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Analysis of development and effects of electronic trade in Serbia based on SF-TOPSIS and TOPSIS methods

Анализа развоја и ефекти електронске трговине у Србији на бази СФ-ТОПСИС и ТОПСИС метода

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Abstract: The issues of measuring and analysing the development dynamics and effects of electronic trade are currently topical, significant and complex in any country, including Serbia. In the observed period from 2017 to 2021, according to the obtained empirical results based on the SF TOPSIS method, the largest number of trading companies introducing e-business (IT technology) and e-trading appeared in Serbia in 2017. According to the obtained empirical results based on the classical TOPSIS method, the largest number of trading companies introducing e-business (IT technology) and e-trading was recorded in Serbia in 2019. The following is the ranking according to the SF-TOPSIS method: 2021, 2018, 2019 and 2020. The ranking according to the TOPSIS method is as follows: 2020, 2021, 2018 and 2017**.** The digitalisation factors of overall business operation of trade industry in Serbia are the global trend and requirements, degree of development of contemporary IT technology and the possibility of application in all the segments of trading operations, the economic climate, financial opportunities, entry of international retail chains, development of multichannel sale – classic and e-retail facilities, around-the clock business operations without time and geographical barriers etc. Considering the positive effects, significantly more should be invested in new information and communication technology in the future.

Keywords: development, effects, electronic trade, Serbia, SF-TOPSIS- TOPSIS method
JEL classification: D22, P25

Сажетак: Нема сумње да је данас врло актуелна, значајна и сложена проблематика мерења и анализе динамике развоја и ефекти електронске трговине у свакој земљи. У посматраном временском периоду 2017 – 2021, према добијеним емпиријским резултатима на бази СФ-ТОПСИС методе, највећи број трговинских предузећа у Србији са увођењем електронског пословања (информационе и комуникационе технологије) и електронским прометом је био у 2017. Следе по реду: 2021, 2018 , 2019. и 2020. Према добијеним емпиријским резултатима применом класичне ТОПСИС методе у периоду 2017 – 2021. највећи број трговинских предузећа у Србији са увођењем електронског пословања и електронским прометом забележен је у 2019. Следе по реду: 2020, 2021, 2018. и 2017. Фактори дигитализације целокупног пословања трговине у Србији су глобални тренд и потребе, развијеност савремене информационе и комуникационе технологије и могућности примене у свим сегментима трговачког пословања, економска клима, финансијске могућности, прилив страних малопродајних ланца, разавој мултиканалске продаје – класична и електронска продавница, пословање нон -стоп без временске и географске баријере, итд.
Кључне речи: развој, ефекти, електронска трговина, Србија, СФ-ТОПСИС метода, ТОПСИС метода
ЈЕЛ класификација: Д22, П25

Introduction

The application of modern information and communication technology in trade has a positive effect on sales revenues and costs, i.e. affects the achievement of the target profit (Berman et al., 2018; Levy et al., 2019; Lacey, 2021; Zu et al., 2022; Končar, 2003; Lukic & Vojteski Kljenak, 2017; Kazakov et al., 2021; Lovreta & Petković, 2021; Jorgensen et al., 2022; Miller & Miller, 2021; Miletic et al., 2021, Gluhović, 2020; Lukic, 2022, 2023; Antić et al., 2021). The effects of the improvement of electronic trade are the improvement of the overall performance (higher revenues from sales, lower costs and, finally, higher profits) of trade in Serbia (López González & Jouanjean, 2017; Argilés-Bosch et al., 2022; Gu et al., 2021; Liu et al., 2022; Lukić et al., 2016; Rehman et al., 2022; Tolstoy et al., 2022; Belouaar et al., 2022). This is completely and understandable when you take into account the fact that empirical analysis has established that information and communication technology significantly contributes to the improvement of financial performance and efficiency of all sectors, which means trade as well (Lukić, 2011; Berman et al., 2018; Levy et al. ., 2019; Lovreta & Petković, 2021; Gherghina et al., 2021; Alam et al., 2022).

1. Methodology

The procedure of the **SF-TOPSIS** method takes place through several stages shown below (Gündoğdu & Kahraman, 2019a,c; Gündoğdu & Kahraman, 2019a,b,c, 2020a,b; Sharaf, 2022).

