Универзитет Привредна академија у Новом Саду
University Business Academy in Novi Sad

Факултет за примењени менаџмент, економију и финансије Београд
Faculty of Applied Management, Economics and Finance Belgrade

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INNOVATION AS AN INITIATOR OF THE DEVELOPMENT

ИНОВАЦИЈЕ КАО ПОКРЕТАЧ РАЗВОЈА

INTERNATIONAL CONFERENCE PROCEEDINGS

ЗБОРНИК РАДОВА СА МЕЂУНАРОДНОГ СКУПА

INNOVATIONS

December 5th
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Факултет за примењени менаџмент, економију и финансије, Београд
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ПРЕДГОВОР

Поштовани аутори, читаоци, колеге, студенти и ентузијасти жељни знања,

Пред вама се налази зборник радова десете јубиларне Међународне научно-стручне конференције „Иновације као покретач развоја“ коју организује Факултет за примењени менаџмент, економију и финансије, Београд. Већ десет година заредом заједно истражујемо границе и могућности реализације иновативних активности, а стечена сазнања презентујемо у виду чланака обједињених у зборнику радова. На том десетогодишњем путу учили смо, расли и развијали се заједно, а све са циљем креирања базе знања која ће допринети будућем економском развоју и просперитету. Значај конференције препознало је Министарство науке, технолошког развоја и иновација Републике Србије које је пружило финансијску подршку у њеној организацији. До сада смо се дотакли многих тема које прожимају различите научне области и сагледали их кроз призму иновативности. Неки научни одговори су понуђени, неки чак и усвојени, а за неким одговорима и решењима још увек трагамо. Захваљујемо вам што сте десет година уз нас и изражавамо наду да ћете и надаље учествовати у потрази за иновативним решењима и одговорима који ће овај свет учинити бољим него што је сада.

У Београду, децембра 2024.

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FOREWORD

Dear authors, readers, colleagues, students, and enthusiasts seeking for knowledge,

In front of you are the proceedings of the tenth Jubilar International Scientific & Professional Conference, "Innovations as an initiator of the Development," which is organized by the Faculty of Applied Management, Economics and Finance, Belgrade. Ten years in a row, we explored the borders and possibilities for realizing innovative activities and gained knowledge presented in the form of articles united in the conference proceedings. In that ten-year road, we have learned, grown, and developed together, all with the goal of creating the knowledge base that will contribute to future economic development and prosperity. Conference significance is recognized by the Ministry of Science, Technological Progress and Innovation of the Republic of Serbia, which financially supports it. We have touched on many subjects that pervade different scientific fields and perceive them through the prism of innovativeness. Some scientific answers are offered, some are even accepted, and for some of them, we are still looking. Thank you for being these ten years by us, and we hope you will still be a part of the quest for innovative solutions and answers that will make this world better than it is now.

In Belgrade, December, 2024

Editors

Darjan Karabašević, PhD

Svetlana Vukotić, PhD

Gabrijela Popović, PhD

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Hybrid MCDM model for hotel selection leveraging Python for data gathering

Хибридни ВКО модел за избор хотела заснован на коришћењу Python-а за прикупљање података

Gabrijela Popović[1], Đorđe Pucar[2], Dragiša Stanujkić[3]

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Abstract: *The essential goal of this article is to propose an approach that will facilitate potential guests' decisions about booking an adequate hotel. To achieve this objective, we introduced a hybrid approach based on the Python and MCDM model. Using Python, the necessary data regarding the hotels were gathered from TripAdvisor. After that, the hotels were evaluated with Axial-Distance-Based Aggregated Measurement (ADAM) and Comprehensive Distance-Based RAnking (COBRA) methods. The reliability of the obtained results was proved using the well-known SAW method. The final results were defined using the Borda rule.*
Keywords: *ADAM, COBRA, Entropy, SAW, Python, Hotel selection.*

Апстракт: *Кључни циљ овог рада је предлагање приступа који ће помоћи потенцијалним гостима да лакше изаберу адекватан хотел. Ради постизања наведеног циља предложен је хибридни приступ заснован на Python-у и моделу Вишекритеријумског одлучивања (ВКО). Применом Python-а прикупљени су неопходни подаци о хотелима са TripAdvisor-а. Након тога, извршена је њихова евалуација применом метода Axial-Distance-Based Aggregated Measurement (ADAM) и COmprehensive Distance Based RAnking (COBRA). Поузданост добијених резултата потврђена је применом добро познате SAW методе. Финални резултати дефинисани су применом Борда правила.*
Кључне речи: *ADAM, COBRA, Entropy, SAW, Python, избор хотела.*

