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Research Article

A Hybrid Multiattribute Decision Making Model for Evaluating Students' Satisfaction towards Hostels

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This paper proposes a new hybrid multiattribute decision making (MADM) model which deals with the interactions that usually exist between hostel attributes in the process of measuring the students' satisfaction towards a set of hostels and identifying the optimal strategies for enhancing their satisfaction. The model uses systematic random stratified sampling approach for data collection purpose as students dwelling in hostels are "naturally" clustered by block and gender, factor analysis for extracting large set of hostel attributes into fewer independent factors, λ-measure for characterizing the interactions shared by the attributes within each factor, Choquet integral for aggregating the interactive performance scores within each factor, Mikhailov's fuzzy analytical hierarchy process (MFAHP) for determining the weights of independent factors, and simple weighted average (SWA) operator to measure the overall satisfaction score of each hostel. A real evaluation involving fourteen Universiti Utara Malaysia (UUM) hostels was carried out in order to demonstrate the model's feasibility. The same evaluation was performed using an additive aggregation model in order to illustrate the effects of ignoring the interactions shared by attributes in hostel satisfaction analysis.

1. Introduction

These days, mushrooming number of universities forces each of them to try all the possible means to survive or win in the competitive marketplace. In the attempt to reflect themselves as the best place for pursuing tertiary education, certain universities are unceasingly putting effort in offering accommodations or hostels with satisfying quality as pleasing hostel condition always appears as one of the criteria for some students in choosing a university [1]. Apart as a strategy to attract large number of students, providing satisfying hostel life is also a key to encourage the students to be more engaged with the education environment [2] and thus could drive them for better academic performance [3, 4]. Besides, the students who are satisfied with their hostels express higher sense of attachment and tend to further their studies in the same intuition. In nutshell, it is essential for the universities to timely identify and implement appropriate strategies in fulfilling the students' actual needs and enhance the students' satisfaction towards their hostels.

Unfortunately, identifying the optimal strategies is not a simple task as the degree of students satisfaction towards the hostels is normally influenced by multiple attributes. Following are some of the hostel attributes highlighted in past studies: number of roommates [5]; floor level [6]; recreation area, drain condition, and distance to clinic [7]; thermal comfort, indoor air quality, and furniture quality [8]; hostel maintenance, laundry [9]; internet facilities [10]; fees, room safety, and room size [11]; study room, ATM machine [12].

Besides, the review on past literature discloses that there is only minimal number of quantitative approaches that have been presented to this date in determining the optimal strategies for boosting the satisfaction towards a hostel. Most of the past studies (e.g., [11]) only employed factor analysis to discover the factors that influence the students' satisfaction but the tool alone failed to offer other types of essential information for the hostel administration (e.g., type of interactions between attributes and weights of the factors) in deciding efficient strategies. In addition, in several studies, the overall satisfaction score of each hostel under evaluation was simply computed by using the common arithmetic aggregator which presumes independency among attributes. However, in reality most of the attributes used for an assessment are interacted to each other [13]. The hostel attributes hold the same characteristic as well.

Hence, it is can be concluded that there is a need for a quantitative model which mainly deals with or considers the interactions between attributes in the process of evaluating the performance of a set of hostels based on students' satisfaction, in order to implement more practical strategies in enhancing their satisfaction.

This paper is organized as follows. Firstly, the needs for enhancing students' satisfaction towards a hostel and the existing problems relating to hostel evaluation are elucidated. Secondly, a review on past literature focusing on the usage of Choquet integral and its associated λ-measure is presented. Thirdly, the proposed hybrid MADM model is introduced. Fourthly, the workability of the proposed model is demonstrated by conducting a real analysis involving fourteen University Utara Malaysia (UUM) hostels. The contributions of the paper and the potential future research are summarized in the final section.

2. Aggregation Phase in MADM

MADM refers to a process of selecting, ranking, or classifying a set of alternatives based on varied, usually conflicting, attributes [14]. Applying multiple attribute utility theory (MAUT) techniques appears as a well-accepted standard, quantitative means for modeling MADM problems [15]. There are only three basic phases in implementing any of the MAUT techniques [16]. In the first phase, all the pertinent attributes for evaluating the alternatives under consideration are identified. The core components of a typical MAUT model are comprised of a set of m alternatives denoted by $A = \{a_1, a_2, \ldots, a_m\}$ and a set of n attributes represented by $C = \{c_1, c_2, \ldots, c_n\}$. In the following phase, the weights of attributes and performance score of each alternative with respect to each attribute are derived where some judgments or preference values from the experts or respondents are usually required for this purpose [17]. In the final phase, a specific function, namely, aggregation operator, is used to compose the set of weights and performance scores of each alternative into a single global score [18]. Based on these global scores, the alternatives can be then ranked up, classified, or selected where an alternative with highest global score signifies the most preferred alternative for the evaluation problem.