Let us mark the alternative with $X = \{x_1, x_2, \dots, x_m\}\ (x \geq 2)$, the criteria with $C = \{C_1, C_2, \dots, C_n\}$, and the weight vector of criteria with $w = \{w_1, w_2, \dots, w_n\}$; $0 \leq w_j \leq 1$ and $\sum_{j=1}^{n} w_j = 1$.

Step 1: Using linguistic terms, spherical fuzzy numbers (Gündoğdu & Kahraman, 2019a)

Step 2: Evaluation of decision makers (DM),

that is

$$w = (w_1, w_2, \cdots\cdots, w_n);\ w_j \in [0,1];\ \sum_{i=1}^{n} w_i = 1$$

Spherical Weighted Arithmetic Mean (SWAM) is defined as

$$SWAM_w(\tilde{A}_{S1}, \dots, \tilde{A}_{Sn}) = w_1\tilde{A}_{S1} + w_2\tilde{A}_{S2} \dots\dots w_n\tilde{A}_{Sn}$$
$$= \left\{ \left[1 - \prod_{i=1}^{n} \left(\mu_{\tilde{A}_{Si}}^2\right)^{w_i} \right]^{1/2}, \prod_{i=1}^{n} \upsilon_{\tilde{A}_{Si}}^{w_i}, \left[\prod_{i=1}^{n} \left(1 - \mu_{\tilde{A}_{Si}}^2\right)^{w_i} - \prod_{i=1}^{n} \left(1 - \mu_{\tilde{A}_{Si}}^2 - \pi_{\tilde{A}_{Si}}^2\right)^{w_i} \right]^{1/2} \right\} \quad (1)$$

that is

$$w = (w_1, w_2 \cdots\cdots, w_n);\ w_j \in [0,1];\ \sum_{i=1}^{n} w_i = 1$$

Spherical Weighted Geometric Mean (SWGM) is defined as

$$SWGM_w\left(\left(\tilde{A}_1, \cdots\cdots, \tilde{A}_n\right)\right) = \tilde{A}_{S1}^{w_1} + \tilde{A}_{S2}^{w_2} + \cdots\cdots + \tilde{A}_{Sn}^{w_n}$$
$$= \left\{ \prod_{i=1}^{n} \mu_{S_i}^{w_i}, \left[1 - \prod_{i=1}^{n} \left(1 - \upsilon_{\tilde{A}_{Si}}^2\right) \right]^{1/2}, \left[\prod_{i=1}^{n} \left(1 - \nu_{\tilde{A}_{Si}}^2\right)^{w_i} - \prod_{i=1}^{n} \left(1 - \upsilon_{\tilde{A}_{Si}}^2 - \pi_{\tilde{A}_{Si}}^2\right)^{w_i} \right]^{1/2} \right\} \quad (2)$$

2.1: Aggregation of criteria weights

2.2: Aggregated spherical fuzzy decision matrix

Denote the values of the evaluation of alternatives by $X_i(i = 1,2 \dots\dots m)$, respecting the criteria $C_j(j = 1,2 \dots\dots n)$, with $C_j(X_j) = (\mu_{ij}, \nu_{ij}, \pi_{ij})$and $D = \left(C_j(X_i)\right)_{mxn}$ for the purposes of determining the spherical fuzzy decision matrix. For the MCDM problem with SFS (Spherical Fuzzy Set), the decision matrix $D = \left(C_j(X_i)\right)_{mxn}$ is constructed as

$$D = \left(C_j(X_i)\right)_{mxn} = \begin{pmatrix} (\mu_{11}, \nu_{11}, \pi_{11}) & (\mu_{12}, \nu_{12}, \pi_{12}) & \cdots & (\mu_{1n}, \nu_{1n}, \pi_{1n}) \\ (\mu_{21}, \nu_{21}, \pi_{21}) & (\mu_{22}, \nu_{22}, \pi_{22}) & & (\mu_{2n}, \nu_{2n}, \pi_{2n}) \\ & \vdots & \ddots & \vdots \\ (\mu_{m1}, \nu_{m1}, \pi_{m1}) & (\mu_{m2}, \nu_{m2}, \pi_{m2}) & \cdots & (\mu_{mn}, \nu_{mn}, \pi_{mn}) \end{pmatrix} \quad (3)$$

