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Optimizing University Student Housing Decisions: A MARCOS-Based Multi-Criteria Analysis

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Abstract
Multi-criteria decision making (MCDM) techniques are crucial in decision-making situations with several conflicting criteria, helping to make well-informed and optimum decisions. This study utilizes the MARCOS technique, a well-known MCDM strategy, to help university students choose the optimal apartment leasing option nearby a Vietnamese institution. Data on two critical criteria, namely location distance to the university and monthly rental price, were collected from 18 apartment rental options. Through rigorous analysis utilizing the MARCOS method, the study identifies the most suitable apartment rental option for university students.

Keywords: Multi-Criteria Decision Making, MARCOS Technique, Apartment Selection, Decision Analysis, Optimal Accommodation

1. Introduction

Multi-Criteria Decision Making (MCDM) approaches are crucial in complicated decision-making situations that involve considering numerous criteria concurrently. These approaches offer structured frameworks for assessing and choosing the optimal option from a range of choices using many competing criteria. MCDM is applied in several areas like information management (Kazimieras *et al*., 2018) [3], banking (Daiy *et al*., 2021) [1], venue locating (Zolfani *et al*., 2013) [2], business sustainability (Mijajlović *et al*., 2020) [4], CBN grinding (Huy *et al*., 2022) [5], etc. One notable method among the several MCDM strategies is the MARCOS method. MARCOS was created to tackle decision-making issues in many situations. It provides a robust system for choice analysis, presenting a well-organized and thorough approach to assessing options across multiple aspects.

Utilizing MCDM is important in several fields, such as real estate and housing. University students confront a complex decision-making process while seeking apartment rentals due to their various demands, preferences, and limits. This study seeks to utilize the MARCOS method to overcome complexity and help university students choose the best apartment leasing alternative. The MARCOS method provides a structured way to prioritize and choose the most appropriate accommodation for university students. Hence, this research aims to provide significant insights into the decision-making process of apartment rentals for university students by utilizing the MARCOS method, leading to better informed and satisfying outcomes.

2. Methodology

2.1 Method for MCDM

The MARCOS technique was used in this study to solve the MCDM challenge. To adopt this technique, the following steps need to be [18]:

Step 1: Creating the initial decision-making matrix:

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ x_{21} & \cdots & x_{2n} \\ \vdots & \cdots & \vdots \\ x_{mn} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

In which, *n* and *m* are the number of criterion and alternative.

Step 2: By adding an ideal (AI) and anti-ideal solution (AAI) to the initial decision-making matrix, an extended initial matrix can be generated:

$$X = \begin{matrix} AAI \\ A_1 \\ A_2 \\ \vdots \\ A_m \\ AI \end{matrix} \begin{bmatrix} x_{aa1} & \cdots & x_{aan} \\ x_{11} & \cdots & x_{1n} \\ x_{21} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots \\ x_{m1} & \cdots & x_{mn} \\ x_{ai1} & \cdots & x_{ain} \end{bmatrix} \quad (2)$$

Where, $AAI = min\,(x_{ij})$ and $AI = max\,(x_{ij})$ if criterion j is as large as possible; $AAI = max\,(x_{ij})$ and $AI = min\,(x_{ij})$ if criterion j is as small as possible; I = 1, 2,..., m; j = 1, 2,..., n.
Step 3: Finding the normalized matrix $N = |n_{ij}|_{m\times n}$:

$$u_{ij} = x_{AI}/\,x_{ij} \quad (3)$$

$$u_{ij} = x_{ij}/\,x_{AI} \quad (4)$$

Equation (3) is used when the criterion j is as small as possible, and (4) is applied when j is as large as possible.
Step 4: Calculating the weighted normalized matrix $C = [c_{ij}]_{m\times n}$ by:

$$c_{ij} = u_{ij} \cdot w_j \quad (5)$$

In which, w_j is the weight coefficient of criterion *j*.
Step 5: Determining the utility of alternatives K_i^- and K_i^+ by:

$$K_i^- = S_i/S_{AAI} \quad (6)$$

$$K_i^+ = S_i/S_{AI} \quad (7)$$

In (6) and (7), S_i can be determined by:

$$S_i = \sum_{i=1}^{m} c_{ij} \quad (8)$$

Step 6: Calculating the utility function f(Ki) of alternatives by:

$$f(K_i) = \frac{K_i^+ + K_i^-}{1+\frac{1-f(K_i^+)}{f(K_i^+)}+\frac{1-f(K_i^-)}{f(K_i^-)}} \quad (9)$$

Where $f(K_i^-)$ is the utility function linked with the anti-ideal solution and $f(K_i^+)$ is the utility function linked with the ideal solution. These functions are determined by:

$$f(K_i^-) = K_i^+/(K_i^+ + K_i^i) \quad (10)$$

$$f(K_i^+) = K_i^-/(K_i^+ + K_i^i) \quad (11)$$

Step 7: Arrange the options based on the final utility function values to discover which option has the highest value.

