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ANALIZA DINAMIKE LIKVIDNOSTI BANKARSKOG SEKTORA U SRBIJI NA BAZI TOPSIS METODE

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Rezime: Problematika analize likvidnosti bankarskog sektora je vrlo izazovna, značajna, kontinuirano aktuelna i složena. Polazeći od toga, u ovom radu se analizira likvidnost bankarskog sektora na bazi TOPSIS metode. Rezultati TOPSIS metode pokazuju da u top pet godina po likvidnosti bankarskog sektora u Srbiji u posmatranom vremenskom periodu 2008 – 2022. god. spadaju po redosledu: 2013, 2020, 2014, 2019. i 2015. god. Najlošija likvidnost zabeležena je u 2010. god. Može se slobodno kazati da se u poslednje vreme blago povećavala likvidnost bankarskog sektora u Srbiji. Na to su pozitivno uticali brojni makro i mikro faktori (ekonomska klima, kamata, inflacija, devizni kurs, privredna aktivnost, upravljanje aktivom i pasivom, upravljanje neto obrtnim kapitalom, upravljanje rizicima i drugi).

Ključne reči: likvidnost, faktori, bankarski sektor, Srbija, TOPSIS metoda

JEL klasifikacija: E41, G21

Uvod

Istraživanje likvidnosti bankarskog sektora je vrlo izazovno, kontinuirano aktuelno, značajno i složeno. Imajući to u vidu, predmet analize u ovom radu je likvidnost bankarskog sektora u Srbiji na bazi TOPSIS metode. Cilj i svrha toga je da se što realnije sagleda likvidnost bankarskog sektora u Srbiji u funkciji unapređenja u budućnosti primenom relevantnih mera.

Literatura posvećena razvoju i značaju primene DEA modela vrlo je bogata (Andersen, 1993; Banker, 1984; Chen, 2021; Chang, 2020; Guo, 2020; Lee, 2011; Lin, 2020; Pendharkar, 2021; Tone, 2002; Podinovski, 2021; Rostamzadeh, 2021; Fenyves, 2020; Tsai, 2021). Oni se vrlo uspešno primenjuju i u analizi efikasnosti banaka i osiguravajućih kompanija (Savić, 2012; Maletić, 2013; Radojičić, 2018; Cvetkoska, 2017, 2020, 2021; Lukić, 2017; 2018a,b, 2021). Isto tako, prilikom analize finansijskih performansi (profitabilnost, likvidnost) i efikasnosti banaka se sve više primenjuju, integralno ili pojedinačno, i različiti metodi više kriterijumskog odlučivanja, uključujući TOPSIS metodu (Ünlü, 2022; Ali,2022, Lukić, 2022a,b; 2023; Demir, 2022). Sva relevantna literatura u ovom radu se koristi kao teorijsko-metodološka i empirijska osnova za analizu dinamike likvidnosti bankarskog sektora u Srbiji pomoću TOPSIS metode.

Istraživačka hipoteza u ovom radu je zasnovana na činjenici da je kontinuirano praćenje faktora dinamike likvidnosti bankarskog sektora, u konkretnom slučaju u Srbiji, osnova za unapređenje u budućnosti primenom relevantnih mera. U tome značajnu ulogu ima i primena TOPSIS metode.

U odnosu na klasičnu racio analizu, TOPSIS metoda pruže realnije informacije o ostvarenoj likvidnosti bankarskog sektora u Srbiji jer se bazira na integrisanju nekoliko pokazatelja. Zato se, pored racio analize, preporučuje u analizi likvidnosti bankarskog sektora u Srbiji.

Potrebni empirijski podaci za analizu likvidnosti bankarskog sektora u Srbiji na bazi TOPSIS metode su prikupljeni od Narodne banke Srbije. Oni su „proizvedeni“ u skladu sa relevantnim međunarodnim standardima. U pogledu međunarodne komparacije rezultata TOPSIS metode ne postoje nikakva ograničenja.

TOPSIS metoda

TOPSIS metoda (Technique for Order Preference by Similarity to Ideal Solution) veoma se uspešno koristi u proceni finansijskih performansi preduzeća. To je tehnika višekriterijumskog odlučivanja koji su prvi razvili i primenili Hwang and Yoon (1981), (Hwang, 1981, 1995; Amin, 2019). Prema ovoj metodi, alternative su definisane sa njihovim distancama od idealne solucije. Cilj je izbor optimalne alternative koja je najbliža optimalnom rešenju, odnosno najudaljenija od negativnog idealnog rešenja (Young, 1994). Pozitivno idealno rešenje maksimizira korisnost, tj. minimizira troškove (u odnosu na dati problem). Nasuprot tome, negativno idealno rešenje maksimizira troškove, odnosno minimalizuje korisnost.

TOPSIS metoda se sastoji iz 6 koraka (Üçüncü et al., 2018):

Korak 1: Kreiranje inicijalne matrice

U prikazanoj inicijalnoj matrici A_{ij} sa "*m*" je označen broj alternative a sa "*n*" broj kriterijuma:

$$A_{ij} = \begin{vmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{vmatrix} \quad (1)$$

Korak 2: Formiranje težinske normalizovane matrice odlučivanja

Normalizovana matrica odlučivanja (R_{ij}; $i=1,\ldots,m$; $j=1,\ldots,n$) određuje se jednačinom (2) sa elementima matrice A_{ij}:

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^2}}$$

$$t = 1,2,3,\ldots,m \qquad j = 1,2,3,\ldots,n \quad (2)$$

$$R_{ij} = \begin{vmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{vmatrix}$$

U jednačini (3) težinska mera „j" je reprezentovana sa W_{ij}. Težinski normalizovana matrica odlučivanja (V_{ij}; $i=1,\ldots,m$; $j=1,\ldots,n$) je utvrđena korišćenjem jednačine (3) sa elementima normalizovane matrice:

$$V_{ij} = W_{ij} * r_{ij} \quad (3)$$

$$i = 1,2,3,\ldots,m \qquad j = 1,2,3,\ldots,n$$

Korak 3: Određivanje pozitivnog i negativnog-idealnog rešenja

Vrednost pozitivnog-idealnog rešenja (A^+) i negativnog-idealnog rešenja (A^-) se utvrđuje iz vrednosti težinski normalizovane matrice (V_{ij}). A^+ je bolji, a A^- lošiji performansi rezultat (performance score).

Vrednost pozitivnog-idealnog rešenja (A^+) i negativnog-idealnog rešenja (A^-) se određuje na sledeći način (jednačina (4) (5) respektivno):

$$A^+ = \{v_i^+, \dots, v_n^+\} = \left\{\left(\max_i v_{ij}, j \in j\right)\left(\min_i v_{ij}, j \in j'\right)\right\} \; i = 1,2, \dots, m \tag{4}$$

$$A^- = \{v_i^-, \dots, v_n^-\} = \left\{\left(\min_i v_{ij}, j \in j\right)\left(\max_i v_{ij}, j \in j'\right)\right\} \; i = 1,2, \dots, m \tag{5}$$

gde je j u vezi sa benefitnim kriterijumom, i j' u vezi sa troškovnim kriterijumom.

Korak 4: Određivanje posebnih mera (tj. rastojanja alternativa od idealnog i negativno-idealnog rešenja)

Rastojanje od pozitivnog-idealnog rešenja (S_i^+) i negativnog-idealnog rešenja (S_i^-) za svaku alternativu prema datom kriterijumu se utvrđuje korišćenjem jednačina (6) (7):

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \tag{6}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \tag{7}$$

$$i = 1,2,3, \dots, m \qquad\qquad j = 1,2,3, \dots, n$$

Korak 5: Određivanje koeficijenta relativne bliskosti idealnom rešenju

Posebne mere pozitivnog-idealnog rešenja (S_i^+) i negativnog-idealnog rešenja (S_i^-) su korišćene za određivanje relativne bliskosti idealnom rešenju (C_i^+) za svaku tačku odlučivanja. C_i^+ reprezentuje relativnu bliskost idealnom rešenju i uzima vrednost u rasponu $0 \leq C_i + \leq 1$. "C_i^+" $= 1$ pokazuje relativnu bliskost pozitivnom-idealnom rešenju. "C_i^+" $= 0$ pokazuje relativnu bliskost negativnom-idealnom rešenju.

Relativna bliskost idealnom rešenju (C_i^+; i=1,…,m; $j=1,\dots,n$) je utvrđena korišćenjem jednačine (8):

$$C_i^+ = \frac{S_i^-}{S_i^- + S_i^+} \tag{8}$$

$$i = 1,2,3, \dots, m$$

Korak 6: Sortiranje alternativa prema relativnoj superiornosti

Utvrđivanje relativne superiornosti rezultata (score) reprezentuje ostvarene kompanijske performanse. Visoki rezultati korespondiraju sa boljim performansama. Rezultati se mogu koristiti za utvrđivanja ranga kompanije u okviru industrije (Üçüncü et al., 2018).