2.1. Aggregation Based on Choquet Integral. Normally, additive operators such as SWA which assume independency between attributes [19] are simply employed for the aggregation purpose. Unfortunately, this assumption is completely irrelevant to real scenario where in many cases, the attributes hold interactive characteristics [13, 20]. Therefore, aggregation should not be always performed via additive aggregators as they failed to model the interactions between attributes [21, 22]. However, with the aid of Choquet integral operator [23], the interactions between attributes can be captured during aggregation [24, 25]. The usage of Choquet integral requires a prior identification of monotone measure weights, g. These weights represent not only the importance of each attribute but also the importance of all possible combinations or subsets of attributes [26–28]. As a result, for a MADM problem comprising n number of attributes, 2^n number of weights needs to be identified prior to employing Choquet integral [29, 30].

λ-measure which was introduced by Sugeno [31] appears as one of the broadly used monotone measures due to its ease of usage, mathematical soundness, and modest degree of freedom characteristics [32]. Let $C = (c_1, c_2, \ldots, c_n)$ be a finite set. A set function $g_\lambda(\cdot)$ defined on the set of the subsets of C, $P(C)$, is called a λ-measure if it meets the following conditions:

(a) $g_\lambda : P(C) \rightarrow [0, 1]$, and $g_\lambda(\emptyset) = 0$, $g_\lambda(C) = 1$ (boundary condition);

(b) $\forall A, B \in P(C)$, if $A \subseteq B$, then implies $g_\lambda(A) \leq g_\lambda(B)$ (monotonic condition);

(c) $g_\lambda(A \cup B) = g_\lambda(A) + g_\lambda(B) + \lambda g_\lambda(A) g_\lambda(B)$, for all $A, B \in P(C)$ where $A \cap B = \emptyset$ and $\lambda \in [-1, +\infty]$.

According to [33, 34], consider the following.

(a) If $\lambda < 0$ then it implies that the attributes are sharing subadditive (redundancy) effects. This means a significant increase in the performance of the target can be achieved by only enhancing some attributes in C which have higher individual weights.

(b) If $\lambda > 0$ then it interprets that the attributes are sharing superadditive (synergy support) effects. This means a significant increase in the performance of the target can be achieved by simultaneously enhancing all the attributes in C regardless of their individual weights.

(c) If $\lambda = 0$ then it indicates that the attributes are non-interactive.

As $C = c_j = \{c_1, c_2, \ldots, c_n\}$ is finite, the entire λ-measure weights can be identified using

$$g_\lambda \{c_1, c_2, \ldots, c_n\} = \frac{1}{\lambda} \left| \prod_{j=1}^{n} \left(1 + \lambda g_j\right) - 1 \right|, \quad \text{for } -1 < \lambda < +\infty, \tag{1}$$

where $g_j = g_\lambda(c_j)$, $j = 1, \ldots, n$ denotes the individual weights of attributes. If $\sum_{j=1}^{n} g_j = 1$, $\lambda = 0$ whereas if $\sum_{j=1}^{n} g_j \neq 1$, the value of λ can be identified by solving

$$1 + \lambda = \prod_{j=1}^{n} \left(1 + \lambda g_j\right). \tag{2}$$

The identified λ-measure weights and the available performance scores can be then swapped into Choquet integral model to compute the global score of each alternative. Let g_λ be a monotone measure on $C = (c_1, c_2, \ldots, c_n)$ and let $X = (x_1, x_2, \ldots, x_n)$ be the performance score of an alternative with respect to each attribute in C. Suppose $x_1 \geq x_2 \geq \cdots \geq x_n$. Then, $T_n = (c_1, c_2, \ldots, c_n)$ and the aggregated score using Choquet integral can be determined using the following equation [35]:

$$\begin{aligned}\text{Choquet}_{g_\lambda}(x_1, x_2, \ldots, x_n) &= x_n \cdot g_\lambda(T_n) + [x_{n-1} - x_n] \cdot g_\lambda(T_{n-1}) + \cdots \\ &\quad + [x_1 - x_2] \cdot g_\lambda(T_1) \\ &= x_n \cdot g_\lambda(c_1, c_2, \ldots, c_n) + [x_{n-1} - x_n] \\ &\quad \cdot g_\lambda(c_1, c_2, \ldots, c_{n-1}) + \cdots + [x_1 - x_2] \cdot g_\lambda(c_1),\end{aligned} \tag{3}$$

where T_n relies on the performance score with respect to each attribute. For better understanding, assume that the scores of a student, x in three subjects (attributes), Mathematics (x_M), Physics (x_P), Literature (x_L), are 75, 80, and 50 respectively. Since $x_P \geq x_M \geq x_L$, $T_n = (P, M, L)$ and the aggregated score of the student using Choquet integral, $\text{Choquet}_{g_\lambda}(x_M, x_P, x_L) = x_L \cdot g_\lambda(P, M, L) + (x_M - x_L) \cdot g_\lambda(P, M) + (x_P - x_M) \cdot g_\lambda(P)$.