Step 3: The aggregated weighted spherical fuzzy decision matrix

The aggregated weighted spherical decision matrix is constructed by applying the following equation:

$$\tilde{A}_s \otimes \tilde{B}_S = \left\{ \mu_{\tilde{A}_S} \mu_{\tilde{B}_S}, \left(\nu_{\tilde{A}_S}^2 + \nu_{\tilde{B}_S}^2 - \nu_{\tilde{A}_S}^2 \nu_{\tilde{B}_S}^2\right)^{1/2}, \left(\left(1 - \nu_{\tilde{B}_S}^2\right)\pi_{\tilde{A}_S}^2 + \left(1 - \nu_{\tilde{A}_S}^2\right)\pi_{\tilde{B}_S}^2 - \pi_{\tilde{A}_S}^2 \pi_{\tilde{B}_s}^2\right)^{1/2} \right\} \quad (4)$$

($\tilde{A}_S$and $\tilde{B}_S$are spherical fuzzy sets.)

The aggregated weighted spherical fuzzy decision matrix is defined as

$$D = \left(C_j(X_{iw})\right)_{mxn} = \begin{pmatrix} (\mu_{11w}, \nu_{11w}, \pi_{11w}) & (\mu_{12w}, \nu_{12w}, \pi_{12w}) & \cdots & (\mu_{1nw}, \nu_{1nw}, \pi_{1nw}) \\ (\mu_{21w}, \nu_{21w}, \pi_{21w}) & (\mu_{22w}, \nu_{22w}, \pi_{22w}) & & (\mu_{2nw}, \nu_{2nw}, \pi_{2nw}) \\ & \vdots & \ddots & \vdots \\ (\mu_{m1w}, \nu_{m1w}, \pi_{m1w}) & (\mu_{m2w}, \nu_{m2w}, \pi_{m2w}) & \cdots & (\mu_{mnw}, \nu_{mnw}, \pi_{mnw}) \end{pmatrix} \quad (5)$$

Step 4: Diffusing the aggregated decision weight matrix using the following equation

$$Score\left(C_j(X_{iw})\right) = \left(2\mu_{ijw - \pi_{ijw}/2}\right)^2 - \left(\nu_{ijw} - \pi_{ijw}/2\right)^2 \quad (6)$$

Step 5. Spherical fuzzy positive ideal solution (SF-PIS) and spherical fuzzy negative ideal solution (SF-NIS)

For SF-PIS

$$X^* = \left\{ \left\{ C_{j,} \max_i < Score\left(C_j(X_{iw})\right) > \middle| j = 1,2 \cdots n \right\} \right\} \quad (7)$$

$$X^* = \left\{ \langle C_j, (\mu_1^*, \nu_1^*, \pi_1^*) \rangle \langle C_2, (\mu_2^*, \nu_2^*, \pi_2^*) \rangle \cdots \cdots \langle C_n, (\mu_n^*, \nu_n^*, \pi_n^*) \rangle \right\}$$

For SF-NIS

$$X^- = \left\{\left\{C_j, \min_i < Score\left(C_j(X_{iw})\right) > \middle| j = 1,2 \cdots n\right\}\right\} \quad (8)$$

$$X^- = \left\{\langle C_j, (\mu_1^-, \nu_1^-, \pi_1^-)\rangle \langle C_2, (\mu_2^-, \nu_2^-, \pi_2^-)\rangle \cdots \cdots \langle C_n, (\mu_n^-, \nu_n^-, \pi_n^-)\rangle\right\}$$

Step 6: The distance between alternativesX_i, SF-PIS and SF-NIS

For SF-NIS

$$D(X_i, X^-) = \sqrt{\frac{1}{2n}\sum_{i=1}^{n}\left(\left(\mu_{X_i} - \mu_{X^-}\right)^2 + \left(\nu_{X_i} - \nu_{X^-}\right)^2 + \left(\pi_{X_i} - \pi_{X^-}\right)^2\right)} \quad (9)$$

For SF-PIS

$$D(X_i, X^*) = \sqrt{\frac{1}{2n}\sum_{i=1}^{n}\left(\left(\mu_{X_i} - \mu_{X^*}\right)^2 + \left(\nu_{X_i} - \nu_{X^*}\right)^2 + \left(\pi_{X_i} - \pi_{X^*}\right)^2\right)} \quad (10)$$

Step 7: The classical proximity ratio

$$\xi(X_i) = \frac{D(X_i, X^-)}{D(X_i, X^*) + D(X_i, X^-)} \quad (11)$$

Step 8: Optimal alternatives

Alternatives are ranked in order of decreasing proximity value.