Metoda analitičkog hijerarhijskog procesa (AHP)

S obzirom na to da se u ovom radu težinski koeficijenti kriterijuma kod primene TOPSIS metode utvrđuju pomoću AHP metode, ukratko ćemo se osvrnuti na njene teorijsko-metodološke karakteristike.

Sam proces primene metode analitičkog hijerarhijskog procesa (AHP) (Analytic Hierarchy Process) sastoji se iz sledećih koraka (Saaty, 2008):

Korak 1: Definisanje matrice parova poređenja

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \quad (9)$$

Korak 2: Normalizacija matrice parova poređenja

$$a_{ij}^{*} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, i, j = 1, \ldots, n \quad (10)$$

Korak 3: Utvrđivanje relativnog značaja, tj. vektora težina

$$w_i = \frac{\sum_{i=1}^{n} a_{ij}^{*}}{n}, i, j = 1, \ldots, n \quad (11)$$

Indeks konzistentnosti - CI (consistency index) predstavlja meru odstupanja n od λmax i može se predstaviti sledećom formulom:

$$CI = \frac{\lambda_{max} - n}{n} \quad (12)$$

Ukoliko je CI < 0,1 procenjene vrednosti koeficijenata a_{ij} su konzistentne, a odstupanje λ_{max} od *n* je zanemarljivo. To znači, drugim rečima, da AHP metoda prihvata nekonzistentnost manju od 10%.

Na bazi indeksa konzistentnosti može se izračunati odnos konzistentnosti CR = CI/RI, pri čemu je RI slučajni indeks.

Rezultati i diskusija

U kontekstu analize likvidnosti bankarskog sektora u Srbiji kao kriterijumi su uzeti najvažniji pokazatelji. Alternative su posmatrane godine. Oni su, kao i inicijalni podaci prikazani u Tabeli 1. (U ovom radu sva izračunavanja i rezultati su autorovi.)

Tabela 1 - Inicijalni podaci

	Likvidna aktiva u užem smislu u odnosu na ukupnu aktivu	Likvidna aktiva u užem smislu u odnosu na kratkoročne obaveze	Likvidna aktiva u odnosu na ukupnu aktivu	Likvidna aktiva u odnosu na kratkoročne obaveze	Depoziti u odnosu na kredite (ne monetarni sektori)	Devizni krediti u odnosu na ukupne kredite	Prosečan mesečni pokazatelj likvidnosti	Prosečan mesečni uži pokazatelj likvidnosti
	C1	C2	C3	C4	C5	C6	C7	C8
A1 2008	47,8	75,7	47,8	75,7	82,7	73,9	1,8	1,2
A2 2009	48,2	73,8	49	75,1	88,3	75,8	1,9	1,2
A3 2010	41,8	67,1	43,7	70,1	80,1	76,8	2	1,3
A4 2011	40,3	67,3	42,3	70,6	83,1	69,8	2,2	1,5
A5 2012	35,2	58,9	38,9	65	84,9	74,1	2,1	1,6
A6 2013	36,1	58,3	41	66,4	92,3	71,6	2,4	1,8
A7 2014	35,7	56,3	42,2	66,7	95,7	70,1	2,2	1,7
A8 2015	32,5	49,3	40,5	61,3	99,7	72,3	2,1	1,7
A9 2016	30,5	44,3	38,9	56,6	108,1	69,4	2,1	1,7
A10 2017	27,5	39,9	35,1	50,9	106,9	67,5	2	1,7
A11 2018	28	39,6	35,7	50,5	110,6	68,5	2	1,7
A12 2019	25,7	36,1	36	50,5	109,2	67,1	2,2	1,8
A13 2020	26,7	36,4	37,3	50,9	116,4	64,7	2,2	1,9
A14 2021	27,9	36,8	37,7	49,6	119,5	63,2	2,1	1,7
A15 2022	24,6	31,9	35	45,4	114,4	66,6	2	1,6

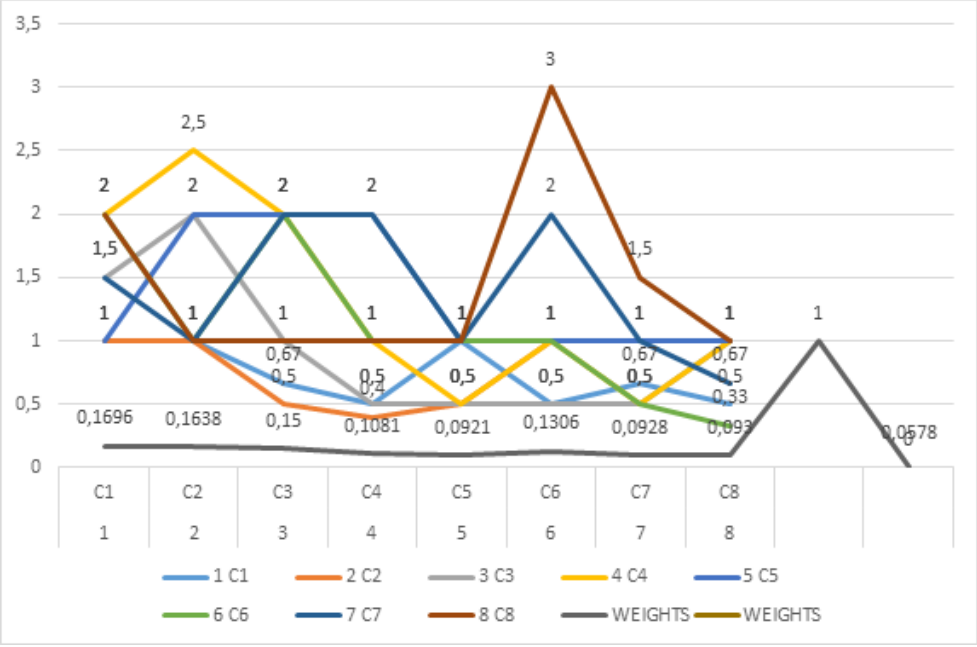
Napomena: Podaci za 2022. su prikazani za III kvartal

Izvor: Narodna banaka Srbije

Težinski koeficijenti kriterijuma su utvrđeni pomoću AHP metode. U Tabeli 2. i na Slici 1. su prikazani težinski koeficijenti kriterijuma.

Tabela 2 - Težinski koeficijenti kriterijuma

$W = \lim_{k\to\infty} \frac{A^k.e}{e^T.A^k.e}$		1	2	3	4	5	6	7	8	**Težinski koeficijenti**	
		C1	C2	C3	C4	C5	C6	C7	C8		
1	C1	1,00	1,00	1,50	2,00	1,00	2,00	1,50	2,00	**0,1696**	
2	C2	1,00	1,00	2,00	2,50	2,00	1,00	1,00	1,00	**0,1638**	
3	C3	0,67	0,50	1,00	2,00	2,00	2,00	2,00	1,00	**0,1500**	
4	C4	0,50	0,40	0,50	1,00	2,00	1,00	2,00	1,00	**0,1081**	
5	C5	1,00	0,50	0,50	0,50	1,00	1,00	1,00	1,00	**0,0921**	
6	C6	0,50	1,00	0,50	1,00	1,00	1,00	2,00	3,00	**0,1306**	
7	C7	0,67	1,00	0,50	0,50	1,00	0,50	1,00	1,50	**0,0928**	
8	C8	0,50	1,00	1,00	1,00	1,00	0,33	0,67	1,00	**0,0930**	
										1,0000	
										Indeks konzistentnosti	**0,0578**



Slika 1 - Težinski koeficijenti kriterijuma

Najznačajniji kriterijumi su likvidna aktiva u užem smislu u odnosu na ukupnu aktivu, likvidna aktiva u užem smislu u odnosu na kratkoročne obaveze, likvidna aktiva u odnosu na ukupnu aktivu i devizni krediti u odnosu na ukupne kredite. Adekvatnim upravljanjem ovim pokazateljima može se i te kako ostvariti ciljna likvidnost bankarskog sektora u Srbiji.

U Tabelama 3 – 6 i na Slici 2. su prikazana izračunavanja i rezultati TOPSIS metode.