Introduction

The satisfaction with the chosen hotel strongly influences the tourist travel experience. When tourists go to new places, deciding which hotel to choose is very challenging. The appearance of online booking sites that include the experiences and opinions of real tourists makes travel planning and hotel selection more convenient. Tourists could discover useful information about the hotels' location, quality, and offers in the desired destination (Wu et al., 2022a). Although it contains valuable information and reviews, browsing the booking site could be frustrating for tourists because they could be overwhelmed with information. A significant number of hotels and a number of the criteria that could be conflicting outline this kind of problem as a Multiple-Criteria Decision-Making (MCDM) kind of problem (Yu et al., 2018).

Researchers have already recognized the potential of the MCDM methods and applied it in the decision process regarding hotel selection using booking sites (Wu et al., 2022b; Tao & You, 2022; Zhao et al., 2021; Zhang, 2020). The crucial goal of this article is to enhance the selection of adequate hotels by introducing the hybrid model based on Python, Axial-Distance-Based Aggregated Measurement

(ADAM) and COmprehensive Distance RAnking (COBRA). Python was used to acquire the data from TripAdvisor for analysis.

The significance of the criteria was determined using the Entropy method (Shannon, 1948; Shannon & Weaver, 1964) which proved its applicability in many research studies (Wu et al., 2023c; Mukhametzyanov, 2021; Chen, 2021). The reason for involving the Entropy method in the hybrid model is its objectiveness. Namely, the procedure of the Entropy method is based on the input data, which decreases the subjectiveness of the decision process and increases the reliability of the obtained criteria weights.

As it is noted, the selected alternative hotels were evaluated using two relatively recently introduced MCDM methods, the ADAM method (Krstić et al., 2023) and the COBRA method (Krstić et al., 2022). The ADAM method belongs to the geometric MCDM methods group. This method considers the ranking of the alternatives by volumes of complex polyhedral determined by points (coordinate origin – O, reference points – R, and weighted reference points – P) in a three-dimensional coordinate system. Although entirely novel, this method was used for facilitating decision processes in different fields (Popović et al., 2024; Andrejić et al., 2023; Agnus Dei et al., 2023).

The COBRA method involves the determination of the distance from the selected reference points, more precisely from ideal, anti-ideal, and average solutions. By combining the distance measures, the COBRA method used their benefits to obtain more reliable ranking results which is observed in several research articles (Asker, 2024; Oğuz & Satır, 2024; Ulutaş et al., 2023; Popović et al., 2022; Krstić et al., 2022). Considering that the ADAM and the COBRA methods are relatively new, the obtained results were confirmed using the well-known Simple Additive Weighting (SAW) method (Fishburn, 1967; McCrimmon, 1968). The final ranking and emphasis on the most appropriate hotel were achieved by applying the Borda rule (Nanson, 1882).

To present the applicability of the proposed hybrid MCDM model, fifteen four-star hotels located in Belgrade, Serbia, were assessed against four evaluation criteria. The input data was retrieved from TripAdvisor and represents the ratings of previous guests. The remainder of the article is organized as follows: Section 2 contains the methodological approach, Section 3 presents the case study, and the conclusion is at the end of the article.

1. Methodological approach

1.1. The Entropy method

Shannon (1948) and Shannon and Weaver (1964) introduced the Entropy method, which could be signified as the objective weighting method. Its simple computation procedure makes it very popular for determining the weightings while performing the decision processes.

The equation for defining the criteria weighting using the Entropy method looks as follows:

$$w_j = \frac{1-e_j}{\sum_{j=1}^{n}(1-e_j)}, \tag{1}$$

where $j =,\dots,n$.

The output entropy e_j of the j_{th} factor is determined in the following way:

$$e_j = -\frac{1}{\ln(m)}\sum_{j=1}^{n} r_{ij} \ln(r_{ij}), \tag{2}$$

where $j =,\dots,n,$ and $\sum_{j=1}^{n} w_j = 1$.

1.2. The ADAM method

The ADAM method, proposed by Krstić et al. (2023), is a pioneer of the new group of the MCDM method – geometric MCDM. The following steps could illustrate the ADAM method.