3. Methodology

The steps for executing the proposed hybrid model can be summarized as follows.

3.1. Identification of Attributes. In the first stage, a set of relevant attributes to assess the hostels under consideration are identified. Omitting any important attributes could lead to misleading decision.

3.2. Data Collection Using Systematic Random Stratified Sampling Approach. In the second stage, a questionnaire is designed based on the predetermined attributes as an instrument to collect the required data for the evaluation. Through the questionnaire, the selected students (respondents) are requested to express their satisfaction on each attribute with respect to their hostels and also to state their general views on the importance each attribute in determining a student's satisfaction, based on a preset Likert scale. Systematic random stratified sampling approach can be utilized in selecting the respondents for the survey purpose. According to [12], this sampling approach has been applied in many hostel evaluation studies as the students are usually or "naturally" grouped into groups, that is, by block and gender.

3.3. Deriving Decision Matrix (Hostels versus Attributes). In the third stage, the decision matrix of the evaluation problem which shows the performance score of each hostel with respect to each attribute is derived. The performance score of a hostel i with respect to an attribute j can be identified by averaging the satisfaction scores given by the students from hostel i.

3.4. Factor Analyzing the Data on the Importance of Attributes. In the fourth stage, the large dataset on the importance of attributes is used to perform factor analysis in order to extract the large set of attributes into fewer independent factors.

3.5. Constructing Simpler Hierarchal Evaluation System. By adhering to the result of factor analysis, the complex hostel evaluation problem is decomposed into a simpler hierarchical structure which depicts the goal of the evaluation, the factors which independently contributes to the actualization of the goal, and the interacted attributes within each factor together with the hostels' performance scores extracted from the derived decision matrix, in order to conduct the analysis in an organized means with better understanding.

3.6. Identification of Monotone Measure Weights. Since the attributes within each factor are being interactive, Choquet integral can be then employed in order to aggregate the performance scores within each factor. However, before applying Choquet integral, the λ-measure weights need to be identified. The identification process can be simplified as follows.

Firstly, the experts are required to express the individual importance or contribution of each attribute towards its corresponding factor in linguistic terms. Based on these terms, one of the eight fuzzy conversion scales as suggested by Chen and Hwang [36] is selected in order to quantify the linguistic terms into their respective fuzzy numbers. Further details on the principle of selecting the best scale can be found in [36]. Then, the corresponding crisp values for each of these fuzzy values are identified using a fuzzy scoring method as suggested in [36]. Subsequently, the final individual importance $\bar{I}_{jp}$ of an attribute j corresponding to factor p can be determined using

$$\bar{I}_{jp} = \frac{1}{z} \sum_{e=1}^{z} I_{j_e p}. \tag{4}$$

Suppose $E_e = \{E_1, E_2, \ldots, E_z\}$ represents the experts involved in the analysis; then, based on (4), $I_{j_e p}$ denotes the crisp importance of attribute j with respect to factor p that is derived from expert e and z implies the total number of experts involved. These final values actually represent the individual weights of attributes, $g_j = g_\lambda(c_j)$, $j = 1, 2, \ldots, n$. Equations (2) and (1) can be then applied in order to find the interaction parameter, λ and λ-measure weights of each factor.

3.7. Choquet Integral for Aggregating Interactive Scores. With the available λ-measure weights, Choquet integral model (3) can be then used to aggregate the interactive performance scores within each factor. As a result, by end of this step, each hostel will have an aggregated score with respect to each factor (in other words, each hostel will have a set of factor scores) and thus a new decision matrix (hostels versus factors) can be developed for further analysis.

3.8. Using MFAHP for Allocating Weights on Independent Factors. MFAHP [37] is used to identify the weights of independent factors due to its ability to capture the uncertainty

Table 1: Fuzzy AHP scale.