The stages of the **TOPSIS** method are as follows (Hwang & Yoon, 1981, 1995; Young et al., 1994: Üçüncü *et al*., 2018):

Step 1: Creating the initial matrix

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

Step 2: The weighted normalized decision matrix

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^2}} \quad (12)$$

$$t = 1,2,3,\dots,m\ j = 1,2,3,\dots,n$$

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

$$V_{ij} = W_{ij} * r_{ij}, i = 1,2,3,\dots,m\ j = 1,2,3,\dots,n \quad (13)$$

Step 3: (A^+) Positive ideal solution; (A^-) Negative ideal solution

$$A^+ = \{v_i^+, \dots, v_n^+\} = \left\{\left(\max_i v_{ij}, j \in j\right)\left(\min_i v_{ij}, j \in j'\right)\right\}\ i = 1,2,\dots,m \quad (14)$$

$$A^- = \{v_i^-, \dots, v_n^-\} = \left\{\left(\min_i v_{ij}, j \in j\right)\left(\max_i v_{ij}, j \in j'\right)\right\}\ i = 1,2,\dots,m \quad (15)$$

(j benefit criterion, j' cost criterion.)

Step 4: Special measures

(S_i^+) Positive ideal solution; (S_i^-) Negative ideal solution:

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \quad (16)$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \quad (17)$$

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

Step 5: The relative closeness to the ideal solution (C_i^+)

It is determined as follows:

(C_i^+; i=1,..., m; j=*1,..., n*):

$$C_i^+ = \frac{S_i^-}{S_i^- + S_i^+}, i = 1,2,3,\dots,m \quad (18)$$

Step 6: Optimal alternatives

High scores correspond to better performance (Üçüncü *et al*., 2018).

2. Results

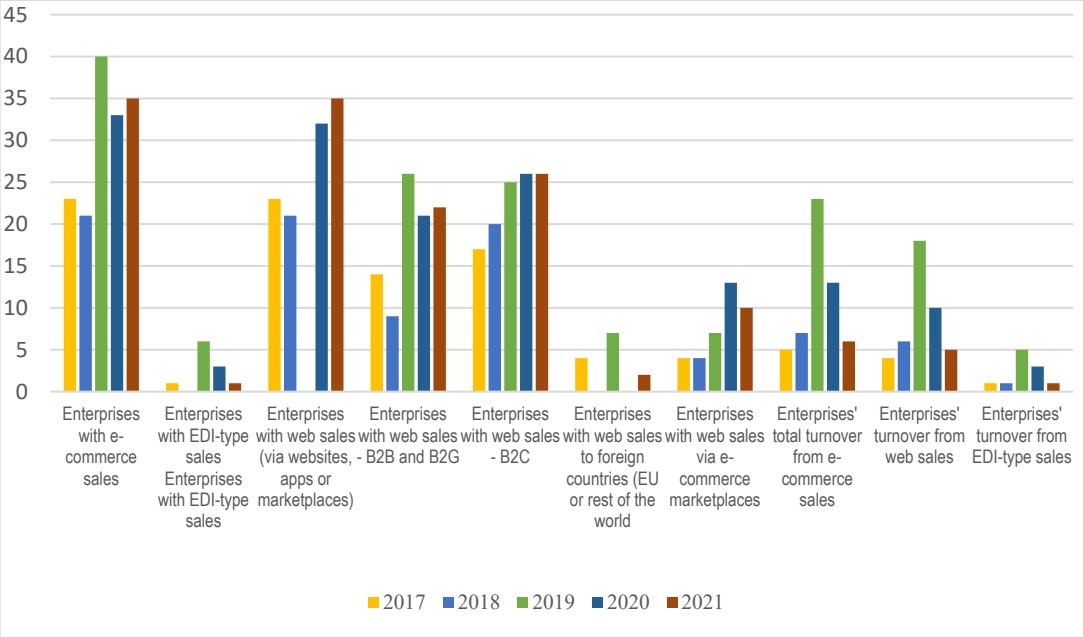
The initial statistical data of EUROSTAT indicators for the period 2017 - 2021 are presented in Table 1 and Figure 1. (All calculations and results are the author's.)