Step 1. Define the decision matrix *D*.

Step 2. Define the sorted decision matrix *S*:

$$S = [s_{ij}]_{nxm}, \tag{3}$$

where s_{ij} denotes the sorted evaluations e_{ij} in descending order regarding the criteria weightings.

Step 3. Define the normalized sorted decision matrix *N*:

$$n_{ij} = \begin{Bmatrix} \frac{s_{ij}}{\max\limits_{i} s_{ij}} & for \quad j \in B \\ \frac{\min\limits_{i} s_{ij}}{s_{ij}} & for \quad j \in C \end{Bmatrix}, \tag{4}$$

where n_{ij} represents the normalized evaluations, *B* is the benefit set, and *C* is the non-benefit criteria.

Step 4. Define the *x*, *y*, and *z* coordinates of the R_{ij} reference and P_{ij} weighted reference points that define the complex polyhedron in the following manner:

$$x_{ij} = n_{ij} \times sin\, \alpha_j, \; \forall j = 1, \ldots, m; \; \forall i = 1, \ldots, n, \tag{5}$$

$$y_{ij} = n_{ij} \times \cos \alpha_j, \; \forall j = 1, \ldots, m; \; \forall i = 1, \ldots, n, \tag{6}$$

$$z_{ij} = \begin{cases} 0, for\ R_{ij} \\ w_j, for\ P_{ij} \end{cases}, \; \forall j = 1, \ldots, m; \; \forall i = 1, \ldots, n, \tag{7}$$

where α_j is the angle that determines the orientation of the vector that defines the value of the alternative, designated as follows:

$$\alpha_j = (j-1)\frac{90^\circ}{m-1}, \forall j = 1, \ldots, m. \tag{8}$$

Step 5. Calculate the complex polyhedral V_i^C volumes as the sum of the volumes of the composing pyramids in the following way:

$$V_i^C = \sum_{k=1}^{m-1} V_k, \quad \forall i = 1, \ldots, m, \tag{9}$$

where V_k denotes the volume of the pyramid determined as follows:

$$V_k = \frac{1}{3} B_k \times h_k, \forall k = 1, \ldots, m-1, \tag{10}$$

where B_k is the surface of the base of the pyramid defined by the reference and weighted reference points of two successive criteria calculated using the following Eq.:

$$B_k = c_k \times a_k + \frac{a_k \times (b_k - c_k)}{2}, \tag{11}$$

where α_k denotes the Euclidean distance between the reference points of two successive criteria, determined in the following way:

$$a_k = \sqrt{(x_{j+1} - x_j)^2 + (y_{j+1} - y_j)^2}, \tag{12}$$

b_k and c_k are the magnitudes of the vectors corresponding to the weights of two successive criteria:

$$b_k = z_j, \tag{13}$$

$$c_k = z_{j+1}, \tag{14}$$

h denotes the height of the pyramid from the defined base to the top of the pyramid discovered in the coordinate origin (*O*), which is calculated in the following way:

$$h_k = \frac{2\sqrt{s_k(s_k - a_k)(s_k - d_k)(s_k - e_k)}}{a_k}, \tag{15}$$

where s_k represents the semicircumference of the triangle defined by the x and y coordinates of two successive criteria and the coordinate origin, computed using the following Eqs.:

$$d_k \sqrt{x_j^2 + y_j^2}, \tag{16}$$

$$e_k = \sqrt{x_{j+1}^2 + y_{j+1}^2}. \tag{17}$$

Step 6. The alternatives should be ranked in decreasing order regarding the volumes of complex polyhedral $V_i^C (i = 1, \dots, n)$. The first-positioned alternative has the highest volume value.

1.3. The COBRA method

The COBRA method, introduced by Krstić et al. (2022), is a distance-based MCDM method that combines three distance measures: distance from the positive reference point, distance from the negative reference point, and distance from the average reference point. All three distance measures were integrated into the COBRA method to retain their good features.

The application of COBRA can be illustrated using the following series of steps.

Step 1. Define the decision matrix as in the ADAM method.

Step 2. Create the normalized decision matrix in the following way:

$$\Delta = [r_{ij}]_{m \times n}, \tag{18}$$

where

$$r_{ij} = \frac{a_{ij}}{\max_i a_{ij}}. \tag{19}$$

Step 3. Define the weighted normalized decision matrix as follows:

$$\Delta_w = [\mathrm{w_j} \times \mathrm{r_j}]_{\mathrm{m \times n}}, \tag{20}$$

where w_j designates the relative weight of criterion *j*.