Linguistic terms	Corresponding TFNs	Descriptions
Equally important	$\tilde{1} = (1, 1, 2)$	Two factors contribute equally
Slightly important	$\tilde{3} = (2, 3, 4)$	One factor is slightly favoured over another
Strongly important	$\tilde{5} = (4, 5, 6)$	One factor is strongly favoured over another
Very strongly important	$\tilde{7} = (6, 7, 8)$	One factor is very strongly favoured over another
Extremely important	$\tilde{9} = (8, 9, 9)$	One factor is most favoured over another
The intermediate values	$\tilde{2} = (1, 2, 3)$, $\tilde{4} = (3, 4, 5)$, $\tilde{6} = (5, 6, 7)$, $\tilde{8} = (7, 8, 9)$	Used to compromise between two judgments

that usually embedded in human's judgments and to derive the weights of the factors and consistency value of pairwise comparison matrix simultaneously by simply solving the nonlinear optimization model suggested in [37]. With respect to the proposed model, MFAHP can be executed as follows.

Firstly, after achieving consensus via Delphi method, the experts are required to linguistically express the mutually agreed judgments on the relative importance of the factors through a single pairwise matrix (for sake of simplicity) based on Saaty's fuzzy AHP scale as shown in Table 1. It has to be mentioned here that in order to avoid using reciprocal judgment (values between $\tilde{9}^{-1}$ and $\tilde{1}^{-1}$) which could lead to rank reversal problem, MFAHP only requires the experts to offer assessment whenever factor f_a is equally or more important than f_b. If they consider that f_a is less important than f_b then the assessment should be done oppositely where f_b is compared to f_b. It can be noticed that the reciprocal judgments are not offered in Table 1 as they are not required for using MFAHP.

Secondly, the linguistic terms in the assessed pairwise matrix are quantified into their corresponding triangular fuzzy numbers (TFNs). Finally, the suggested nonlinear optimization model (5) can be constructed based on the fuzzy pairwise matrix and solved with the aid of EXCEL Solver to derive the consistency value of the matrix and the weights of the factors:

$$\begin{aligned} &\text{Maximize} \quad \mu \\ &\text{Subject to;} \quad (m_{ab} - l_{ab})\,\mu w_b - w_a + l_{ab} w_b \le 0, \\ &\qquad (u_{ab} - m_{ab})\,\mu w_b + w_a - u_{ab} w_b \le 0, \\ &\qquad \sum_{p=1}^{q} w_p = 1, \quad w_p > 0, \ p = 1, \ldots, q. \end{aligned} \tag{5}$$

With regard to the proposed model, l_{ab}, u_{ab}, and u_{ab} represent the lower, upper, and most probable values corresponding to the fuzzy judgment given by the experts when comparing factor f_a to f_b. Meanwhile, w_p denotes the weight of factor f_p and μ represents the consistency index of the pairwise comparison. Positive μ value indicates that the fuzzy pairwise comparison matrix is being consistent. If the value is negative then it implies that the comparison matrix is being inconsistent and reevaluation on the pairwise comparison is required.

3.9. SWA Operator for Aggregating Independent Factor Scores. With the identified weights of factors, the independent factor scores can be then aggregated using SWA operator (6) in order to compute the overall satisfaction score of each hostel:

$$\sum_{p=1}^{q} \left(w_p \cdot y_p \right), \tag{6}$$

where w_p implies the weight of factor p and y_p represents the score of a hostel with respect to factor p. The hostels can be then ranked in a descending order based on their overall scores. The result or information derived through the model can be utilized by each hostel administration to develop the optimal strategies for enhancing the students' satisfaction towards their respective hostels.

4. Real Application

Universiti Utara Malaysia (UUM) offers accommodation for nearly 22,000 students through its fifteen hostels which are named after multinational companies: MAS, TNB, Tradewinds, Proton, Petronas, EON, Sime Darby, MISC, TM, Perwaja, Bank Muamalat, YAB, Bank Rakyat, SME, and Maybank. The accommodation is provided for all the undergraduate students ranging from first to final semester and the postgraduate students are allowed to stay upon the approval of the authorized unit. In the attempt to test the feasibility of the proposed model, this paper has focused on evaluating and suggesting the strategies to improve the students' satisfaction towards fourteen UUM hostels. Maybank hostel which is specially designed for married students was excluded from the evaluation to minimize biasness as it has different standard of facilities, management, and service.

4.1. Hostel Attributes for Evaluation. Through the participation of five panels of experts who are familiar with UUM's hostels management in a series of brainstorming sessions, 22 attributes as listed in Table 2 were finalized for the evaluation purpose.

4.2. Data Collection. The questionnaire designed for the data collection process was divided into two main sections: first section to let the respondents to specify their level of satisfaction on each attribute with respect to their own hostel and second section to let the respondents to indicate their

Table 2: List of hostel attributes.