Table 1: Indicators

	Enterprises with e-commerce sales (% enterprises) C1	Enterprises with EDI-type sales Enterprises with EDI-type sales (% enterprises) C2	Enterprises with web sales (via websites, apps or marketplaces) (% enterprises) C3	Enterprises with web sales - B2B and B2G (% enterprises) C4	Enterprises with web sales - B2C (% enterprises) C5	Enterprises with web sales to foreign countries (EU or rest of the world (% enterprises) C6	Enterprises with web sales via e-commerce marketplaces (% enterprises) C7	Enterprises' total turnover from e-commerce sales (% total turnover) C8	Enterprises' turnover from web sales (% total turnover) C9	Enterprises' turnover from EDI-type sales (% total turnover) C10
A1 2017	23	1	23	14	17	4	4	5	4	1
A2 2018	21	0	21	9	20	0	4	7	6	1
A3 2019	40	6	0	26	25	7	7	23	18	5
A4 2020	33	3	32	21	26	0	13	13	10	3
A5 2021	35	1	35	22	26	2	10	6	5	1

Source: Eurostat

Figure 1: Indicators of electronic commerce in Serbia



Source: the author's picture

Table 2 shows descriptive statistics of indicators of electronic commerce in Serbia.

Table 2: Descriptive statistics

Statistics										
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Mean	30.4000	2.2000	22.2000	18.4000	22.8000	2.6000	7.6000	10.8000	8.6000	2.2000
Median	33.0000	1.0000	23.0000	21.0000	25.0000	2.0000	7.0000	7.0000	6.0000	1.0000
Std. Deviation	8.11172	2.38747	13.73681	6.80441	4.08656	2.96648	3.91152	7.49667	5.72713	1.78885
Minimum	21.00	.00	.00	9.00	17.00	.00	4.00	5.00	4.00	1.00
Maximum	40.00	6.00	35.00	26.00	26.00	7.00	13.00	23.00	18.00	5.00

Source: the author's calculation

Descriptive statistics show that the criteria range from C1 21.00 (2018) to 40.00 (2019), from C2 .00 (2018) to 6.00 (2019), from C3 .00 (2019) to 35.00 (2021), from C4 9.00 (2018) to 26.00 (2019), from C5 17.00 (2017) to 26.00 (2020, 2021), from C6 .00

(2018,2020) to 7.00 (2019), from C7 4.00 (2017,2018) to 13.00 (2020), from C8 5.00 (2017) to 23.00 (2019), from C9 4.00 (2017) to 18.00 (2019) and from C10 1.00 (2017,2018,2021) to 5.00 (2019). The averages are C1 30.4000, C2 2.2000, C3 22.200, C4 18.4000, C5 22.8000, C6 1.6000, C7 7.600, C8 10.800, C9 8.600 and C10 2.200. Therefore, the importance of e-commerce in Serbia has increased recently.

The correlation between criteria C1 and C4 is strong, and at the level of statistical significance (Table3).

Table 3: Correlations

Correlations											
		1	2	3	4	5	6	7	8	9	10
1 C1	Pearson Correlation	1	.808	-.277	.984**	.855	.486	.629	.738	.731	.751
	Sig. (2-tailed)		.098	.652	.002	.065	.406	.256	.155	.161	.143
2 C2	Pearson Correlation	.808	1	-.688	.809	.518	.685	.305	.967**	.958*	.983**
	Sig. (2-tailed)	.098		.200	.097	.372	.202	.618	.007	.010	.003
3 C3	Pearson Correlation	-.277	-.688	1	-.239	.099	-.777	.458	-.755	-.768	-.704
	Sig. (2-tailed)	.652	.200		.698	.874	.122	.438	.141	.130	.184
4 C4	Pearson Correlation	.984**	.809	-.239	1	.795	.530	.637	.698	.685	.731
	Sig. (2-tailed)	.002	.097	.698		.108	.358	.248	.190	.202	.160
5 C5	Pearson Correlation	.855	.518	.099	.795	1	-.029	.854	.512	.508	.520
	Sig. (2-tailed)	.065	.372	.874	.108		.963	.066	.377	.382	.369
6 C6	Pearson Correlation	.486	.685	-.777	.530	-.029	1	-.297	.591	.592	.584
	Sig. (2-tailed)	.406	.202	.122	.358	.963		.627	.294	.293	.301
7 C7	Pearson Correlation	.629	.305	.458	.637	.854	-.297	1	.235	.214	.300
	Sig. (2-tailed)	.256	.618	.438	.248	.066	.627		.703	.729	.624
8 C8	Pearson Correlation	.738	.967**	-.755	.698	.512	.591	.235	1	.999**	.992**
	Sig. (2-tailed)	.155	.007	.141	.190	.377	.294	.703		.000	.001