2.2 Method to find the weight of criteria

The entropy technique was used in this work to establish the weights of the criteria. The following actions can be used to put this strategy into practice [19].
Step 1: Calculating indicator normalized values:

$$p_{ij} = \frac{x_{ij}}{m+\sum_{i=1}^{m} x_{ij}^2} \quad (12)$$

Step 2: Determining the Entropy for each indicator:

$$me_j = -\sum_{i=1}^{m}[p_{ij} \times ln(p_{ij})] - (1 - \sum_{i=1}^{m} p_{ij}) \times ln(1 - \sum_{i=1}^{m} p_{ij}) \quad (13)$$

Step 3: Finding the weight of each indicator:

$$w_j = \frac{1-me_j}{\sum_{j=1}^{m}(1-me_j)} \quad (14)$$

2.3 Data collection

Data on the locations and costs of 18 apartment rental alternatives near Thai Nguyen University of Technology, Vietnam has been collected. The data includes the distance in kilometers from each rental flat to Thai Nguyen University of Technology. This information is an essential factor for students, since the distance to the university greatly affects convenience and accessibility. The distance data was acquired by direct measurements utilizing GPS technology or online mapping services to ensure precision and dependability. The second criteria – price - is the monthly rental payments for each of the 18 apartment rental choices, expressed in thousand Vietnamese Dong (thousand VND). Price is a crucial factor for university students as it directly impacts affordability and financial viability. The rental costs were collected by directly contacting landlords or rental agencies to ensure current and accurate information. During the data gathering procedure, landlords or rental agencies were asked for permission before gathering rental price to adhere to data privacy legislation and ethical standards. Confidentiality measures were maintained to protect the privacy of persons and businesses participating in the rental transactions.

3. Determining the best apartment rental option

3.1 Determining the weights for the criteria

Using the Entropy approach (see Section 2.2), the weights of the criterion have been determined as follows: First, use equation (12) to obtain the normalized values of p_{ij}. Equation (13), for each indication me_j, yields the Entropy value. Finally, use Equation (14). to find the weight of the criteria w_j. The weights of location and price were determined to be 0.70129 and 0.29871, respectively.

3.2 Determining the best apartment rental option using MARCOS method

Section 2.1 delineates the multi-objective decision-making phases of the MARCOS technique. The finding is as followed: Determine the ideal solution (AI) and the anti-ideal solution (AAI) using formula (2). The outcomes demonstrated that, although location and price with AAI were 1.8 (km) and 800 (thousand VND), location and price with AI were 0.2 (km) and 2500 (thousand VND), respectively. The next step is to calculate the normalized values u_ij using formulas (3) and (4). Formula (5) was then used to calculate the normalized values while accounting for the weight c_ij. Moreover, the coefficients K_i^- and K_i^+ are obtained from Equations (6) and (7). Equations (10) and (11) were used to find the values of $f(K_i^-)$ and $f(K_i^+)$. The

values of $f(K_i^+)$= 0.7572 and $f(K_i^-)$ = 0.2428 were discovered. Finally, formula (9) is used to compute the values of $f(K_i)$. Table 1 displays the options' rankings as well as the results of a few different parameters.

Among the options in Table 3, Option 5 is the best option. This is because of its largest utility function value (f(Ki)=0.000367). Therefore, the optimal solution consists of the following values: Location=0.2 (km); Price = 2400 (thousand VND).

Table 1: Several calculated results and ranking of alternatives

Option	K+	K-	f(K+)	f(K-)	f(Ki)	Rank
1	0.000232	0.000722	0.757177	0.242823	0.000215	4
2	0.000248	0.000773	0.757177	0.242823	0.00023	3
3	0.000104	0.000325	0.757177	0.242823	9.66E-05	13
4	0.000134	0.000418	0.757177	0.242823	0.000124	11
5	0.000395	0.001232	0.757177	0.242823	0.000367	1
6	0.000116	0.000362	0.757177	0.242823	0.000108	12
7	0.000135	0.000421	0.757177	0.242823	0.000125	10
8	0.000147	0.000457	0.757177	0.242823	0.000136	9
…						
17	7.33E-05	0.000229	0.757177	0.242823	6.8E-05	18
18	7.42E-05	0.000231	0.757177	0.242823	6.88E-05	17

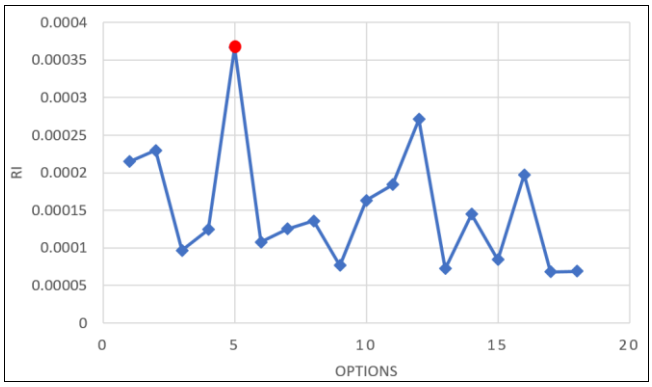

Fig 1: Relation between options and Ri

4. Conclusion

This study utilized the MARCOS method together with the Entropy method to gain significant insights into the decision-making process of university students looking for the best apartment leasing option near Thai Nguyen University of Technology. The MARCOS Method allowed students to evaluate available alternatives comprehensively by evaluating several characteristics such as geographic distance and rental price, enabling them to make educated judgments based on their preferences and limits. Through the extensive analysis undertaken in this study, it has been concluded that Option 5 emerges as the most advantageous apartment leasing choice. This choice has the closest proximity to the institution and has the most affordable rental pricing compared to the other alternatives being considered. Using a utility function with a maximum value of f(Ki)=0.000367 indicates the higher performance of Option 5 compared to the other 18 test runs.

This study highlights the need of using sophisticated decision-making approaches, such the MARCOS Method, to tackle intricate real-world situations. University students may use these analytical tools to better understand and make judgments about apartment rentals. Furthermore, using quantitative analytical methods like utility function optimization improves the accuracy and impartiality of decision-making, resulting in more favorable results for students.

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