Number	Attributes	Descriptions
1	Hostel's exterior	Attractive landscape and exterior design
2	Distance to university facilities	Distance to university facilities such as library, post office, book store, bank, mini market, and sports complex
3	Bus	Frequent and prompt bus service, hospitable driver
4	Room population	The room is not too crowded
5	Security system	Effectiveness of security guard and availability of CCTV surveillance
6	Safety	Availability and condition of fire extinguishers, smoke detectors, and handrails for stairs
7	Room size	Room is spacious
8	Fees	Fees per semester is reasonable, value for money
9	Cafeteria	Fresh, hygienic, variety of food with reasonable price, cleanliness of cafeteria and so forth
10	Maintenance service	The defect facilities and equipment in room are fixed promptly after the complaint is made/effectiveness of service
11	Cleaning service	The cleanliness level of toilets, corridors, exterior of building are well maintained
12	Physical condition of room	Ventilation, lighting, furniture, and painting
13	Wi-Fi accessibility	Good Wi-Fi connection, accessible everywhere within the hostel
14	Computer lab facility	Organized, computers are in good condition, availability of printing service and so forth
15	Study room facility	Quite, clean, encouraging environment to study and so forth
16	Accessibility to ATM	Easy to get to the nearest ATM
17	TV facility	Quality of TV, number of TVs available, availability of ASTRO channel packages
18	Laundry facility	Laundry room and washing machines in good condition, suitable and enough space to dry up laundry, and so forth
19	Sports facility	Variety of sports facilities within hostel, good condition of futsal/netball court/other sports facilities within hostel
20	Management	Satisfaction with principal, fellows, and administrative staff services
21	Washrooms and toilets	Well-equipped, privacy is secured, sufficient numbers of toilets, spacious and comfortable toilets
22	Students representative committee (SRC)	SRC really conscious about students' problems and needs, organizing valuable and interesting programs for students throughout the semester

general views on the importance of each hostel attribute for a student. Prior to conducting the actual survey, the questionnaire was pretested with a small group of students and based on their feedbacks, some alterations were made on the questionnaire; especially some puzzling terms were replaced with straightforward words. The actual data collection process was then conducted using the revised version of the questionnaire.

The respondents from each hostel were selected using a systematic random stratified sampling approach; the students living in each hostel were naturally clustered by block and gender. The respondents from each "cluster" or block were then selected by using a systematic random sampling approach where the students residing in every forth room in the block were chosen for the survey purpose after randomly selecting the first room at the first floor.

As a cautionary measure, during survey the actual purpose of the survey which was to evaluate the satisfaction towards 14 residential halls was kept confidential as they could offer biased judgment due to the sense of attachment factor. Therefore, the respondents were simply informed that the purpose of the survey was just to analyze and enhance the current condition of the particular hostel. Besides, prior to offering the questionnaire, a screening question was asked to the respondents to ensure they are really staying in the hostel and not there for visiting or other reasons. We assisted the respondents throughout the answering process and assured that the questionnaires were fulfilled completely. The survey was scheduled and conducted after 5 pm as most of the students would be free from classes or any other campus activities after this point of time. The survey took almost three weeks to be accomplished with the help of two male and female postgraduate students.

4.3. Decision Matrix (Hostels versus Attributes). By averaging the scores given by the students from each hostel with respect to each attribute, the decision matrix as shown in Table 3 was derived.

Table 3: Hostels versus attributes.

	Exterior	Distance	Bus	Population	Security	Safety	Size	Fees	Cafeteria	Maintenance	Cleaning
BR[1]	5.549	4.703	3.773	7.043	4.673	5.685	6.255	4.830	3.045	4.890	5.475
SME	5.415	4.575	4.620	7.230	5.303	6.255	6.923	5.340	5.497	6.098	5.445
SD[2]	5.573	5.865	4.763	6.570	4.110	5.618	5.610	4.822	3.000	4.560	4.350
EON	5.475	5.640	4.928	6.690	4.095	5.100	5.587	5.115	4.995	5.092	5.227
MT[3]	5.175	5.535	5.978	4.800	3.998	4.710	3.855	4.163	4.912	4.845	4.703
YAB	5.018	4.785	5.325	5.873	3.915	4.673	5.250	4.800	4.350	4.372	5.310
PR[4]	4.793	5.888	3.675	6.555	3.735	4.950	5.483	4.658	4.500	4.613	3.885
MAS	5.280	4.965	4.718	6.915	4.493	5.213	6.540	4.912	3.893	4.642	3.975
PS[5]	5.663	6.930	4.305	6.615	4.673	5.460	5.490	4.830	4.800	4.838	4.860
TNB	5.078	5.790	4.140	6.473	4.583	5.445	5.873	5.415	4.793	5.423	4.433
TS[6]	4.590	6.015	4.237	6.068	3.420	4.687	5.205	4.230	3.795	4.395	4.793
PJ[7]	5.258	5.940	5.670	7.297	3.818	5.933	5.955	5.108	6.262	5.213	5.820
MISC	5.565	4.935	5.385	6.923	3.427	4.860	5.820	5.055	5.047	4.815	5.325
TM	4.905	5.040	5.587	7.425	3.922	4.957	5.925	4.815	2.970	4.875	5.430