Tabela 3 - Inicijalna matrica

Težinski koeficijenti kriterijuma	0,1696	0,1638	0,15	0,1081	0,0921	0,1306	0,0928	0,93
Vrsta kriterijuma	1	1	1	1	1	1	1	1
Inicijalna matrica	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
A1	47,8	75,7	47,8	75,7	82,7	73,9	1,8	1,2
A2	48,2	73,8	49	75,1	88,3	75,8	1,9	1,2
A3	41,8	67,1	43,7	70,1	80,1	76,8	2	1,3
A4	40,3	67,3	42,3	70,6	83,1	69,8	2,2	1,5
A5	35,2	58,9	38,9	65	84,9	74,1	2,1	1,6
A6	36,1	58,3	41	66,4	92,3	71,6	2,4	1,8
A7	35,7	56,3	42,2	66,7	95,7	70,1	2,2	1,7
A8	32,5	49,3	40,5	61,3	99,7	72,3	2,1	1,7
A9	30,5	44,3	38,9	56,6	108,1	69,4	2,1	1,7
A10	27,5	39,9	35,1	50,9	106,9	67,5	2	1,7
A11	28	39,6	35,7	50,5	110,6	68,5	2	1,7
A12	25,7	36,1	36	50,5	109,2	67,1	2,2	1,8
A13	26,7	36,4	37,3	50,9	116,4	64,7	2,2	1,9
A14	27,9	36,8	37,7	49,6	119,5	63,2	2,1	1,7
A15	24,6	31,9	35	45,4	114,4	66,6	2	1,6

Informacije za normalizaciju	**Suma kvadrata**	18079,85	42799,59	24353,41	56116,41	150970,5	73918,96	65,61	39,37
	SQRT	134,4613	206,8806	156,0558	236,8890	388,5492	271,8804	8,1000	6,2746

Tabela 4 - Normalizovana matrica

Težinski koeficijenti kriterijuma	0,1696	0,1638	0,15	0,1081	0,0921	0,1306	0,0928	0,93
Vrsta kriterijuma	1	1	1	1	1	1	1	1
Inicijalna matrica	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
A1	0,3555	0,3659	0,3063	0,3196	0,2128	0,2718	0,2222	0,1912
A2	0,3585	0,3567	0,3140	0,3170	0,2273	0,2788	0,2346	0,1912

A3	0,3109	0,3243	0,2800	0,2959	0,2062	0,2825	0,2469	0,2072
A4	0,2997	0,3253	0,2711	0,2980	0,2139	0,2567	0,2716	0,2391
A5	0,2618	0,2847	0,2493	0,2744	0,2185	0,2725	0,2593	0,2550
A6	0,2685	0,2818	0,2627	0,2803	0,2376	0,2634	0,2963	0,2869
A7	0,2655	0,2721	0,2704	0,2816	0,2463	0,2578	0,2716	0,2709
A8	0,2417	0,2383	0,2595	0,2588	0,2566	0,2659	0,2593	0,2709
A9	0,2268	0,2141	0,2493	0,2389	0,2782	0,2553	0,2593	0,2709
A10	0,2045	0,1929	0,2249	0,2149	0,2751	0,2483	0,2469	0,2709
A11	0,2082	0,1914	0,2288	0,2132	0,2846	0,2519	0,2469	0,2709
A12	0,1911	0,1745	0,2307	0,2132	0,2810	0,2468	0,2716	0,2869
A13	0,1986	0,1759	0,2390	0,2149	0,2996	0,2380	0,2716	0,3028
A14	0,2075	0,1779	0,2416	0,2094	0,3076	0,2325	0,2593	0,2709
A15	0,1830	0,1542	0,2243	0,1917	0,2944	0,2450	0,2469	0,2550

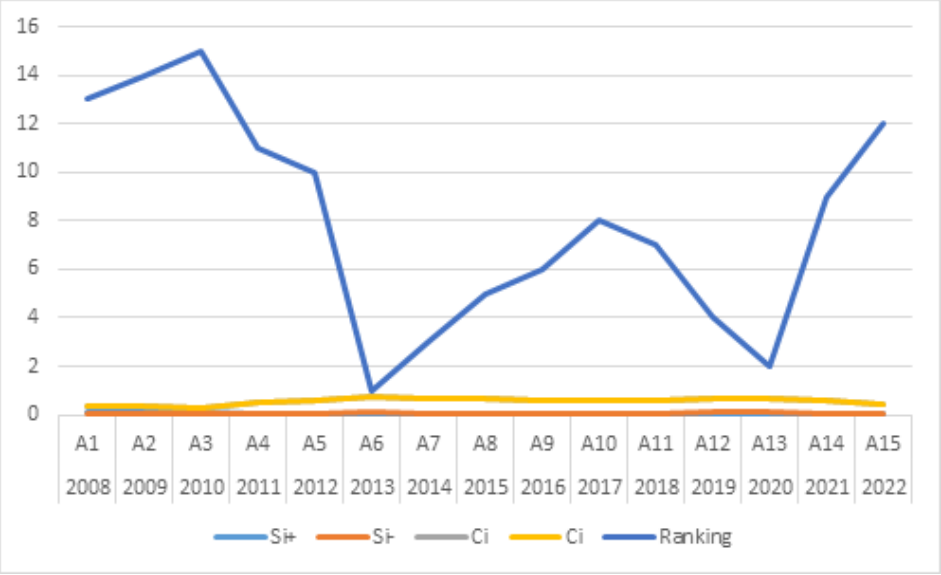
Tabela 5 - Normalizovana težinska matrica

Normalizovana težinska matrica								
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
A1	0,0603	0,0599	0,0459	0,0345	0,0196	0,0355	0,0206	0,1779
A2	0,0608	0,0584	0,0471	0,0343	0,0209	0,0364	0,0218	0,1779
A3	0,0527	0,0531	0,0420	0,0320	0,0190	0,0369	0,0229	0,1927
A4	0,0508	0,0533	0,0407	0,0322	0,0197	0,0335	0,0252	0,2223
A5	0,0444	0,0466	0,0374	0,0297	0,0201	0,0356	0,0241	0,2371
A6	0,0455	0,0462	0,0394	0,0303	0,0219	0,0344	0,0275	0,2668
A7	0,0450	0,0446	0,0406	0,0304	0,0227	0,0337	0,0252	0,2520
A8	0,0410	0,0390	0,0389	0,0280	0,0236	0,0347	0,0241	0,2520
A9	0,0385	0,0351	0,0374	0,0258	0,0256	0,0333	0,0241	0,2520
A10	0,0347	0,0316	0,0337	0,0232	0,0253	0,0324	0,0229	0,2520
A11	0,0353	0,0314	0,0343	0,0230	0,0262	0,0329	0,0229	0,2520
A12	0,0324	0,0286	0,0346	0,0230	0,0259	0,0322	0,0252	0,2668
A13	0,0337	0,0288	0,0359	0,0232	0,0276	0,0311	0,0252	0,2816
A14	0,0352	0,0291	0,0362	0,0226	0,0283	0,0304	0,0241	0,2520
A15	0,0310	0,0253	0,0336	0,0207	0,0271	0,0320	0,0229	0,2371

MIN	0,0310	0,0253	0,0336	0,0207	0,0190	0,0304	0,0206	0,1779
MAX	0,0608	0,0599	0,0471	0,0345	0,0283	0,0369	0,0275	0,2816
A+	0,0608	0,0599	0,0471	0,0345	0,0283	0,0369	0,0275	0,2816
A-	0,0310	0,0253	0,0336	0,0207	0,0190	0,0304	0,0206	0,1779

Tabela 6 - Rezultati TOPSIS metode

	Alternative	Si+	Si-	Ci	Ci	Rangiranje
2008	**A1**	0,1044	0,0493	0,3207	0,321	13
2009	**A2**	0,1042	0,0489	0,3195	0,320	14
2010	**A3**	0,0903	0,0414	0,3141	0,314	15
2011	**A4**	0,0616	0,0580	0,4850	0,485	11
2012	**A5**	0,0512	0,0655	0,5611	0,561	10
2013	**A6**	0,0277	0,0936	0,7716	0,772	1
2014	**A7**	0,0383	0,0791	0,6734	0,673	3
2015	**A8**	0,0431	0,0769	0,6409	0,641	5
2016	**A9**	0,0469	0,0758	0,6180	0,618	6
2017	**A10**	0,0522	0,0748	0,5893	0,589	8
2018	**A11**	0,0518	0,0750	0,5914	0,591	7
2019	**A12**	0,0483	0,0894	0,6495	0,650	4
2020	**A13**	0,0447	0,1044	0,7001	0,700	2
2021	**A14**	0,0529	0,0751	0,5866	0,587	9
2022	**A15**	0,0670	0,0599	0,4722	0,472	12



Slika 2 - Rangiranje alternativa

Prema tome, rezultati TOPSIS metode pokazuju da u top pet godina po likvidnosti bankarskog sektora u Srbiji u posmatranom vremenskom periodu 2008 – 2022. god. spadaju po redosledu: 2013, 2020, 2014, 2019. i 2015. god. Najlošija likvidnost bankarskog sektora u Srbiji u posmatranom vremenskom periodu je bila u 2010. god. U poslednje vreme, može se slobodno kazati, blago se povećavala likvidnost bankarskog sektora u Srbiji.