Step 4. Define the positive ideal (PIS_j), negative ideal (NIS_j), and average solution (AS_j) relative to each criterion function as it is presented:

$$PIS_j = \max_i(w_j \times r_{ij}), \forall_j = 1, \dots, n \;\; for \;\; j \in B, \tag{21}$$

$$PIS_j = \min_i(w_j \times r_{ij}), \forall_j = 1, \dots, n \;\; for \;\; j \in C, \tag{22}$$

$$NIS_j = \min_i(w_j \times r_{ij}), \forall_j = 1, \dots, n \;\; for \;\; j \in B, \tag{23}$$

$$NIS_j = \max_i(w_j \times r_{ij}), \forall_j = 1, \dots, n \;\; for \;\; j \in C, \tag{24}$$

$$AS_j = \frac{\sum_{i=1}^m (w_j \times r_{ij})}{n}, \forall_j = 1, \dots, n \;\; for \;\; j \in B, C, \tag{25}$$

where B represents the benefit set, and C is the non-benefit criteria.

Step 5. Determine the distance from the positive ideal solution $\left(d(PIS_j)\right)$, negative ideal solution $\left(d(NIS_j)\right)$, the positive distance from the average solution $\left(d(AS_j^+)\right)$, and the negative distance from the average solution $\left(d(AS_j^-)\right)$ as follows:

$$d(S_j) = dE(S_j) + \sigma \times dE(S_j) \times dT(S_j), \forall_j = 1, \dots n, \tag{26}$$

where S_j represents any solution $(PIS_j, NIS_j, \text{or } AS_j)$, σ is the correction coefficient defined as follows:

$$\sigma = \max_i dE(S_j)_i - \min_i dE(S_j)_i, \tag{27}$$

where $dE(S_j)_i$ and $dT(S_j)_i$ denote the Euclidian and Taxicab distances, respectively. These distances are calculated for the positive ideal solution in the following way:

$$dE(PIS_j)_i = \sqrt{\sum_{j=1}^{n}(PIS_j - w_j \times r_{ij})^2}, \forall_i = 1, \dots, m, \quad \forall_j = 1, \dots, n, \tag{28}$$

$$dT(PIS_j)_i = \sum_{j=1}^{n}|PIS_j - \ w_j \times r_{ij}|, \quad \forall_i = 1, \dots, m, \quad \forall_j = 1, \dots, n. \tag{29}$$

The Euclidian and Taxicab distances are computed for the negative ideal solution using the following Eqs.:

$$dE(NIS_j)_i = \sqrt{\sum_{j=1}^{n}(NIS_j - w_j \times r_{ij})^2}, \forall_i = 1, \dots, m, \quad \forall_j = 1, \dots, n. \tag{30}$$

$$dT(NIS_j)_i = \sum_{j=1}^{n}|NIS_j - \ w_j \times r_{ij}|, \forall_i = 1, \dots, m, \quad \forall_j = 1, \dots, n. \tag{31}$$

For the positive distance from the average solution, the Euclidian and Taxicab distances are computed in the following way:

$$dE(AS_j)_i^+ = \sqrt{\sum_{j=1}^{n}\tau^+(AS_j - w_j \times r_{ij})^2}, \forall_i = 1, \dots, m, \quad \forall_j = 1, \dots, n. \tag{32}$$

$$dT(AS_j)_i^+ = \sum_{j=1}^{n}\tau^+|AS_j - \ w_j \times r_{ij}|, \forall_i = 1, \dots, m, \quad \forall_j = 1, \dots, n. \tag{33}$$

$$\tau^+ = \begin{cases} 1 \ if \ AS_j < w_j \times r_{ij} \\ 0 \ if \ AS_j > w_j \times r_{ij} \end{cases}. \tag{34}$$