	Physical	Wi-Fi	Lab	Study room	ATM	TV	Laundry	Sports	Management	Washroom	SRC
BR[1]	5.783	3.112	5.775	4.838	6.180	4.020	3.915	5.303	5.243	5.175	4.192
SME	6.885	3.495	5.767	5.295	5.288	3.060	3.945	5.573	5.430	5.632	4.687
SD[2]	5.985	4.620	5.775	3.795	4.133	3.150	2.985	4.350	4.860	4.088	4.755
EON	5.902	5.670	5.947	4.448	4.763	3.975	4.455	5.295	5.722	4.785	5.258
MT[3]	4.845	3.720	5.835	3.930	6.120	3.975	4.343	4.890	4.898	4.912	4.703
YAB	5.452	4.410	4.343	4.433	5.168	3.368	4.597	5.168	5.344	4.950	5.520
PR[4]	6.233	4.695	5.722	4.673	4.230	3.848	4.613	4.095	4.275	3.195	3.713
MAS	5.677	5.685	6.248	4.358	3.015	2.310	4.065	3.825	4.725	4.035	4.313
PS[5]	6.098	5.640	6.675	4.822	6.518	5.565	5.670	5.182	5.085	5.198	5.205
TNB	5.925	5.063	5.745	4.650	4.035	2.685	3.495	3.870	4.710	3.900	4.335
TS[6]	5.992	4.770	5.317	4.845	5.213	5.280	4.845	4.905	5.130	4.875	4.763
PJ[7]	6.615	5.550	6.383	4.440	2.797	4.020	4.350	4.440	5.055	4.568	4.943
MISC	5.288	4.793	6.105	3.472	2.250	2.895	3.112	3.945	4.133	3.533	5.303
TM	6.503	5.632	6.622	4.620	2.880	3.713	4.425	4.057	4.620	4.530	5.280

[1]BR = Bank Rakyat, [2]SD = Sime Darby, [3]MT = Muamalat, [4]PR = Proton, [5]PS = Petronas, [6]TS = Tradewinds, and [7]PJ = Perwaja.

4.4. Conducting Factor Analysis. Before factor analyzing the large dataset on the importance of attributes obtained through the second section of the questionnaire, the suitability of the data for factor analysis was verified with the aid of SPSS software. The inspection on the correlation matrix revealed the presence of many coefficients of 0.3 and above. Besides, the Kaiser-Meyer-Olkin (KMO) value of the dataset exceeded the recommended value, 0.6, and Bartlett's Test of Sphericity reached statistical significance as the p value was less than 0.05. These three circumstances indicated that the dataset was suitable for factor analysis.

By performing factor analysis, the large set of hostel attributes was clustered into five independent factors. However, it has to be emphasized that the attributes within each extracted factor are still interacted to each other. The result of factor analysis for this study can be further detailed as follows (refer to Table 4). Extraction through principal component analysis revealed the presence of five common factors with eigenvalues exceeding one, explaining 30.014%, 8.487%, 5.667%, 5.522%, and 5.291% of the variance, respectively. The total variance explained reached 54.982%. To aid in the interpretation of these five common factors, varimax rotation was performed.

Five attributes, "cleaning," "washrooms," "maintenance," "management," and "SRC," which had higher loading at factor 1, were renamed as service factor (f_1). Meanwhile, "TV," "laundry," "ATM," "sports," and "study room" which showed higher loading at factor 2 were relabeled as "facility" factor (f_2). "Population," "size," "physical," "lab," and "Wi-Fi" which were clustered into factor 3 were identified as convenience factor (f_3) and "bus," "distance," "cafeteria," "exterior," and "fees" were classified as value for money factor (f_4). Finally, "security" and "safety" which had higher loading at factor 5 were renamed as precaution factor (f_5).

