102	29315
2015	22085	3048183	619442	128962	32324
2016	24096	3243450	634330	136332	38215
2017	22817	3369391	667115	182405	68871
2018	22875	3774098	676704	175871	71349
2019	22739	4083760	705369	175090	65316

Napomena: Podaci su iskazani u milionima dinara. Broj zaposlenih je iskazan u celom broju

Izvor: Agencija za privredni registar Republike Srbije

Težinski koeficijenti kriterijuma su utvrđeni pomoću AHP (Analitički Hijerarhijski Procesi) metode (Saaty, 2008; Lukic, 2020 a, b, c). Oni su prikazani u Tabeli 2, kao i na Slici 1.

Težinski koeficijenti kriterijuma su utvrđeni pomoću AHP (Analitički Hijerarhijski Procesi) metode (Saaty, 2008). Oni su prikazani u Tabeli 2, kao i na Slici 1.

Tabela 2 - Težinski koeficijenti kriterijuma

AHP sa metodom aritmetičke sredine					
Inicijalna matrica poređenja					
	A	B	C	D	E
A		2,5			1
B	0,4			1,25	2
C	0,25	0,333333		0,5	1
D	0,5	0,8			1
E		0,5			1
SUM	3,15	5,13333		5,75	6

Normalizovana matrica						
	A	B	C	D	E	Težine kriterijuma
A	0,3175	0,4870	0,3636	0,3478	0,1667	0,3365
B	0,1270	0,1948	0,2727	0,2174	0,3333	0,2290
C	0,0794	0,0649	0,0909	0,0870	0,1667	0,0978
D	0,1587	0,1558	0,1818	0,1739	0,1667	0,1674
E	0,3175	0,0974	0,0909	0,1739	0,1667	0,1693
					SUM	1
Odnos konzistentnosti			0,0607	UPOREDITI SA 0,1; TREBA BITI MANJE OD 0,1		

Napomena: A – broj zaposlenih, B – aktiva, C – kapital, D – ukupni neto poslovni prihodi i E – neto dobitak

Slika 1: Težinski koeficijenti kriterijuma

Po značaju kriterijuma na prvom mestu je broj zaposlenih. To je sasvim i razumljivo s obzirom na to da banke pripadaju uslužnom sektoru čija je karakteristika velika zaposlenost i u uslovima digitalizacije celokupnog poslovanja. Zatim slede po redosledu značaja kriterijuma: aktiva, neto dobitak, ukupni neto poslovni prihodi, i kapital. Ovakvo rangiranje izabranih kriterijuma prema značaju je odraz specifičnosti samog poslovanja bankarskog sektora.

U daljim izlaganjima tretirane problematike prikazaćemo dobijene rezultate analize efikasnosti banaka u Srbiji na bazi EDAS metode.

U Tabeli 3 - je prikazana inicijalna matrica odlučivanja.

Tabela 3: Inicijalna matrica

Inicijalna matrica					
Težine kriterijuma	0,3365		0,0978	0,1674	0,1693
Vrsta kriterijuma					
	C1	C2	C3	C4	C5
A1	25188	2809333	589559	120705	30808
A2	23983	2968012	612895	126102	29315
A3	22085	3048183	619442	128962	32324
A4	24096	3243450	634330	136332	38215
A5	22817	3369391	667115	182405	68871
A6	22875	3774098	676704	175871	71349
A7	22739	4083760	705369	175090	65316
Prosečno rešenje	23397,5714	3328032,4286	643630,5714	149352,4286	48028,2857

U Tabeli 4 - je prikazano pozitivno rastojanje od prosečne vrednosti - Dij+.

Tabela 4: Pozitivno rastojanje od prosečne vrednosti

Dij+					
Težine kriterijuma	0,3365		0,0978	0,1674	0,1693
	C1	C2	C3	C4	C5
A1	0,0765	0,0000	0,0000	0,0000	0,0000
A2	0,0250	0,0000	0,0000	0,0000	0,0000
A3	0,0000	0,0000	0,0000	0,0000	0,0000
A4	0,0299	0,0000	0,0000	0,0000	0,0000
A5	0,0000	0,0124	0,0365	0,2213	0,4340
A6	0,0000	0,1340	0,0514	0,1776	0,4856
A7	0,0000	0,2271	0,0959	0,1723	0,3599

U Tabeli 5 je prikazano negativno rastojanje od prosečne vrednosti - Dij-.