Faktori likvidnosti bankarskog sektora u Srbiji su makro i mikro prirode. To su: ekonomska klima, kamata, inflacija, devizni kurs, privredna aktivnost, upravljanje aktivom i pasivom, upravljanje neto obrtnim kapitalom, upravljanje rizicima i drugi. Njihovom adekvatnom kontrolom može se ostvariti ciljna likvidnost bankarskog sektora u Srbiji.

Treba posebno naglasiti da su u poslednje vreme na likvidnost bankarskog sektora u Srbiji, kao i u drugim zemljama uticali specifični faktori kao što su globalna politička klima, pandemija korona virusa Covid – 19 i energetska kriza. Oni su prouzrokovali pad privredne, a time i kreditne aktivnosti. U izvesnoj meri banke su se prilagođavale ovoj situaciji sa primenom elektronskog bankarstva i na taj način uložili negativan efekat spomenutih faktora na njihovu profitabilnost i likvidnost.

Zaključak

Dobijeni rezultati TOPSIS metode pokazuju da u top pet godina po likvidnosti bankarskog sektora u Srbiji u posmatranom vremenskom periodu 2008 – 2022. god. spadaju po redosledu: 2013, 2020, 2014, 2019. i 2015. god. Najlošija likvidnost bankarskog sektora u Srbiji je bila u 2010. god. U poslednje vreme blago se povećavala likvidnost bankarskog sektora u Srbiji.

Determinante tome su: ekonomska klima, kamata, inflacija, devizni kurs, privredna aktivnost, upravljanje aktivom i pasivom, upravljanje neto obrtnim kapitalom, upravljanje rizicima i drugi. Njihovom adekvatnom kontrolom može se ostvariti ciljna likvidnost bankarskog sektora.

Literatura

1. Ali, S.M., Hoq, S.M.N., Bari, A.B.M.M., Kabir, G., Paul, S.K. (2022). Evaluating factors contributing to the failure of information system in the banking industry. PLoS ONE, 17(3): e0265674. https://doi.org/10.1371/journal.pone.0265674
2. Andersen, P.; Petersen, N.C. (1993). A procedure for ranking efficient units in data envelopment analysis. Management Science, 39, 1261-1264.
3. Amini, A., Alinezhad, A., & Yazdipoor, F. (2019). A TOPSIS, VIKOR and DEA integrated evaluation method with belief structure under uncertainty to rank alternatives. Inter national Journal of Advanced Operations Management, 11(3), 171–188.
4. Banker, R.D., Charnes, A. and Cooper, W.W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management Science, 30(9), 1078–1092.
5. Božanić, D., Pamučar, D., Milić,A., Marinković, M.and Komazec, N. (2022). Modification of the Logarithm Methodology of Additive Weights (LMAW) by a Trian gular Fuzzy Number and Its Application in Multi-Criteria Decision Making. Axioms, 11(3), 89. https://doi.org/10.3390/axioms11030089

6. Chang, X. and 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. doi: 10.1109/ITAIC49862.2020.9339131
7. Chen, Chunhua, Liu, Haohua, Tang, Lijun and Ren, Jianwei. (2021). A Range Adjusted Measure of Super-Efficiency in Integer-Valued Data Envelopment Analysis with Un-desirable Outputs. Journal of Systems Science and Information, 9(4), 378-398. https://doi.org/10.21078/JSSI-2021-378-21
8. Cvetkoska, V., and Savic, G. (2017). Efficiency of bank branches: Empirical evidence from a two-phase research approach. Economic Research-Ekonomska istraživanja, 30(1), 318–333. doi: 10.1080/1331677X.2017.1305775
9. Cvetkoska, V. and Cikovic, K.F.(2020). Assessing the relative efficiency of commercial banks in the Republic of North Macedonia: DEA window analysis. Croatian Operational Research Review 217 CRORR 11, 217-227.
10. Cvetkoska, V., Fotova Ciković, K. and Tasheva, M. (2021). Efficiency of Commercial Banking in Developing Countries. Mathematic , 9, 1597. https://doi.org/10.3390/math9141597
11. Demir, G. (2022). Analysis of the financial performance of the deposit banking sector in the Covid-19 period with LMAW-DNMA methods. International Journal of Insurance and Finance, 2(2), 17-36.https://doi.org/10.52898/ijif.2022.7
12. Fenyves, V. and Tarnóczi, T. (2020). Data envelopment analysis for measuring performance in a competitive market. Problems and Perspectives in Management, 18(1), 315-325. doi:10.21511/ppm.18(1).2020.27
13. Guo, D. and Cai, Z.Q. (2020). Super-Efficiency Infeasibility in the Presence of Nonradial Measurement. Mathematical Problems in Engineering, 2020, Article ID 6264852, 7 pages. https://doi.org/10.1155/2020/6264852
14. Hwang C.L., Yoon K.S. (1981). Multiple attribute decision making: methods and appli- cations. Berlin: Springer.
15. Hwang, C. L., Yoon, K.P. (1995). Multiple Attribute Decision Making: An Introduction. Paperback / Sage Publications.
16. Lee, H.S., Chu, C.W. and J. Zhu, J. (2011). Super-efficiency DEA in the presence of infeasibility. European Journal of Operational Research, 212(1), 141–147.
17. 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.
18. Lukic, R., Sokic, M. & Vojteski Kljenak, D. (2017). Efficiency Analysis Of Banking Sector In Republic Of Serbia. Business Excellence and Management, 7(4), 5-17.
19. Lukić, R. (2018a). Bankarsko računovodstvo. Beograd: Ekonomski fakultet.
20. Lukic, R. (2018d). Analysis of the efficiency of insurance companies. In: Insurance in the post-crisis era, Belgrade: Faculty of Economics, University of Belgrade. ISBN:978- 86-403-1548-7.
21. 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 Strossmaye, 145-162.

22. Lukic, R. (2021). Application of the EDAS method in the evaluation of bank efficiency in Serbia. Bankarstvo - Banking, 50(2), 13-24. doi: 10.5937/bankarstvo2102064L
23. Lukić, R. (2022a). Evaluation of the efficiency of banks in Serbia using the MABAC method. Bankarstvo - Banking, 2, 35-60. DOI: 10.5937/bankarstvo2202010L
24. Lukić, R. (2022b). Analysis of financial performance and efficiency of banks in Serbia using fuzzy LMAW and MARCOS methods. Bankarstvo – Banking, 4, 130-169.
25. Lukić, R. (2023). Measurement and analysis of profitability dynamics of the banking sector in Serbia based on the flmaw-marcos method. Bankarstvo, 1/2023.
26. Maletić, R., Kreća, M., & Maletić, P. (2013). Application of dea methodology in measuring efficiency in the banking sector. Economics of Agriculture, 60(4), 843–855. https://www.ea.bg.ac.rs/index.php/EA/article/view/423
27. Milenković, N., Radovanov, B., Kalaš, B. and Horvat, A.M. (2022). External Two Stage DEA Analysis of Bank Efficiency in West Balkan Countries. Sustainability, 14, 978. https:// doi.org/10.3390/su14020978
28. Pamučar, D., Žižović, M., Biswas, S., Božanić, D. (2021). A new logarithm methodology of additive weights (LMAW) for multiλcriteria decisionλmaking: Application in logistics. Facta Univ. Ser. Mech. Eng., 2021, 19, 361–380. https://doi.org/10.22190/FUME210214031P
29. Puška, A., Božanić, D., Nedeljković, M., Janošević, M. (2022). Green Supplier Selection in an Uncertain Environment in Agriculture Using a Hybrid MCDM Model: ZλNumbers–Fuzzy LMAW–Fuzzy CRADIS Model. Axioms, 11, 427. https://doi.org/10.3390/axioms1109042
30. 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.
31. Peykani, P., Seyed Esmaeili, F.S., Mirmozaffari, M., Jabbarzadeh, A. and Khamechian, M. (2022). Input/Output Variables Selection in Data Envelopment Analysis: A Shannon Entropy Approach. Mach. Learn. Knowl. Extr., 4, 688–699. https://doi.org/10.3390/ make4030032
32. Peykani, P., Gheidar-Kheljani, J., Farzipoor Saen, R., & Mohammadi, E. (2022a). Generalized Robust Window Data Envelopment Analysis Approach for DynamicPerformance Measurement under Uncertain Panel Data. Operational Research, 1-36.https://doi.org/10.1007/s12351-022-00729-7.
33. Podinovski, V.V. and 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
34. Radojičić, M., Savić, G., & Jeremić, V. (2018). Measuring the efficiency of banks: the bootstrapped I-distance GAR DEA approach. Technological and Economic Development of Economy, 24(4), 1581-1605. https://doi.org/10.3846/tede.2018.3699
35. 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