4.5. Hierarchical Evaluation System for Analyzing UUM Hostels. Table 5 is hierarchical structure constructed based on the result of factor analysis used to systematically evaluate

Table 4: Result of factor analysis.

Total variance explained				Rotated component matrix					
Component	Initial eigenvalues			Attributes	Component				
	Total	% of variance	Cumulative %		1	2	3	4	5
1	6.603	30.014	30.014	Cleaning (c_{11})	.749				
2	1.867	8.487	38.501	Washroom (c_{21})	.717	.379			
3	1.247	5.667	44.169	Maintenance (c_{10})	.612				
4	1.215	5.522	49.691	Management (c_{20})	.602	.341			
5	1.164	5.291	54.982	SRC (c_{22})	.527				
6	.929	4.222	59.204	TV (c_{17})		.786			
7	.871	3.961	63.166	Laundry (c_{18})		.723			
8	.777	3.530	66.696	ATM (c_{16})		.665			
9	.768	3.489	70.184	Sports (c_{19})		.638			
10	.710	3.225	73.410	Study room (c_{15})		.435			.346
11	.649	2.949	76.359	Population (c_4)			.673		
12	.594	2.701	79.060	Size (c_7)			.647		.412
13	.582	2.644	81.704	Physical (c_{12})	.409		.583		
14	.570	2.591	84.295	Lab (c_{14})			.561	.412	
15	.515	2.339	86.635	Wi-Fi (c_{13})			.547	.427	
16	.490	2.229	88.864	Bus (c_3)	.307			.650	
17	.476	2.163	91.027	Distance (c_2)		.329		.649	
18	.458	2.082	93.109	Cafeteria (c_9)	.449			.453	
19	.427	1.941	95.050	Exterior (c_1)				.453	.448
20	.391	1.779	96.829	Fees (c_8)			.355	.391	
21	.375	1.705	98.535	Security (c_5)					.756
22	.322	1.465	100.000	Safety (c_6)					.684

the students' satisfaction towards the 14 hostels. It has to be emphasized that Table 5 exemplifies that the attributes within each factor are interacted to each other whereas the factors are playing independent roles in determining the students' overall satisfaction.

4.6. Identification of λ-Measure Weights. Based on the judgements from the experts, the 11-point scale, as shown in Table 6, was chosen to aid the process of identifying the individual weights of attributes. The Identification of aggregated or final individual weights of the attributes within each factor based on the judgements from the five experts is summarized in Table 7.

With the available individual weights, (2) and (3) were then used in order to obtain the interaction parameter, λ, and monotone measure weights of each factor as presented in Table 8.

Through the proposed model, by extracting the attributes into fewer independent factors, the actual number of monotone measure weights which need to be identified prior to applying Choquet integral was reduced from 4194304 (2^{13}) weights to 132 ($2^5 + 2^5 + 2^5 + 2^5 + 2^2$) weights. In general, the proposed model reduces the required number of monotone measure weights from 2^n to $\sum_{p=1}^{q} 2^{|f_p|}$ where $f_p = (f_1, f_1, \ldots, f_q)$ is the set of extracted factors, q denotes the total number of factors, and $|f_p|$ represents the number of attributes within factor, p.

4.7. Aggregation Using Choquet Integral. By aggregating the interactive scores within each factor using the identified monotone measure and Choquet integral model (3), a new decision matrix (14 hostels versus 5 factors) as shown in Table 10 was attained.

4.8. Identifying the Weights of Independent Hostel Factors. After achieving consensus through Delphi method, the five experts have linguistically expressed their judgments on the relative importance of the hostel factors through a single pairwise matrix based. The linguistic pairwise matrix was then converted into fuzzy pairwise matrix as shown in Table 9 based on fuzzy AHP scale (refer to Table 1). It can be noticed that since the "value for money" was found to be less important than "precaution" factor, the evaluation was done vice versa to avoid using reciprocal values.

Based on the fuzzy pairwise comparison, the suggested nonlinear optimization model (5) was constructed and solved with the aid of EXCEL Solver. Following result was obtained: weight of service factor, $w_1 = 0.374$; weight of facility factor, $w_2 = 0.309$; weight of convenience factor, $w_3 = 0.147$; weight of value for money factor, $w_4 = 0.065$; weight of

Table 5: Hierarchical system for evaluating students' satisfaction towards UUM hostels.