Tabela 5: Negativno rastojanje od prosečne vrednosti

Dij-					
Težine kriterijuma	0,3365		0,0978	0,1674	0,1693
	C1	C2	C3	C4	C5
A1	0,0000	0,1559	0,0840	0,1918	0,3585
A2	0,0000	0,1082	0,0478	0,1557	0,3896
A3	0,0561	0,0841	0,0376	0,1365	0,3270
A4	0,0000	0,0254	0,0145	0,0872	0,2043
A5	0,0248	0,0000	0,0000	0,0000	0,0000
A6	0,0223	0,0000	0,0000	0,0000	0,0000
A7	0,0281	0,0000	0,0000	0,0000	0,0000

U Tabeli 6 je prikazana težinski normalizovana suma PDA.

Tabela 6: Težinski normalizovana suma PDA

PDA							
	C1	C2	C3	C4	C5	Qi+	Si+
A1	0,0257	0,0000	0,0000	0,0000	0,0000	0,0257	0,1703
A2	0,0084	0,0000	0,0000	0,0000	0,0000	0,0084	0,0557
A3	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
A4	0,0100	0,0000	0,0000	0,0000	0,0000	0,0100	0,0664
A5	0,0000	0,0028	0,0036	0,0370	0,0735	0,1169	0,7735
A6	0,0000	0,0307	0,0050	0,0297	0,0822	0,1476	0,9767
A7	0,0000	0,0520	0,0094	0,0288	0,0609	0,1512	1,0000
					MAX	0,1512	

U Tabeli 7 je prikazana težinski normalizovana suma NDA.

Tabela 7: Težinski normalizovana suma NDP

NDA							
	C1	C2	C3	C4	C5	Qi-	Si-
A1	0,0000	0,0357	0,0082	0,0321	0,0607	0,1367	0,0000
A2	0,0000	0,0248	0,0047	0,0261	0,0660	0,1215	0,1115
A3	0,0189	0,0193	0,0037	0,0229	0,0554	0,1200	0,1221
A4	0,0000	0,0058	0,0014	0,0146	0,0346	0,0564	0,5873
A5	0,0083	0,0000	0,0000	0,0000	0,0000	0,0083	0,9389
A6	0,0075	0,0000	0,0000	0,0000	0,0000	0,0075	0,9450
A7	0,0095	0,0000	0,0000	0,0000	0,0000	0,0095	0,9307
					MAX	0,1367	

U Tabeli 8 i na Slici 2 je prikazano rangiranje alternativa (Si).

Tabela 8: Rangiranje alternativa

	Si	Si	RANKING
2013	0,085	0,085	5
2014	0,084	0,084	6
2015	0,061	0,061	7
2016	0,327	0,327	4
2017	0,856	0,856	3
2018	0,961	0,961	2
2019	0,965	0,965	1

Slika 2: Ocenjivanje i rangiranje alternativa

Dobijeni rezultati empirijskog istraživanja efikasnosti banaka u Srbiji na bazi OCRA metode pokazuju da se ona u poslednje vreme kontinuirano povećavala u posmatranom vremenskom periodu (2013 – 2019) iz godine u godinu. Najbolja je bila u 2019. god. Zatim slede po redosledu: 2018, 2017, 2016, 2013, 2014. i 2015. Na ovakvu dinamiku efikasnosti banaka u Srbiji uticali su brojni makro i mikro faktori (ekonomska klima, životni standard, politička stabilnost, digitalizacija celokupnog poslovanja, i drugi).

Zaključak

Na osnovu dobijenih rezultata empirijskog istraživanja efikasnosti banaka u Srbiji na bazi OCRA metode može se zaključiti da se ona u poslednje vreme kontinuirano povećavala u posmatranom vremenskom periodu (2013 – 2019) iz godine u godinu. Najbolja je bila u 2019. god. Zatim slede po redosledu: 2018, 2017, 2016, 2013, 2014. i 2015. Na ovakvu dinamiku efikasnosti banaka u Srbiji uticali su brojni makro i mikro faktori, kao što su: ekonomska klima, životni standard, politička stabilnost, digitalizacija celokupnog poslovanja, i drugi.

U cilju povećanja efikasnosti banaka u Srbiji u budućnosti neophodno je što efikasnije upravljati ljudskim kapitalom, aktivom, kapitalom, prihodima i profitom.