35. 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
36. Savić, G., Radosavljević, M., & Ilievski, D. (2012). DEA Window analysis approach for measuring the efficiency of Serbian banks. Management - časopis za teoriju i praksu menadžmenta, 17(65), 5-14.
37. Saaty, T. L. (2008). Decision Making With The Analytic Hierarchy Process. Int J Serv Sci, 1(1), 83-98. https://doi.org/10.1504/IJSSCI.2008.017590
38. Stević, Ž., Pamučar, D., Puška, A. and Chatterjee, P. (2020a). Sustainable supplier selection in healthcare industries using a new MCDM method: Measurement of alternatives and ranking according to Compromise solution (MARCOS). Computers & Industrial Engineering, 140, 106231. https://doi.org/10.1016/j.cie.2019.106231.
39. Stević, Ž. and Brković, N. A. (2020b). Novel Integrated FUCOM-MARCOS Model for Evaluation of Human Resources in a Transport Company. Logistics, 4, 4. https://doi.org/10.3390/ logistics4010004
40. Tone, K. (2002). A slacks-based measure of super-efficiency in data envelopment analysis. European Journal of Operational Research, 143, 32-41.
41. Tsai, Chi-Mao; Lee, Hsuan-Shih; and 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. DOI: 10.51400/2709-6998.1006
42. Üçüncü, T., Akyüz, K. C., Akyüz, İ., Bayram, B. Ç., Ve Ersen, N. (2018). Evaluation Of Financial Performance Of Paper Companies Traded At BIST With TOPSIS Method. Kastamonu Unıversıty Journal Of ForestryFaculty, 18(1), 92-98.
43. Ünlü, U., Yalçın, N. and Avşarlıgil, N. (2022). Analysis of Efficiency and Productivity of Commercial Banks in Turkey Pre- and during COVID-19 with an Integrated MCDM Approach. Mathematics, 10(13), 2300. https://doi.org/10.3390/math10132300

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ANALYSIS OF THE LIQUIDITY DYNAMICS OF THE BANKING SECTORIN SERBIA BASED ON THE TOPSIS METHOD

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Summary: The problem of analyzing the liquidity of the banking sector is very challenging, significant, continuously updated and complex. Based on that, this paper analyzes the liquidity of the banking sector based on the TOPSIS method. The results of the TOPSIS method show that the top five years in terms of liquidity of the banking sector in Serbia in the observed time period 2008 - 2022 are in the following order: 2013, 2020, 2014, 2019 and 2015. The worst liquidity was recorded in 2010. It can be safely said that recently the liquidity of the banking sector in Serbia has slightly increased. This was positively influenced by numerous macro and micro factors (economic climate, interest rate, inflation, exchange rate, economic activity, asset and liability management, net working capital management, risk management and others).

Keywords: liquidity, factors, banking sector, Serbia, TOPSIS method

JEL classification: E41, G21

Introduction

Banking sector liquidity research is very challenging, continuously topical, significant and complex. Bearing that in mind, the subject of analysis in this paper is the liquidity of the banking sector in Serbia based on the TOPSIS method. The goal and purpose of this is to assess the liquidity of the banking sector in Serbia, as realistically as possible, in order to improve it in the future, by applying relevant measures.

The literature devoted to the development and importance of the application of the DEA model is abundant (Andersen, 1993; Banker, 1984; Chen, 2021; Chang, 2020; Guo, 2020; Lee, 2011; Lin, 2020; Pendharkar, 2021; Tone, 2002; Podinovski , 2021; Rostamzadeh, 2021; Fenyves, 2020; Tsai, 2021). They are also very successfully applied in the analysis of the efficiency of banks and insurance companies (Savic, 2012; Maletić, 2013; Radojicic, 2018; Cvetkoska, 2017, 2020, 2021; Lukic, 2017; 2018a,b, 2021, 2022a,b, 2023). Likewise, when analyzing financial performance (profitability, liquidity) and efficiency, banks increasingly apply, integrally or individually, different methods of multi-criteria decision-making, including the TOPSIS method (Ünlü, 2022; Ali, 2022, Lukic, 2022a,b; Demir, 2022). All relevant literature in this paper is used as a theoretical-methodological and empirical basis for the analysis of the liquidity dynamics of the banking sector in Serbia using the TOPSIS method.

The research hypothesis in this paper is based on the fact that continuously monitoring the factors of liquidity dynamics of the banking sector, in the specific case of Serbia, is the basis for improvement in the future, by applying relevant measures. The application of the TOPSIS method plays a significant role in this.

Compared to the classic ratio analysis, the TOPSIS method provides more realistic information about the realized liquidity of the banking sector in Serbia because it is based on the integration of several indicators. That is why, in addition to the ratio analysis, the TOPSIS methos is recommended in the analysis of the liquidity of the banking sector in Serbia.

The necessary empirical data for the analysis of the liquidity of the banking sector in Serbia based on the TOPSIS method were collected from the National Bank of Serbia. They are "manufactured" in

TOPSIS method

The TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution) is used very successfully in evaluating the financial performance of companies. This is a technique of multicriteria decision-making, first developed and implemented by Hwang and Yoon (1981), (Hwang, 1981, 1995; Amin, 2019). According to this method, alternatives are defined by their distances from the ideal solution. The goal is to choose the optimal alternative that is closest to the optimal solution, that is, the farthest from the negative ideal solution (Young, 1994). A positive ideal solution maximizes utility, i.e., minimizes costs (relative to the given problem). Conversely, a negative ideal solution maximizes costs, i.e., minimizes utility.

The TOPSIS method consists of 6 steps (Üçüncü et al., 2018):

Step 1: Creating the initial matrix

In the displayed initial matrix A_{ij}, the number of the alternative is marked with "*m*" and the number of criteria with "*n*":

$$A_{ij} = \begin{vmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{vmatrix} \quad (1)$$

Step 2: Formation of the weighted normalized decision matrix

The normalized decision matrix (R_{ij}; $i=1,\ldots,m$; $j=1,\ldots,n$) is determined by equation (12) with matrix elements A_{ij} :

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^2}} \quad (2)$$

$$t = 1,2,3,\ldots,m \qquad j = 1,2,3,\ldots,n$$

$$R_{ij} = \begin{vmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{vmatrix}$$

In equation (3), the weight measure "j" is represented by W_{ij}. The weight-normalized decision matrix (V_{ij}; $i=1,\ldots,m$; $j=1,\ldots,n$) was determined using equation (3) with the elements of the normalized matrix:

$$V_{ij} = W_{ij} * r_{ij}$$

$$i = 1,2,3,\ldots,m \qquad j = 1,2,3,\ldots,n \quad (3)$$

Step 3: Determination of positive and negative-ideal solutions

The value of the positive-ideal solution (A^+) and the negative-ideal solution (A^-) is determined from the value of the weight-normalized matrix (V_{ij}). A^+ is better, and A^- is a worse performance score.

The value of the positive-ideal solution (A^+) and the negative-ideal solution (A^-) is determined as follows (equation (4) and (5) respectively):

$$A^+ = \{v_i^+, \dots, v_n^+\} = \left\{\left(\max_i v_{ij}, j \in j\right)\left(\min_i v_{ij}, j \in j'\right)\right\} \; i = 1,2, \dots, m \tag{4}$$

$$A^- = \{v_i^-, \dots, v_n^-\} = \left\{\left(\min_i v_{ij}, j \in j\right)\left(\max_i v_{ij}, j \in j'\right)\right\} \; i = 1,2, \dots, m \tag{5}$$

where j is related to the benefit criterion, and j′ is related to the cost criterion.

Step 4: Determining special measures (i.e., distance of alternatives from ideal and negative-ideal solution)

The distance from the positive-ideal solution (S_i^+) and the negative-ideal solution (S_i^-) for each alternative according to the given criterion is determined using equations (6) and (7):

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \tag{6}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \tag{7}$$

$i = 1,2,3, \dots, m$ $\qquad$ $j = 1,2,3, \dots, n$

Step 5: Determination of the coefficient of relative closeness to the ideal solution

Separate measures of positive-ideal solution (S_i^+) and negative-ideal solution (S_i^-) were used to determine the relative closeness to the ideal solution (C_i^+) for each decision point. C_i^+ s the relative closeness to the ideal solution and takes a value in the range $0 \le C_i + \le 1$. "C_i^+" $= 1$ shows the relative closeness to the positive-ideal solution."C_i^+" $= 0$ shows relative closeness to the negative-ideal solution.

The relative closeness to the ideal solution (C_i^+; i=1,…,m; $j=1, \dots, n$) was determined using equation (8):

$$C_i^+ = \frac{S_i^-}{S_i^- + S_i^+} \tag{8}$$

$$i = 1,2,3, \dots, m$$

Step 6: Sorting alternatives according to relative superiority

Determining the relative superiority of the score is the achieved company performance. High scores correspond to better performance. The results can be used to determine the company's ranking within the industry (Üçüncü et al., 2018).