These distances for the negative distance from the average solution are calculated using the following Eqs.:

$$dE(AS_j)_i^- = \sqrt{\sum_{j=1}^{n}\tau^-(AS_j - w_j \times r_{ij})^2}, \forall_i = 1, \dots, m, \quad \forall_j = 1, \dots, n. \tag{35}$$

$$dT(AS_j)_i^- = \sum_{j=1}^{n}\tau^-|AS_j - \ w_j \times r_{ij}|, \forall_i = 1, \dots, m, \quad \forall_j = 1, \dots, n. \tag{36}$$

$$\tau^- = \begin{cases} 1 \ if \ AS_j > w_j \times r_{ij} \\ 0 \ if \ AS_j < w_j \times r_{ij} \end{cases}. \tag{37}$$

Step 6. The ranking order is defined using the following Eq.:

$$dC_i = \frac{d(PIS_j)_i - d(NIS_j)_i - d(AS_j)_i^+ + d(AS_j)_i^-}{4}, \forall_i = 1, \dots, m. \tag{38}$$

where (dC_i) represents comprehensive distances, and the ranking is performed in ascending order.

2. Results

Since we defined the research objective, we had to obtain the necessary hotel data. Using Python, we collected data about the best-rated four-star hotels in Belgrade, Serbia, from TripAdvisor (https://www.tripadvisor.com/). Thirty hotel ratings were retrieved, but fifteen were involved in the MCDM analysis.

The authors used different combinations of the criteria to assess the considered hotels (Wu et al., 2022; Liang et al., 2019; Nilashi et al., 2019). In this case, a slightly simpler model based on the four criteria is presented. The criteria used involve:

- location (Lo),
- cleanliness (Cl),
- service (Se), and
- value (Va).

This time, the price is not involved in the procedure because we hypothesized that the potential guest is ready and capable of fulfilling any price for the perceived quality level.

The ratings on TripAdvisor range from 1 to 5, where 1 stands for the lowest and 5 for the highest rating. The names of the hotels are not presented intentionally to avoid their advertising. The collected data regarding the considered hotels are presented in Table 1.

Table 1. The initial data

	Lo	*Cl*	*Se*	*Va*
H_1	4.4	5	4.9	4.9
H_2	4.7	4.8	4.7	4.5
H_3	4.9	4.6	4.4	4.3
H_4	4.2	4.7	4.7	4.6
H_5	4.9	4.9	4.9	4.6
H_6	4.9	4.9	4.8	4.7
H_7	4.9	4.8	4.8	4.5
H_8	4.9	4.5	4.4	4.2
H_9	4.9	4.9	4.7	4.4
H_{10}	4.5	4.9	4.8	4.7
H_{11}	4.7	5	4.8	4.7
H_{12}	4.9	4.6	4.6	4.4
H_{13}	5	5	4.9	4.9
H_{14}	4.3	4.7	4.6	4.6
H_{15}	4.9	4.6	4.3	4.4

Source: Author's calculation

Weighting coefficients were defined based on the input data using the Entropy method. The obtained weights are presented in Table 2.

Table 2. Weighting coefficients

Criteria	w_j
Lo	0.2613
Cl	0.2480
Se	0.2413
Va	0.2494

Source: Author's calculation

The weighting coefficients revealed that the most significant criterion is *Va – Value.* This result is entirely acceptable because the hotel guests want to receive the highest possible quality for the price. However, it should be stated that the differences between the criteria weights are not too high. This reflects objectiveness because, among the given criteria, no one could be treated as unimportant.

After determining weighting coefficients, the ADAM and COBRA methods were used to assess the hotels and determine their rankings. Table 3 shows the obtained results.

Table 3. The ADAM and COBRA results

	ADAM		**COBRA**	
	Result	**Rank**	**Result**	**Rank**
H_1	0.1196	2	-0.0069	6
H_2	0.1107	9	-0.0018	9
H_3	0.1037	14	0.0049	11
H_4	0.1068	12	0.0111	15
H_5	0.1171	5	-0.0133	3
H_6	0.1180	3	-0.0138	2
H_7	0.1131	7	-0.0082	5
H_8	0.1006	15	0.0080	13
H_9	0.1122	8	-0.0053	7
H_{10}	0.1147	6	-0.0032	8
H_{11}	0.1180	4	-0.0108	4
H_{12}	0.1068	11	-0.0001	10
H_{13}	0.1247	1	-0.0235	1
H_{14}	0.1068	10	0.0097	14
H_{15}	0.1045	13	0.0050	12

Source: Author's calculation

The results show that the best-ranked alternative according to the ADAM and COBRA methods is the hotel H_{13}. Although the other ranking positions vary between the used methods, the first-positioned hotel remains the same in both cases. The given hotel H_{13} has the most satisfying performance regarding all criteria involved in the procedure that justifies such a result. The obtained results were confirmed using the SAW method. The comparison of the ranking positions of the considered hotels is illustrated graphically (Figure 1).