Literatura

1. Alinezhad, A., Khalili, J. (2019). EDAS Method. In: New Methods and Applications in Multiple Attribute Decision Making (MADM). International Series in Operations Research & Management Science, vol 277, 149-155, Springer, Cham. https://doi.org/10.1007/978-3-030-15009-9_21.
2. Bukvić, R. (2020). Šta pokazuje koncentraciju indeksa: primer bankarskog sektora Srbije (What Demonstrate Concentration Indices: Example of the Banking Sector of Serbia) (September 20, 2020). XLVII Simpozijum o operacionim istraživanjima, SYM-OP-IS 2020 Beograd 20–23 septembar 2020, Zbornik radova, ur. Milorad Vidović, Katarina Vukadinović, Dražen Popović, Univerzitet u Beogradu, Saobraćajni fakultet, Beograd, 55–60., Available at SSRN: <https://ssrn.com/abstract=3711585>.
3. Ersoy, N. (2017). Performance measurement in retail industry by using a multi-criteria decision making methods. *Ege Academic Review*, 17(4):539–551. <https://doi.org/10.21121/eab.2017431302>.
4. Erakovic, E. (2017). CONCENTRATION EFFECT ON THE EFFICIENCY OF BANKING SECTOR IN THE REPUBLIC OF SERBIA CONCENTRATION EFFECT ON THE EFFICIENCY OF BANKING SECTOR IN THE REPUBLIC OF SERBIA. *FACTA UNIVERSITATIS Series: Economics and Organization*, 14(3), 281 – 289. <https://doi.org/10.22190/FUEO1703281E>.
5. Gaur, L., Agarwal, V., Anshu, K. (2020). Fuzzy DEMATEL Approach to Identify the Factors Influencing Efficiency of Indian Retail Websites. In: Kapur P., Singh O., Khatri S., Verma A. (eds) *Strategic System Assurance and Business Analytics. Asset Analytics (Performance and Safety Management)*. Springer, Singapore. https://doi.org/10.1007/978-981-15-3647-2_6.
6. Keshavarz Ghorabae, K., Zavadskas, E.K., Olfat, L., Turskis, Z. (2015). Multi-criteria inventory classification using a new method of Evaluation based on Distance from Average Solution (EDAS). *Informatica*, 26, 435-451, <http://dx.doi.org/10.15388/Informatica.2015.57>.
7. Keshavarz Ghorabae, M.; Zavadskas, E.K.; Amiri, M; Turskis, Z. (2016). Extended EDAS Method for Fuzzy Multi-criteria Decision-making: An Application to Supplier Selection. *Int. J. Comput. Commun. Control*, 11, 358–371.
8. Keshavarz-Ghorabae, M.; Amiri, M.; Zavadskas, E.K.; Turskis, Z.; Antucheviciene, J. A. (2018). Dynamic Fuzzy Approach Based on the EDAS Method for Multi-Criteria Subcontractor Evaluation. *Information*, 9, 68.
9. Lukić, R. (2010). *Revizija u bankama*. Beograd: Ekonomski fakultet.
10. Lukić, R. (2016). *Računovodstvo osiguravajućih kompanija*. Beograd: Ekonomski fakultet.
11. Lukic, R., Sokic, M. and Kljenak-Vojteski, D. (2017). Efficiency analysis of banking sector in Republic of Serbia. *Business excellence and Management*, 7(4), 5-17.
12. Lukic, R. (2018). Analysis of the efficiency of insurance companies. In: *Insurance in the post-crisis era*, Belgrade: Faculty of Economics, University of Belgrade.
13. Lukic, R. (2018). *Bankarsko računovodstvo*. Beograd: Ekonomski fakultet.