Analytical Hierarchy Process (AHP) Method

Considering that in this paper the weighting coefficients of the criteria when applying the TOPSIS method are determined using the AHP method, we will briefly refer to its theoretical and methodological characteristics.

The Analytic Hierarchy Process (AHP) method consists of the following steps (Saaty, 2008):

Step 1: Defining the matrix of comparison pairs

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \quad (9)$$

Step 2: Normalization of the matrix of comparison pairs

$$a_{ij}^{*} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, i, j = 1, \ldots, n \quad (10)$$

Step 3: Determination of relative importance, i.e., vector weights

$$w_i = \frac{\sum_{i=1}^{n} a_{ij}^{*}}{n}, i, j = 1, \ldots, n \quad (11)$$

Consistency index - CI (consistency index) is a measure of the deviation of n from λ_{max} and can be expresesd by the following formula:

$$CI = \frac{\lambda_{max} - n}{n} \quad (12)$$

If CI < 0.1 of the estimated values of the coefficients a_{ij} are consistent, and the deviation of λ_{max} from *n* is negligible. This means, in other words, that the AHP method accepts an inconsistency of less than 10%.

Based on the consistency index, the consistency ratio CR = CI/RI can be calculated, where RI is a random index.

Results and Discussion

In the context of the analysis of the liquidity of the banking sector in Serbia, the most important indicators were taken as criteria. Alternatives are observed years. They, as well as the initial data, are shown in Table 1. (In this paper, all calculations and results are the author's.)

Table 1 - Initial Data

	Liquid assets in the narrower sense in relation to total assets	Liquid assets in the narrower sense in relation to short-term liabilities	Liquid assets in relation to total assets	Liquid assets in relation to short-term liabilities	Deposits in relation to loans (non-monetary sectors)	Foreign currency loans in relation to total loans	Average monthly liquidity indicator	Average monthly narrow liquidity indicator
	C1	C2	C3	C4	C5	C6	C7	C8
A1 2008	47.8	75.7	47.8	75.7	82.7	73.9	1.8	1.2
A2 2009	48.2	73.8	49	75.1	88.3	75.8	1.9	1.2
A3 in 2010	41.8	67.1	43.7	70.1	80.1	76.8	2	1.3
A4 2011	40.3	67.3	42.3	70.6	83.1	69.8	2.2	1.5
A5 in 2012	35.2	58.9	38.9	65	84.9	74.1	2.1	1.6
A6 2013	36.1	58.3	41	66.4	92.3	71.6	2.4	1.8
A7 2014	35.7	56.3	42.2	66.7	95.7	70.1	2.2	1.7
A8 2015	32.5	49.3	40.5	61.3	99.7	72.3	2.1	1.7
A9 2016	30.5	44.3	38.9	56.6	108.1	69.4	2.1	1.7
A10 2017	27.5	39.9	35.1	50.9	106.9	67.5	2	1.7
A11 2018	28	39.6	35.7	50.5	110.6	68.5	2	1.7
A12 in 2019	25.7	36.1	36	50.5	109.2	67.1	2.2	1.8
A13 in 2020	26.7	36.4	37.3	50.9	116.4	64.7	2.2	1.9
A14 in 2021	27.9	36.8	37.7	49.6	119.5	63.2	2.1	1.7
A15 in 2022	24.6	31.9	35	45.4	114.4	66.6	2	1.6

Note: Data for 2022 are shown for the 3rd quarter

Source: National Bank of Serbia

The weighting coefficients of the criteria were determined using the AHP method. Table 2 and Figure 1 show the weighting coefficients of the criteria.

Table 2 - Weight Coefficients of Criteria

$W = \lim_{k\to\infty} \frac{A^k.e}{e^T.A^k.e}$		1	2	3	4	5	6	7	8	WEIGHTS	
		C1	C2	C3	C4	C5	C6	C7	C8		
1	C1	1.00 am	1.00 am	1.50	2.00	1.00 am	2.00	1.50	2.00	**0.1696**	
2	C2	1.00 am	1.00 am	2.00	2.50	2.00	1.00 am	1.00 am	1.00 am	**0.1638**	
3	C3	0.67	0.50	1.00 am	2.00	2.00	2.00	2.00	1.00 am	**0.1500**	
4	C4	0.50	0.40	0.50	1.00 am	2.00	1.00 am	2.00	1.00 am	**0.1081**	
5	C5	1.00 am	0.50	0.50	0.50	1.00 am	1.00 am	1.00 am	1.00 am	**0.0921**	
6	C6	0.50	1.00 am	0.50	1.00 am	1.00 am	1.00 am	2.00	3.00	**0.1306**	
7	C7	0.67	1.00 am	0.50	0.50	1.00 am	0.50	1.00 am	1.50	**0.0928**	
8	C8	0.50	1.00 am	1.00 am	1.00 am	1.00 am	0.33	0.67	1.00 am	**0.0930**	
										1.0000	
										Consistency Ratio	**0,0578**

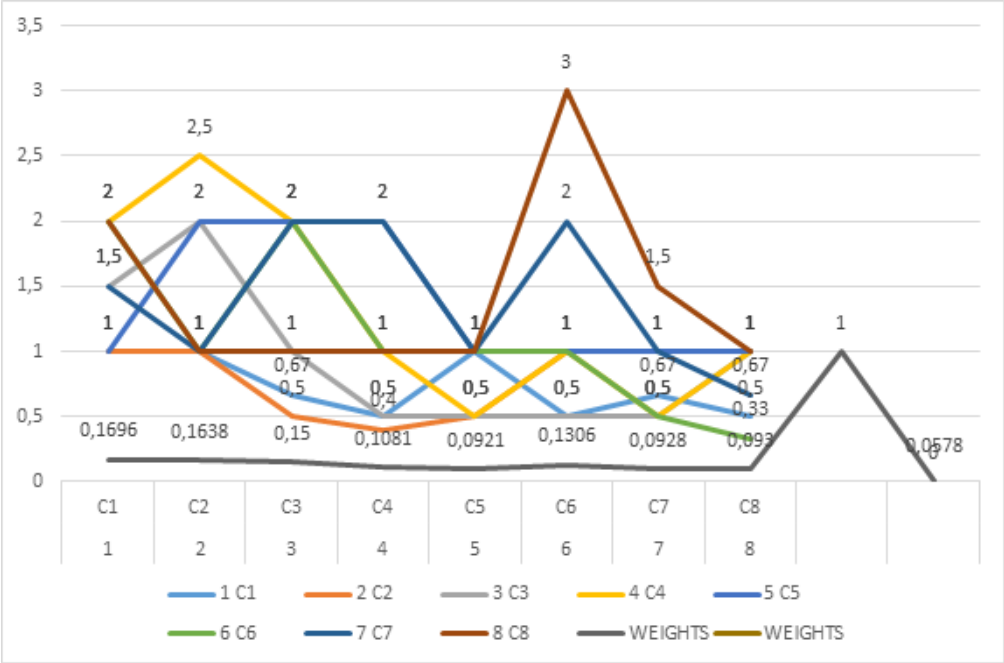

Figure 1 - Weight Coefficients of Criteria

The most important criteria are liquid assets in the narrow sense in relation to total assets, liquid assets in the narrow sense in relation to short-term liabilities, liquid assets in relation to total assets and foreign currency loans in relation to total loans. By adequately managing these indicators, it is possible to achieve the target liquidity of the banking sector in Serbia.

Tables 3 - 6 and Figure 2 show the calculations and results of the TOPSIS method.