9 C9	Pearson Correlation	.731	.958*	-.768	.685	.508	.592	.214	.999**	1	.986**
	Sig. (2-tailed)	.161	.010	.130	.202	.382	.293	.729	.000		.002
	N	5	5	5	5	5	5	5	5	5	5
10 C10	Pearson Correlation	.751	.983**	-.704	.731	.520	.584	.300	.992**	.986**	1
	Sig. (2-tailed)	.143	.003	.184	.160	.369	.301	.624	.001	.002	

Source: the author's calculation

Non-parametric tests are presented in Table 4.

Table 4: Npar Tests – Friedman Test

Ranks	
	Mean Rank
C1	9.70
C2	2.00
C3	7.70
C4	7.40
C5	8.00
C6	2.80
C7	4.80
C8	5.90
C9	4.60
C10	2.10

Test Statistics[a]	
N	5
Chi-Square	35.967
df	9
Asymp. Sig.	.000
a. Friedman Test	

Source: the author's statistics

There is a significant statistical difference between the given variables (Asymp. Sig. .000 < .05).

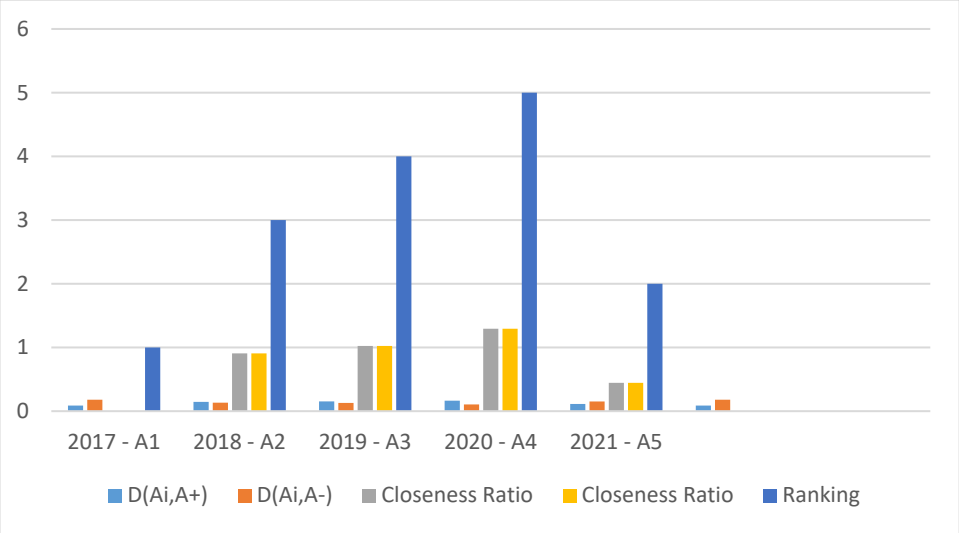
The Relative Closeness Ratio is shown in Table 5 and Figure 2.

Table 5: Relative Closeness Ratio

	D(Ai,A+)	D(Ai,A-)	Closeness Ratio	Closeness Ratio	Ranking
2017 - A1	0.088	0.179	0.000	**0.000**	**1**
2018 - A2	0.145	0.133	0.907	**0.907**	**3**
2019 - A3	0.153	0.129	1.024	**1.024**	**4**
2020 - A4	0.165	0.105	1.294	**1.294**	**5**
2021 - A5	0.113	0.152	0.444	**0.444**	**2**
	0.088	**0.179**			
	MIN	**MAX**			

Source: the author's calculation

Figure 2: Relative Closeness Ratio



Source: the author's picture

The dynamic selection and ranking of electronic trade in Serbia according to the SF-TOPSIS method is as follows: 2017, 2021, 2018, 2019 and 2020. Recently, therefore, the

results have been positive. In the future, considering the positive effects, significantly more should be invested in new information and communication technology.