15. Lukic, R. and 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.
16. Lukic, R, Hadrovic Zekic, B. and Crnjac Milic, D. (2020a). Financial performance evaluation of trading companies in Serbia using the integrated Fuzzy AHP - TOPSIS Approach. 9th INTERNATIONAL SCIENTIFIC SYMPOSIUM REGION, ENTREPRENEURSHIP, DEVELOPMENT, Under the auspices of: REPUBLIC OF CROATIA MINISTRY OF SCIENCE AND EDUCATION, Osijek, June, 690-703.
17. Lukic, R., Vojteski Kljenak, D. and Anđelić, S. (2020b). ANALYZING FINANCIAL PERFORMANCES AND EFFICIENCY OF THE RETAIL FOOD IN SERBIA BY USING THE AHP – TOPSIS METHOD. Economics of Agriculture, 67(1). 55-68).
18. Lukic, R. (2020c), ANALYSIS OF THE EFFICIENCY OF TRADE IN OIL DERIVATIVES IN SERBIA BY APPLYING THE FUZZY AHP-TOPSIS METHOD, Business Excellence and Management, 10 (3), 80-98.
19. Mandic, K., Delibasic, B., Knezevic, S., Benkovic, S. (2014). Analysis of the financial parameters of Serbian banks through the application of the fuzzy AHP and TOPSIS methods. Economic Modelling, 43, 30-27.
20. Ren, J., Hu, Ch., Yu, Sq. et al. (2020). An extended EDAS method under four-branch fuzzy environments and its application in credit evaluation for micro and small entrepreneurs. Soft Comput. <https://doi.org/10.1007/s00500-020-05337-1>.
21. Saaty, T.L. (2008). Decision Making with The Analytic Hierarchy Process. Int J Serv Sci, 1(1), 83-98.
22. Stević, Ž., Vasiljević, M., Puška, A., Tanackov, I., Junevičius, R., & Vesković, S. (2019). Evaluation of suppliers under uncertainty: a multiphase approach based on fuzzy AHP and fuzzy EDAS. Transport, 34(1), 52-66.
23. Torkayesh, S. E., Iranizad , A., Torkayesh , A. E., & Basit , M. N. (2020). Application of BWM-WASPAS model for digital supplier selection problem: A case study in online retail shopping. Journal of Industrial Engineering and Decision Making, 1(1), 12-23. Retrieved from <http://mcdtgroup.com/index.php/jiedm/article/view/2>.

Received: 19.02.2021
Accepted: 03.06.2021

DOI: 10.5937/bankarstvo2102064L

APPLICATION OF THE EDAS METHOD IN THE EVALUATION OF BANK EFFICIENCY IN SERBIA

Radojko Lukić, Retired professor of the Faculty of Economics, University of Belgrade

Summary

Recently, as it is known, the evaluation of the performance (efficiency) of banks is increasingly performed on the basis of multi-criteria analysis. With this in mind, this paper analyzes the efficiency of banks in Serbia based on the EDAS method. In this context, adequate measures have been proposed to improve the efficiency of banks in Serbia in the future. The obtained results of empirical research using the given method show that the efficiency of banks in Serbia has recently significantly improved. It was the best in 2019. It was positively influenced by numerous macro and micro factors (economic climate, living standard, political stability, digitalization of business).

Keywords: efficiency; banks; Serbia; determinants; EDAS method

JEL classification: C02, C44, C61, G21.

Introduction

It is a very current, complex and significant issue to measure the efficiency of banks based on multi-criteria analysis (Mandic, 2014; Erakovic, 2017; Lukic, 2010; Lukic, 2016; Lukic, 2017; Lukic, 2018 a, b ; Bukvic, 2020) . Given that, the subject of research in this paper is the analysis of the efficiency of banks in Serbia based on the EDAS method. The goal and purpose of this is to deal with this issue as comprehensively as possible and propose adequate measures to improve the efficiency of banks in Serbia in the future (Lukic, 2020 a, b, c). This, among other things, reflects the scientific and professional contribution of this paper.

Recently, as is well known, increasingly thorough literature is devoted to the analysis of the efficiency of companies from different economic sectors based on the EDAS method (Alinezhad, 2019; Keshavarz Ghorabae, 2015, 2016, 2018; Ren, 2020; Stevic, 2019; Torkayesh, 2020; Ersoy, 2017; Lukic, 2019, 2020a, b, c; Gaur, 2020). Unlike the application of AHP and TOPSIS methods, however, "there are very few works of this type from the service and financial sectors. In the literature in Serbia, there is, as far as we know, no complete work dedicated to the analysis of the efficiency of banks in Serbia on the basis of the EDAS method" (Lukic, 2020 a, b, c). In this paper, based on the reputation of contemporary foreign literature, for the first time the analysis of the efficiency of banks in Serbia is performed using the EDAS method. And that, among other things, reflects the scientific and professional contribution of this paper.

Research through the literature in this paper serves as a theoretical-methodological and empirical basis for a proper analysis of the efficiency of banks in Serbia based on the EDAS method. This is certainly in the function of improving their efficiency in the future by taking adequate measures (Lukic, 2020 a, b, c).

The basic hypothesis of the research in this paper is that continuous monitoring of bank efficiency is a prerequisite for improvement in the future: in our case in Serbia. This facilitates and indicates what adequate measures should be taken to achieve the target efficiency of banks in Serbia (Lukic, 2020 a, b, c).

In that, methodologically speaking, the application of the EDAS method has a significant role.

The necessary empirical data were collected from the Business Registers Agency of the Republic of Serbia. They are "manufactured" in accordance with relevant international standards. In terms of international comparability, there are no restrictions in this regard (Lukic, 2020 a, b, c).