Table 3 - Initial Matrix

Weights of criteria	0.1696	0.1638	0.15	0.1081	0.0921	0.1306	0.0928	0.93
Kind of criteria	1	1	1	1	1	1	1	1
INITIAL MATRIX	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
A1	47.8	75.7	47.8	75.7	82.7	73.9	1.8	1.2
A2	48.2	73.8	49	75.1	88.3	75.8	1.9	1.2
A3	41.8	67.1	43.7	70.1	80.1	76.8	2	1.3
A4	40.3	67.3	42.3	70.6	83.1	69.8	2.2	1.5
A5	35.2	58.9	38.9	65	84.9	74.1	2.1	1.6
A6	36.1	58.3	41	66.4	92.3	71.6	2.4	1.8
A7	35.7	56.3	42.2	66.7	95.7	70.1	2.2	1.7
A8	32.5	49.3	40.5	61.3	99.7	72.3	2.1	1.7
A9	30.5	44.3	38.9	56.6	108.1	69.4	2.1	1.7
A10	27.5	39.9	35.1	50.9	106.9	67.5	2	1.7
A11	28	39.6	35.7	50.5	110.6	68.5	2	1.7
A12	25.7	36.1	36	50.5	109.2	67.1	2.2	1.8
A13	26.7	36.4	37.3	50.9	116.4	64.7	2.2	1.9
A14	27.9	36.8	37.7	49.6	119.5	63.2	2.1	1.7
A15	24.6	31.9	35	45.4	114.4	66.6	2	1.6

Information For Normal-ization	Sum of Squares	18079.85	42799.59	24353.41	56116.41	150970.5	73918.96	65.61	39.37
	SQRT	134.4613	206.8806	156.0558	236.8890	388.5492	271.8804	8.1000	6.2746

Table 4 - Normalized Matrix

Weights of criteria	0.1696	0.1638	0.15	0.1081	0.0921	0.1306	0.0928	0.93
Kind of criteria	1	1	1	1	1	1	1	1
NORMALIZED MATRIX	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
A1	0.3555	0.3659	0.3063	0.3196	0.2128	0.2718	0.2222	0.1912
A2	0.3585	0.3567	0.3140	0.3170	0.2273	0.2788	0.2346	0.1912

A3	0.3109	0.3243	0.2800	0.2959	0.2062	0.2825	0.2469	0.2072
A4	0.2997	0.3253	0.2711	0.2980	0.2139	0.2567	0.2716	0.2391
A5	0.2618	0.2847	0.2493	0.2744	0.2185	0.2725	0.2593	0.2550
A6	0.2685	0.2818	0.2627	0.2803	0.2376	0.2634	0.2963	0.2869
A7	0.2655	0.2721	0.2704	0.2816	0.2463	0.2578	0.2716	0.2709
A8	0.2417	0.2383	0.2595	0.2588	0.2566	0.2659	0.2593	0.2709
A9	0.2268	0.2141	0.2493	0.2389	0.2782	0.2553	0.2593	0.2709
A10	0.2045	0.1929	0.2249	0.2149	0.2751	0.2483	0.2469	0.2709
A11	0.2082	0.1914	0.2288	0.2132	0.2846	0.2519	0.2469	0.2709
A12	0.1911	0.1745	0.2307	0.2132	0.2810	0.2468	0.2716	0.2869
A13	0.1986	0.1759	0.2390	0.2149	0.2996	0.2380	0.2716	0.3028
A14	0.2075	0.1779	0.2416	0.2094	0.3076	0.2325	0.2593	0.2709
A15	0.1830	0.1542	0.2243	0.1917	0.2944	0.2450	0.2469	0.2550

Table 5 - Normalized Weight Matrix

NORMALIZED WEIGHTED MATRIX								
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
A1	0.0603	0.0599	0.0459	0.0345	0.0196	0.0355	0.0206	0.1779
A2	0.0608	0.0584	0.0471	0.0343	0.0209	0.0364	0.0218	0.1779
A3	0.0527	0.0531	0.0420	0.0320	0.0190	0.0369	0.0229	0.1927
A4	0.0508	0.0533	0.0407	0.0322	0.0197	0.0335	0.0252	0.2223
A5	0.0444	0.0466	0.0374	0.0297	0.0201	0.0356	0.0241	0.2371
A6	0.0455	0.0462	0.0394	0.0303	0.0219	0.0344	0.0275	0.2668
A7	0.0450	0.0446	0.0406	0.0304	0.0227	0.0337	0.0252	0.2520
A8	0.0410	0.0390	0.0389	0.0280	0.0236	0.0347	0.0241	0.2520
A9	0.0385	0.0351	0.0374	0.0258	0.0256	0.0333	0.0241	0.2520
A10	0.0347	0.0316	0.0337	0.0232	0.0253	0.0324	0.0229	0.2520
A11	0.0353	0.0314	0.0343	0.0230	0.0262	0.0329	0.0229	0.2520
A12	0.0324	0.0286	0.0346	0.0230	0.0259	0.0322	0.0252	0.2668
A13	0.0337	0.0288	0.0359	0.0232	0.0276	0.0311	0.0252	0.2816
A14	0.0352	0.0291	0.0362	0.0226	0.0283	0.0304	0.0241	0.2520
A15	0.0310	0.0253	0.0336	0.0207	0.0271	0.0320	0.0229	0.2371

MIN	0.0310	0.0253	0.0336	0.0207	0.0190	0.0304	0.0206	0.1779
MAX	0.0608	0.0599	0.0471	0.0345	0.0283	0.0369	0.0275	0.2816
A+	0.0608	0.0599	0.0471	0.0345	0.0283	0.0369	0.0275	0.2816
A-	0.0310	0.0253	0.0336	0.0207	0.0190	0.0304	0.0206	0.1779

Table 6 - Results of the TOPSIS Method

	Alternatives	Si+	Si-	Ci	Ci	Ranking
2008	**A1**	0.1044	0.0493	0.3207	0.321	13
2009	**A2**	0.1042	0.0489	0.3195	0.320	14
2010	**A3**	0.0903	0.0414	0.3141	0.314	15
2011	**A4**	0.0616	0.0580	0.4850	0.485	11
2012	**A5**	0.0512	0.0655	0.5611	0.561	10
2013	**A6**	0.0277	0.0936	0.7716	0.772	1
2014	**A7**	0.0383	0.0791	0.6734	0.673	3
2015	**A8**	0.0431	0.0769	0.6409	0.641	5
2016	**A9**	0.0469	0.0758	0.6180	0.618	6
2017	**A10**	0.0522	0.0748	0.5893	0.589	8
2018	**A11**	0.0518	0.0750	0.5914	0.591	7
2019	**A12**	0.0483	0.0894	0.6495	0.650	4
2020	**A13**	0.0447	0.1044	0.7001	0.700	2
2021	**A14**	0.0529	0.0751	0.5866	0.587	9
2022	**A15**	0.0670	0.0599	0.4722	0.472	12

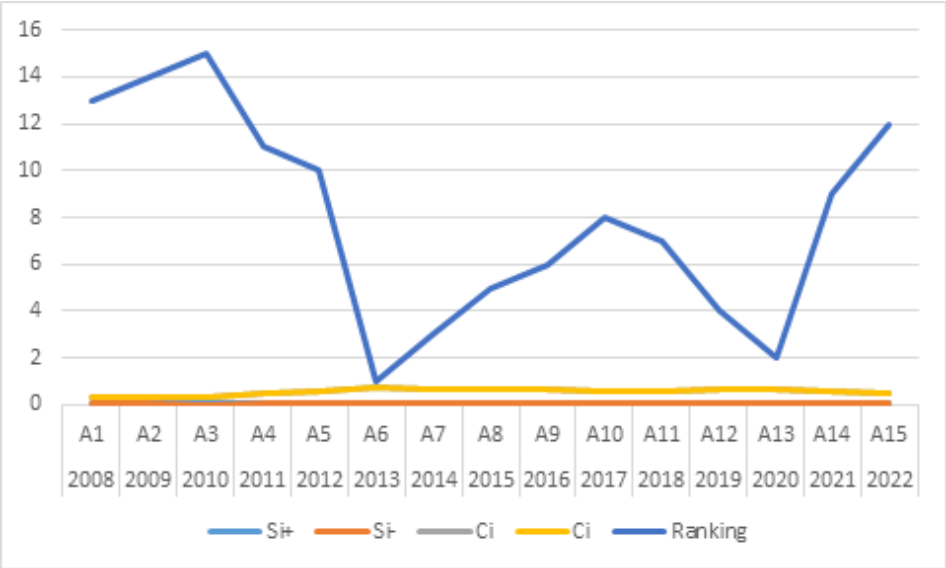

Figure 2 - Ranking of Alternatives

Therefore, the results of the TOPSIS method show that the top five years in terms of liquidity of the banking sector in Serbia in the observed period 2008 - 2022 fall in the following order: 2013, 2020, 2014, 2019 and 2015. The worst liquidity of the banking sector in Serbia in the observed period was in 2010. Lately, it can be said that the liquidity of the banking sector in Serbia has slightly increased.

Liquidity factors of the banking sector in Serbia in macro and micro nature. These are: economic climate, interest rate, inflation, exchange rate, economic activity, asset and liability management, net working capital management, risk management and others. With their adequate control, the target liquidity of the banking sector in Serbia can be achieved.

Conclusion

The obtained results of the TOPSIS method show that the top five years in terms of liquidity of the banking sector in Serbia in the observed period 2008 - 2022 are in order: 2013, 2020, 2014, 2019 and 2015. The worst liquidity of the banking sector in Serbia was in 2010. Lately, the liquidity of the banking sector in Serbia has slightly increased.

Determinants of this are: economic climate, interest rate, inflation, exchange rate, economic activity, asset and liability management, net working capital management, risk management and others. With their adequate control, the target liquidity of the banking sector can be achieved.