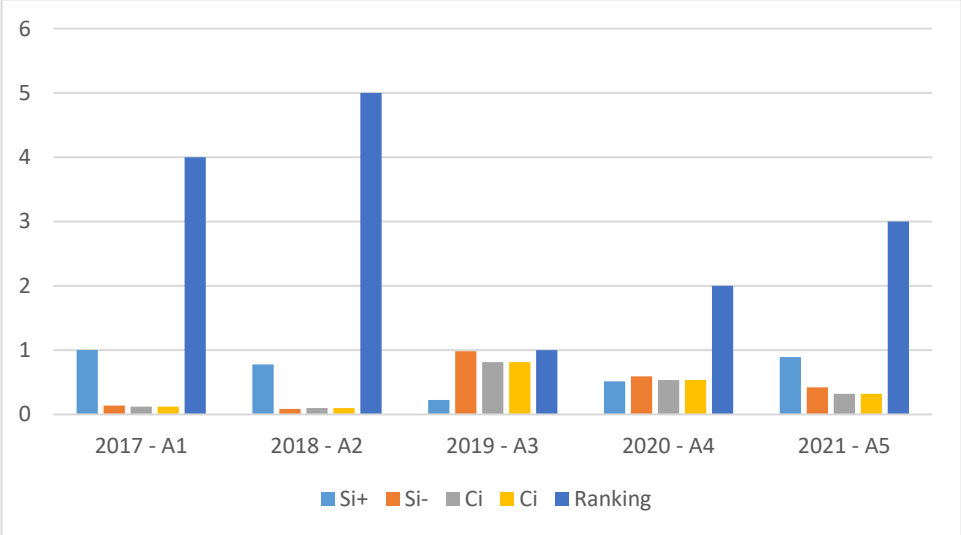
Table 6 and Figure 3 show the results.

Table 6: Ranking

	Si+	Si-	Ci	Ci	Ranking
2017 - A1	1.0023	0.1381	0.1211	0.121	**4**
2018 - A2	0.7780	0.0851	0.0986	0.099	**5**
2019 - A3	0.2249	0.9822	0.8137	0.814	**1**
2020 - A4	0.5146	0.5914	0.5347	0.535	**2**
2021 - A5	0.8914	0.4216	0.3211	0.321	**3**

Source: the author's calculation

Figure 3: Ranking



Source: the author's picture

The ranking results are as follows: (1) SF-TOPSIS method: 2017, 2021, 2018, 2019 and 2020; (2) TOPSIS: 2019, 2020, 2021, 2017 and 2018. The conclusion is that e-commerce in Serbia has improved recently. The conclusion is that e-commerce in Serbia has improved recently. This had a positive impact on the overall performance of trade in Serbia.

Discussion

In order to obtain as complete a picture as possible of the dynamics of the development and effects of electronic trade in Serbia, it is recommended that the analysis be carried out continuously using not only the analysed (SF-TOPSIS, TOPSIS) but also other multi-criteria decision-making methods (MABAC, MARCOS, LMAW-DNMA, etc.).

The SF-TOPSIS method is based on linguistic terms and their assignment to certain criteria by decision makers. To a large extent, it depends on the expertise of the decision-makers, which linguistic term will be assigned to certain criteria, and thus the accuracy of the results obtained. It has elements of "subjectivity". However, regardless of certain elements of "subjectivity" in both methods, those in relation compared to classical methods, for example, ratio analysis, they give more precise results because they simultaneously take into account several criteria – integrated which is not the case with ratio analysis, where each indicator – criterion is considered in isolation.

In any case, it can be freely said that compared to traditional methods, multi-criteria decision-making methods give more precise results in terms of understanding the dynamics of the development of electronic commerce, because they simultaneously include several criteria viewed as factors. For these reasons, their application in the analysis of electronic commerce is recommended.

Conclusion

The ranking results are as follows: (1) SF-TOPSIS method: 2017, 2021, 2018, 2019 and 2020; (2) TOPSIS: 2019, 2020, 2021, 2017 and 2018. By themselves, they point to the general conclusion that electronic trade in Serbia has improved recently. Considering the positive effects in the future, as much as possible should be invested in improving the information and communication technology of trade in Serbia.

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