EDAS Method

The EDAS (Evaluation based on Distance from Average Solution) method is a new method of multi-criteria decision making (Keshavarz Ghorabae, 2015). It is very useful when we have some conflicting criteria. The choice of the best alternative is made according to the distance from the average solution (AV). There are two desirability measures: (1) positive distance from the average (PDA), and (2) negative distance from the average (NDA). They show the difference between each (alternative) and average solution. The desirability of alternatives is assessed against higher PDA values and lower NDA values. A

high PDA value or a lower NDA p value indicates that the choice (alternative e) is better than the average solution.

Suppose we have n alternatives and m criteria. The procedure of the EDAS method is as follows (Keshavarz Ghorabae, 2015):

Step 1: Selection of the most important criteria that describe the alternatives.

Step 2: Forming the decision matrix (X) as follows:

$$X = [X_{ij}]_{n \times m} = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1m} \\ X_{21} & X_{22} & \cdots & X_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ X_{n1} & X_{n2} & \cdots & X_{nm} \end{bmatrix}, \quad (1)$$

where: X_{ij} denotes the performance value of the i -th alternative in relation to the j -th criterion.

Step 3: Determining the average solution according to all criteria as follows:

$$AV = [AV_j]_{1 \times m}, \quad (2)$$

where is:

$$AV_j = \frac{\sum_{i=1}^n X_{ij}}{n}. \quad (3)$$

Step 4: Calculate the positive average distance (PDA) and negative average distance (NDA) of the matrix according to the type of criteria (benefit and costs) as follows:

$$PDA = [PDA_{ij}]_{n \times m}, \quad (4)$$

$$NDA = [NDA_{ij}]_{n \times m}. \quad (5)$$

If the j -th criterion is beneficial:

$$PDA_{ij} = \frac{\max(0, (X_{ij} - AV_j))}{AV_j}, \quad (6)$$

$$NDA_{ij} = \frac{\max(0, (AV_j - X_{ij}))}{AV_j}, \quad (7)$$

and if the j -th criterion is non-beneficial:

$$PDA_{ij} = \frac{\max(0, (AV_j - X_{ij}))}{AV_j}, \quad (8)$$

$$NDA_{ij} = \frac{\max(0, (X_{ij} - AV_j))}{AV_j}, \quad (9)$$

where: PDA_{ij} i NDA_{ij} denote the positive and negative distances of the i -th alternative from the average solution in terms of the j -th criterion, respectively.

Step 5: Determine the weight sum of PDA and NDA for all alternatives as follows:

$$SP_i = \sum_{j=1}^m w_j PDA_{ij}; \quad (10)$$

$$SN_i = \sum_{j=1}^m w_j NDA_{ij}. \quad (11)$$

where is: w_j weight of the j -th criterion.

Step 6: Normalize the SP and MV values for all alternatives as follows:

$$NSP_i = \frac{SP_i}{\max_i(SP_i)}; \quad (12)$$

$$NSN_i = 1 - \frac{SN_i}{\max_i(SN_i)}. \quad (13)$$

Step 7: Calculate the mean (AS) for all alternatives as follows:

$$NSN_i = 1 - \frac{SN_i}{\max_i(SN_i)}. \quad (13)$$

where: $0 \leq AS_i \leq 1$.

Step 8: Ranking the alternatives according to the decreasing mean (AS). The alternative with the highest AS value is the best.

Estimation of Efficiency of Banks in Serbia on the basis of EDAS Method: Results and Discussion

When measuring the efficiency of banks in Serbia using the EDAS method, the criteria were: C1 - number of employees, C2 - assets, C3 - capital, C4 - total net operating revenues and C5 - net profit. Alternatives were observed in the years: A1 - 2013, A2 - 2014, A3 - 2015, A4 - 2016, A5 - 2017, A6 - 2018 and A7 - 2019 (Lukic, 2020 a, b, c). (Calculation of bank efficiency in Serbia was performed using EDAS Software-Excel). The obtained results are shown in the tables below, as well as in the graph.

Table 1 shows the initial data for measuring the efficiency of banks in Serbia for the period 2013 - 2019 based on the EDAS method.

Table 1: Initial Data for Measuring the Efficiency of Banks in Serbia

Year	Number of employees	Assets	Capital	Total net operating revenues	Net profit
2013	25188	2809333	589559	120705	30808
2014	23983	2968012	612895	126102	29315
2015	22085	3048183	619442	128962	32324
2016	24096	3243450	634330	136332	38215
2017	22817	3369391	667115	182405	68871
2018	22875	3774098	676704	175871	71349
2019	22739	4083760	705369	175090	65316

Note: Data are expressed in millions of dinars. The number of employees is expressed in whole numbers

Source: Business Registers Agency of the Republic

The weight coefficients of the criteria were determined using the AHP (Analytical Hierarchical Processes) method (Saaty, 2008). They are shown in Table 2 as well as in Figure 1.