Literature

1. Ali, S.M., Hoq, S.M.N., Bari, A.B.M.M., Kabir, G., Paul, S.K. (2022). Evaluating factors contributing to the failure of information system in the banking industry. PLoS ONE, 17(3): e0265674. https://doi.org/10.1371/journal.pone.0265674
2. Andersen, P.; Petersen, N.C. (1993). A procedure for ranking efficient units in data envelopment analysis. Management Science, 39, 1261-1264.
3. Amini, A., Alinezhad, A., & Yazdipoor, F. (2019). A TOPSIS, VIKOR and DEA integrated evaluation method with belief structure under uncertainty to rank alternatives. Inter national Journal of Advanced Operations Management, 11(3), 171–188.
4. Banker, R.D., Charnes, A. and Cooper, W.W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management Science, 30(9), 1078–1092.
5. Božanić, D., Pamučar, D., Milić,A., Marinković, M.and Komazec, N. (2022). Modification of the Logarithm Methodology of Additive Weights (LMAW) by a Trian gular Fuzzy Number and Its Application in Multi-Criteria Decision Making. Axioms, 11(3), 89. https://doi.org/10.3390/axioms11030089
6. Chang, X. and 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. doi: 10.1109/ITAIC49862.2020.9339131
7. Chen, Chunhua, Liu, Haohua, Tang, Lijun and Ren, Jianwei. (2021). A Range Adjusted Measure of Super-Efficiency in Integer-Valued Data Envelopment Analysis with Un-desirable Outputs. Journal of Systems Science and Information, 9(4), 378-398. https://doi.org/10.21078/JSSI-2021-378-21

8. Cvetkoska, V., and Savic, G. (2017). Efficiency of bank branches: Empirical evidence from a two-phase research approach. Economic Research-Ekonomska istraživanja, 30(1), 318–333. doi: 10.1080/1331677X.2017.1305775
9. Cvetkoska, V. and Cikovic, K.F.(2020). Assessing the relative efficiency of commercial banks in the Republic of North Macedonia: DEA window analysis. Croatian Operational Research Review 217 CRORR 11, 217-227.
10. Cvetkoska, V., Fotova Ciković, K. and Tasheva, M. (2021). Efficiency of Commercial Banking in Developing Countries. Mathematic , 9, 1597. https://doi.org/10.3390/math9141597
11. Demir, G. (2022). Analysis of the financial performance of the deposit banking sector in the Covid-19 period with LMAW-DNMA methods. International Journal of Insurance and Finance, 2(2), 17-36.https://doi.org/10.52898/ijif.2022.7
12. Fenyves, V. and Tarnóczi, T. (2020). Data envelopment analysis for measuring performance in a competitive market. Problems and Perspectives in Management, 18(1), 315-325. doi:10.21511/ppm.18(1).2020.27
13. Guo, D. and Cai, Z.Q. (2020). Super-Efficiency Infeasibility in the Presence of Nonradial Measurement. Mathematical Problems in Engineering, 2020, Article ID 6264852, 7 pages. https://doi.org/10.1155/2020/6264852
14. Hwang C.L., Yoon K.S. (1981). Multiple attribute decision making: methods and appli- cations. Berlin: Springer.
15. Hwang, C. L., Yoon, K.P. (1995). Multiple Attribute Decision Making: An Introduction. Paperback / Sage Publications.
16. Lee, H.S., Chu, C.W. and J. Zhu, J. (2011). Super-efficiency DEA in the presence of infeasibility. European Journal of Operational Research, 212(1), 141–147.
17. 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.
18. Lukic, R., Sokic, M. & Vojteski Kljenak, D. (2017). Efficiency Analysis Of Banking Sector In Republic Of Serbia. Business Excellence and Management, 7(4), 5-17.
19. Lukić, R. (2018a). Bankarsko računovodstvo. Beograd: Ekonomski fakultet.
20. Lukic, R. (2018d). Analysis of the efficiency of insurance companies. In: Insurance in the post-crisis era, Belgrade: Faculty of Economics, University of Belgrade. ISBN:978- 86-403-1548-7.
21. 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 Strossmaye, 145-162.
22. Lukic, R. (2021). Application of the EDAS method in the evaluation of bank efficiency in Serbia. Bankarstvo - Banking, 50(2), 13-24. doi: 10.5937/bankarstvo2102064L
23. Lukić, R. (2022a). Evaluation of the efficiency of banks in Serbia using the MABAC method. Bankarstvo - Banking, 2, 35-60. DOI: 10.5937/bankarstvo2202010L
24. Lukić, R. (2022b). Analysis of financial performance and efficiency of banks in Serbia using fuzzy LMAW and MARCOS methods. Bankarstvo – Banking, 4, 130-169.

25. Lukić, R. (2023). Measurement and analysis of profitability dynamics of the banking sector in Serbia based on the flmaw-marcos method. Bankarstvo, 1/2023.
26. Maletić, R., Kreća, M., & Maletić, P. (2013). Application of dea methodology in measuring efficiency in the banking sector. Economics of Agriculture, 60(4), 843–855. https://www.ea.bg.ac.rs/index.php/EA/article/view/423
27. Milenković, N., Radovanov, B., Kalaš, B. and Horvat, A.M. (2022). External Two Stage DEA Analysis of Bank Efficiency in West Balkan Countries. Sustainability, 14, 978. https:// doi.org/10.3390/su14020978
28. Pamučar, D., Žižović, M., Biswas, S., Božanić, D. (2021). A new logarithm methodology of additive weights (LMAW) for multiλcriteria decisionλmaking: Application in logistics. Facta Univ. Ser. Mech. Eng., 2021, 19, 361–380. https://doi.org/10.22190/FUME210214031P
29. Puška, A., Božanić, D., Nedeljković, M., Janošević, M. (2022). Green Supplier Selection in an Uncertain Environment in Agriculture Using a Hybrid MCDM Model: ZλNumbers–Fuzzy LMAW–Fuzzy CRADIS Model. Axioms, 11, 427. https://doi.org/10.3390/axioms1109042
30. 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.
31. Peykani, P., Seyed Esmaeili, F.S., Mirmozaffari, M., Jabbarzadeh, A. and Khamechian, M. (2022). Input/Output Variables Selection in Data Envelopment Analysis: A Shannon Entropy Approach. Mach. Learn. Knowl. Extr., 4, 688–699. https://doi.org/10.3390/ make4030032
32. Peykani, P., Gheidar-Kheljani, J., Farzipoor Saen, R., & Mohammadi, E. (2022a). Generalized Robust Window Data Envelopment Analysis Approach for DynamicPerformance Measurement under Uncertain Panel Data. Operational Research, 1-36.https://doi.org/10.1007/s12351-022-00729-7.
33. Podinovski, V.V. and 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
34. Radojičić, M., Savić, G., & Jeremić, V. (2018). Measuring the efficiency of banks: the bootstrapped I-distance GAR DEA approach. Technological and Economic Development of Economy, 24(4), 1581-1605. https://doi.org/10.3846/tede.2018.3699
35. 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
36. Savić, G., Radosavljević, M., & Ilievski, D. (2012). DEA Window analysis approach for measuring the efficiency of Serbian banks. Management - časopis za teoriju i praksu menadžmenta, 17(65), 5-14.
37. Saaty, T. L. (2008). Decision Making With The Analytic Hierarchy Process. Int J Serv Sci, 1(1), 83-98. https://doi.org/10.1504/IJSSCI.2008.017590

38. Stević, Ž., Pamučar, D., Puška, A. and Chatterjee, P. (2020a). Sustainable supplier selection in healthcare industries using a new MCDM method: Measurement of alternatives and ranking according to Compromise solution (MARCOS). Computers & Industrial Engineering, 140, 106231. https://doi.org/10.1016/j.cie.2019.106231.
39. Stević, Ž. and Brković, N. A. (2020b). Novel Integrated FUCOM-MARCOS Model for Evaluation of Human Resources in a Transport Company. Logistics, 4, 4. https://doi.org/10.3390/logistics4010004
40. Tone, K. (2002). A slacks-based measure of super-efficiency in data envelopment analysis. European Journal of Operational Research, 143, 32-41.
41. Tsai, Chi-Mao; Lee, Hsuan-Shih; and 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. DOI: 10.51400/2709-6998.1006
42. Üçüncü, T., Akyüz, K. C., Akyüz, İ., Bayram, B. Ç., Ve Ersen, N. (2018). Evaluation Of Financial Performance Of Paper Companies Traded At BIST With TOPSIS Method. Kastamonu Unıversıty Journal Of ForestryFaculty, 18(1), 92-98.
43. Ünlü, U., Yalçın, N. and Avşarlıgil, N. (2022). Analysis of Efficiency and Productivity of Commercial Banks in Turkey Pre- and during COVID-19 with an Integrated MCDM Approach. Mathematics, 10(13), 2300. https://doi.org/10.3390/math10132300