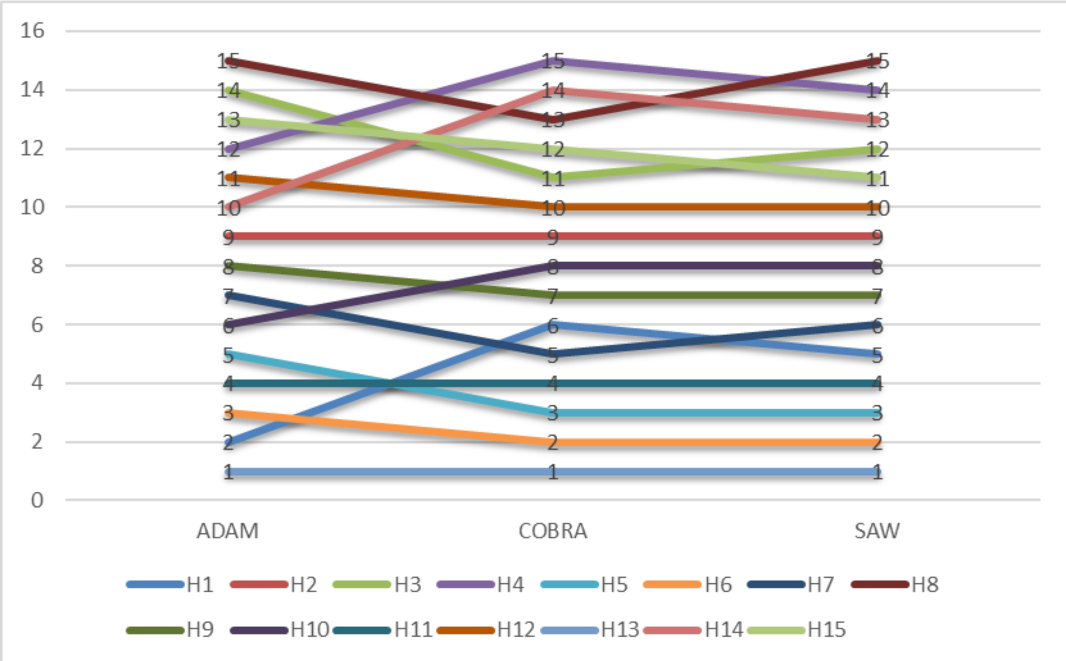

Figure 1. Results comparison – ADAM, COBRA, SAW
Source: Author's calculation

Existing differences in the ranking positions are nuanced with the stability of the proposed hybrid MCDM approach. Finally, using the Borda rule (Nanson, 1882), we defined the hotels' final ranking order, which is presented in Table 4.

Table 4. The final results

	Rank
H_1	3
H_2	9
H_3	12
H_4	14
H_5	3
H_6	2
H_7	6
H_8	15
H_9	8
H_{10}	7
H_{11}	3
H_{12}	10
H_{13}	1
H_{14}	11
H_{15}	12

Source: Author's calculation

Conclusion

This article presents a hybrid model for hotel selection based on TripAdvisor reviews. The model was applied to evaluate fifteen four-star hotels in Belgrade, Serbia, against four criteria. Data on these hotels were collected from TripAdvisor using Python. The assessment and ranking of the hotels were then conducted using a combination of MCDM methods – the ADAM method and the COBRA method. The SAW method was used to validate the results, and the final rankings were determined using the Borda rule. This comprehensive process enabled the identification of the most suitable hotel that met the specified criteria.

The main shortcoming of the article is the limited number of criteria involved in the assessment. The results should be more realistic if a more significant number of criteria are involved in the procedure. Besides, the assessment is based only on quantitative ratings. Application of the sentiment analysis (SA) will enable the nuances expressed in the text reviews to be involved, increasing the rankings' reliability. Additionally, introducing adequate extensions based on fuzzy or neutrosophic logic will acknowledge the hesitation in the decision and selection process. Nevertheless, the proposed hybrid model proved its usefulness. Besides, it could be used to facilitate decision-making processes not only in the tourism field but also in other business fields.

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