Table 2: Weighting coefficients of the Criteria

AHP With Arithmetic Mean Method					
Initial Comparisons Matrix					
	A	B	C	D	E
A		2.5			1
B	0.4			1.25	2
C	0.25	0.333333		0.5	1
D	0.5	0.8			1
E		0.5			1
SUM	3.15	5.13333		5.75	6

Normalized Matrix						
	A	B	C	D	E	Weights of Criteria
A	0.3175	0.4870	0.3636	0.3478	0.1667	0.3365
B	0.1270	0.1948	0.2727	0.2174	0.3333	0.2290
C	0.0794	0.0649	0.0909	0.0870	0.1667	0.0978
D	0.1587	0.1558	0.1818	0.1739	0.1667	0.1674
E	0.3175	0.0974	0.0909	0.1739	0.1667	0.1693
					SUM	1
Consistency Ratio			0.0607	COMPARE WITH 0.1; IT SHOULD BE LESS THAN 0.1.		

Note: A - number of employees, B - assets, C - capital, D - total net operating revenues and E - net profit

Figure 1: Weighting Coefficients of the Criteria

According to the importance of the criteria, the number of employees is in the first place. This is quite understandable, given that banks belong to the service sector, which is characterized by high employment and in terms of digitalization of the entire business. Followed in order of importance criteria: assets, net profit, total and net operating revenues, and capital. This ranking of the selected criteria according to importance is a reflection of the specifics of the banking sector's operations.

In further presentations of the treated issues, we will present the obtained results of the analysis of the efficiency of banks in Serbia on the basis of the EDAS method.

Table 3 features the initial decision matrix.

Table 3: Initial Matrix

Initial Matrix					
Weights of Criteria	0.3365		0.0978	0.1674	0.1693
Kind of Criteria					
	C1	C2	C3	C4	C5
A1	25188	2809333	589559	120705	30808
A2	23983	2968012	612895	126102	29315
A3	22085	3048183	619442	128962	32324
A4	24096	3243450	634330	136332	38215
A5	22817	3369391	667115	182405	68871
A6	22875	3774098	676704	175871	71349
A7	22739	4083760	705369	175090	65316
Average Solution	23397.5714	3328032.4286	643630.5714	149352.4286	48028.2857

Table 4 shows a positive distance from the average value - D_{ij}^+ .

Table 4: Positive Distance from Average Values

D_{ij}^+					
Weights of Criteria	0.3365		0.0978	0.1674	0.1693
	C1	C2	C3	C4	C5
A1	0.0765	0.0000	0.0000	0.0000	0.0000
A2	0.0250	0.0000	0.0000	0.0000	0.0000
A3	0.0000	0.0000	0.0000	0.0000	0.0000
A4	0.0299	0.0000	0.0000	0.0000	0.0000
A5	0.0000	0.0124	0.0365	0.2213	0.4340
A6	0.0000	0.1340	0.0514	0.1776	0.4856
A7	0.0000	0.2271	0.0959	0.1723	0.3599

Table 5 shows a negative distance from the average value - D_{ij}^- .

Table 5: Negative Distance from the Average Value

D_{ij}^-					
Weights of Criteria	0.3365		0.0978	0.1674	0.1693
	C1	C2	C3	C4	C5
A1	0.0000	0.1559	0.0840	0.1918	0.3585
A2	0.0000	0.1082	0.0478	0.1557	0.3896
A3	0.0561	0.0841	0.0376	0.1365	0.3270
A4	0.0000	0.0254	0.0145	0.0872	0.2043
A5	0.0248	0.0000	0.0000	0.0000	0.0000
A6	0.0223	0.0000	0.0000	0.0000	0.0000
A7	0.0281	0.0000	0.0000	0.0000	0.0000

In Table 6 shows the weight-normalized sum of PDA.

Table 6: Weight-Normalized Sum of PDA

PDA							
	C1	C2	C3	C4	C5	Qi+	Si+
A1	0.0257	0.0000	0.0000	0.0000	0.0000	0.0257	0.1703
A2	0.0084	0.0000	0.0000	0.0000	0.0000	0.0084	0.0557
A3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
A4	0.0100	0.0000	0.0000	0.0000	0.0000	0.0100	0.0664
A5	0.0000	0.0028	0.0036	0.0370	0.0735	0.1169	0.7735
A6	0.0000	0.0307	0.0050	0.0297	0.0822	0.1476	0.9767
A7	0.0000	0.0520	0.0094	0.0288	0.0609	0.1512	1.0000
					MAX	0.1512	

In Table 7 shows the weight-normalized sum of NDA.

Table 7: Weight-Normalized Sum of NDA

NDA							
	C1	C2	C3	C4	C5	Qi-	Si-
A1	0.0000	0.0357	0.0082	0.0321	0.0607	0.1367	0.0000
A2	0.0000	0.0248	0.0047	0.0261	0.0660	0.1215	0.1115
A3	0.0189	0.0193	0.0037	0.0229	0.0554	0.1200	0.1221
A4	0.0000	0.0058	0.0014	0.0146	0.0346	0.0564	0.5873
A5	0.0083	0.0000	0.0000	0.0000	0.0000	0.0083	0.9389
A6	0.0075	0.0000	0.0000	0.0000	0.0000	0.0075	0.9450
A7	0.0095	0.0000	0.0000	0.0000	0.0000	0.0095	0.9307
					MAX	0.1367	

Table 8 and Figure 2 feature the ranking of alternatives (Si).

Table 9: Ranking Alternatives

	Si	Si	RANKING
2013	0.085	0.085	5
2014	0.084	0,084	6
2015	0.061	0,061	7
2016	0,327	0,327	4
2017	0,856	0.856	3
2018	0.961	0.961	2
2019	0,965	0.965	1

Figure 2: Evaluating and Ranking Alternatives

The results of empirical research of efficiency of banks in Serbia based on OCRA methods show that it has been continuously increasing in the reporting period (2013 - 2019) on an annual basis. The best value was in 2019. Then follow the other years in the following order: 2018, 2017, 2016, 2013, 2014 and 2015. These dynamics of bank efficiency in Serbia were influenced by numerous macro and micro factors (economic climate, living standard, political stability, digitalization of the entire business, and others).

Conclusion

Based on the obtained results of empirical research of the efficiency of banks in Serbia, based on OCRA methods can conclude that has been continuously increasing in the reporting period (2013-2019) on an annual basis. The best value was in 2019. Then the follow the other years in the following order: 2018, 2017, 2016, 2013, 2014 and 2015. These dynamics of bank efficiency in Serbia were influenced by numerous macro and micro factors, such as: economic climate, living standard, political stability, digitalization of the entire business, and others.

In order to increase the efficiency of banks in Serbia in the future, it is necessary to manage human capital, assets, capital, revenues and profits as efficiently as possible.

References

1. Alinezhad, A., Khalili, J. (2019). EDAS Method. In: New Methods and Applications in Multiple Attribute Decision Making (MADM). International Series in Operations Research & Management Science , 277, 149-155, Springer, Cham. https://doi.org/10.1007/978-3-030-15009-9_21
2. Bukvic, R. (2020). What Demonstrate Concentration Indices: Example of the Banking Sector of Serbia (September 20, 2020). XLVII Symposium on Operations Research, SYM-OP-IS 2020 Belgrade 20–23 September 2020, Proceedings, ed. Milorad Vidovic, Katarina Vukadinovic, Drazen Popovic, University of Belgrade, Faculty of Transportation, Belgrade, 55–60, Available at SSRN: <https://ssrn.com/abstract=3711585>
3. Ersoy, N. (2017). Performance measurement in retail industry by using a multi-criteria decision making methods. *Ege Academic Review* , 17 (4): 539–551. <https://doi.org/10.21121/eab.2017431302>
4. Erakovic, E. (2017). CONCENTRATION EFFECT ON THE EFFICIENCY OF BANKING SECTOR IN THE REPUBLIC OF SERBIA CONCENTRATION EFFECT ON THE EFFICIENCY OF BANKING SECTOR IN THE REPUBLIC OF SERBIA. *FACTA UNIVERSITATIS Series: Economics and Organization* , 14 (3), 281 – 289 <https://doi.org/10.22190/FUEO1703281E>
5. Gaur, L., Agarwal, V., Anshu, K. (2020). Fuzzy DEMATEL Approach to Identify the Factors Influencing Efficiency of Indian Retail Websites. In: Kapur P., Singh O., Khatri S., Verma A. (eds) *Strategic System Assurance and Business Analytics. Asset Analytics (Performance and Safety Management)*. Springer, Singapore. https://doi.org/10.1007/978-981-15-3647-2_6
6. Keshavarz Ghorabae, K., Zavadskas, EK, Olfat, L., Turskis, Z. (2015). Multi-criteria inventory classification using a new method of Evaluation based on Distance from Average Solution (EDAS). *Informatica* , 26, 435–451, [http://dx.doi.org/10.15388/ Informatica.2015.57](http://dx.doi.org/10.15388/Informatica.2015.57)
7. Keshavarz Ghorabae, M .; Zavadskas, EC; Amiri, M .; Turskis, Z. (2016). Extended EDAS Method for Fuzzy Multi-criteria Decision-making: An Application to Supplier Selection. *Int. J. Comput. Commun. Control* , 11, 358–371.
8. Keshavarz-Ghorabae, M .; Amiri, M .; Zavadskas, EC; Turskis, Z .; Antucheviciene, JA (2018). Dynamic Fuzzy Approach Based on the EDAS Method for Multi-Criteria Subcontractor Evaluation. *Information* , 9, 68.
9. Lukic, R. (2010). Audit in banks. Belgrade: Faculty of Economics. (In Serbian: Revizija u bankama. Beograd: Ekonomski fakultet)
10. Lukic. R. (2016). Accounting of insurance companies. Belgrade: Faculty of Economics. (In serbian: Računovodstvo osiguravajućih kompanija. Beograd: Ekonomski fakultet)
11. Lukic, R., Sokic. M. and Kljenak- Vojteski, D. (2017). Efficiency analysis of banking sector in Republic of Serbia. *Business excellence and Management* , 7 (4), 5-17.
12. Lukic, R. (2018a). Analysis of the efficiency of insurance companies. In: Insurance in the
13. post-crisis era, Belgrade: Faculty of Economics, University of Belgrade.

14. Lukic, R. (2018b). Bank accounting. Belgrade: Faculty of Economics. (In Serbian: Bankarsko računovodstvo. Beograd: Ekonomski fakultet)
15. Lukic, R. and Hadrovic Zekic, B. (2019). Evaluation of efficiency of trade companies in Serbia using the DEA approach. Proceedings of the 19th 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.
16. Lukic, R, Hadrovic Zekic, B. and Crnjac Milic, D. (2020a). Financial performance evaluation of trading companies in Serbia using the integrated Fuzzy AHP - TOPSIS Approach. 9th INTERNATIONAL SCIENTIFIC SYMPOSIUM REGION, ENTREPRENEURSHIP, DEVELOPMENT, Under the auspices of: REPUBLIC OF CROATIA MINISTRY OF SCIENCE AND EDUCATION, Osijek, June, 690-703.
17. Lukic, R., Vojteski Kljenak, D. and Andjelic, S. (2020b). ANALYZING FINANCIAL PERFORMANCES AND EFFICIENCY OF THE RETAIL FOOD IN SERBIA BY USING THE AHP - TOPSIS METHOD. Economics of Agriculture , 67(1), 55-68).
18. R. (2020c). ANALYSIS OF THE EFFICIENCY OF TRADE IN OIL DERIVATIVES IN SERBIA BY APPLYING THE FUZZY AHP-TOPSIS METHOD, Business Excellence and Management , 10 (3), 80-98.
19. Mandic, K., Delibasic, B., Knezevic, S., Benkovic, S. (2014). Analysis of the financial parameters of Serbian banks through the application of the fuzzy AHP and TOPSIS methods. Economic Modeling , 43, 30-27.
20. Ren, J., Hu, Ch., Yu, Sq. et al. (2020). An extended EDAS method under four-branch fuzzy environments and its application in credit evaluation for micro and small entrepreneurs. Soft Comput . <https://doi.org/10.1007/s00500-020-05337-1>
21. Saaty, TL (2008). Decision Making With The Analytic Hierarchy Process. Int J Serv Sci , 1 (1), 83-98.
22. Stevic, Z., Vasiljevic, M., Puska, A., Tanackov, I., Junevicius, R., & Veskovic, S. (2019). Evaluation of suppliers under uncertainty: a multiphase approach based on fuzzy AHP and fuzzy EDAS. Transport , 34 (1), 52-66.
23. Torkayesh, S.E., Iranizad, A., Torkayesh, A.E., & Basit, M.N. (2020). Application of BWM-WASPAS model for digital supplier selection problem: A case study in online retail shopping. Journal of Industrial Engineering and Decision Making , 1 (1), 12-23. Retrieved from <http://mcdtgroup.com/index.php/jiedm/article/view/2>