Goal	Evaluating performance of hostels based on students' satisfaction																					
Factors	Service					Convenience					Precaution			Facility				Value for money				
Attributes	c_{11}	c_{21}	c_{10}	c_{20}	c_{22}	c_4	c_7	c_{12}	c_{14}	c_{13}	c_5	c_6	c_{17}	c_{18}	c_{16}	c_{19}	c_{15}	c_3	c_2	c_9	c_1	c_8
Bank Rakyat	5.475	5.175	4.890	5.243	4.192	7.043	6.255	5.783	5.775	3.112	4.673	5.685	4.020	3.915	6.180	5.303	4.838	3.773	4.703	3.045	5.549	4.830
SME	5.445	5.632	6.098	5.430	4.687	7.230	6.923	6.885	5.767	3.495	5.303	6.255	3.060	3.945	5.288	5.573	5.295	4.620	4.575	5.497	5.415	5.340
Sime Darby	4.350	4.088	4.560	4.860	4.755	6.570	5.610	5.985	5.775	4.620	4.110	5.618	3.150	2.985	4.133	4.350	3.795	4.763	5.865	3.000	5.573	4.822
EON	5.227	4.785	5.092	5.722	5.258	6.690	5.587	5.902	5.947	5.670	4.095	5.100	3.975	4.455	4.763	5.295	4.448	4.928	5.640	4.995	5.475	5.115
Muamalat	4.703	4.912	4.845	4.898	4.703	4.800	3.855	4.845	5.835	3.720	3.998	4.710	3.975	4.343	6.120	4.890	3.930	5.978	5.535	4.912	5.175	4.163
YAB	5.310	4.950	4.372	5.344	5.520	5.873	5.250	5.452	4.343	4.410	3.915	4.673	3.368	4.597	5.168	5.168	4.433	5.325	4.785	4.350	5.018	4.800
Proton	3.885	3.195	4.613	4.275	3.713	6.555	5.483	6.233	5.722	4.695	3.735	4.950	3.848	4.613	4.230	4.095	4.673	3.675	5.888	4.500	4.793	4.658
MAS	3.975	4.035	4.642	4.725	4.313	6.915	6.540	5.677	6.248	5.685	4.493	5.213	2.310	4.065	3.015	3.825	4.358	4.718	4.965	3.893	5.280	4.912
Petronas	4.860	5.198	4.838	5.085	5.205	6.615	5.490	6.098	6.675	5.640	4.673	5.460	5.565	5.670	6.518	5.182	4.822	4.305	6.930	4.800	5.663	4.830
TNB	4.433	3.900	5.423	4.710	4.335	6.473	5.873	5.925	5.745	5.063	4.583	5.445	2.685	3.495	4.035	3.870	4.650	4.140	5.790	4.793	5.078	5.415
Tradewinds	4.793	4.875	4.395	5.130	4.763	6.068	5.205	5.992	5.317	4.770	3.420	4.687	5.280	4.845	5.213	4.905	4.845	4.237	6.015	3.795	4.590	4.230
Perwaja	5.820	4.568	5.213	5.055	4.943	7.297	5.955	6.615	6.383	5.550	3.818	5.933	4.020	4.350	2.797	4.440	4.440	5.670	5.940	6.262	5.258	5.108
MISC	5.325	3.533	4.815	4.133	5.303	6.923	5.820	5.288	6.105	4.793	3.427	4.860	2.895	3.112	2.250	3.945	3.472	5.385	4.935	5.047	5.565	5.055
TM	5.430	4.530	4.875	4.620	5.280	7.425	5.925	6.503	6.622	5.632	3.922	4.957	3.713	4.425	2.880	4.057	4.620	5.587	5.040	2.970	4.905	4.815

Table 6: 11-point linguistic scale for expressing individual importance of attributes.

Linguistic terms	Fuzzy numbers	Corresponding crisp values identified via fuzzy scoring approach
Exceptionally low (EL)	(0, 0, 0.1)	0.045
Extremely low (ExL)	(0, 0.1, 0.2)	0.135
Very low (VL)	(0, 0.1, 0.3, 0.5)	0.255
Low (L)	(0.1, 0.3, 0.5)	0.335
Below average (BA)	(0.3, 0.4, 0.5)	0.410
Average (A)	(0.3, 0.5, 0.7)	0.5
Above average (AA)	(0.5, 0.6, 0.7)	0.590
High (H)	(0.5, 0.7, 0.9)	0.665
Very high (VH)	(0.5, 0.7, 0.9, 1)	0.745
Extremely high (ExH)	(0.8, 0.9, 1)	0.865
Exceptionally high (EH)	(0.9, 1, 1)	0.955

precaution factor, $w_5 = 0.106$; consistency index, $\mu = 0.634$. The value of μ implied that the pairwise comparison matrix was consistent.

4.9. Aggregation Using SWA Operator. The identified weights of factors and available factor scores were precisely replaced into SWA model (6) to compute the overall satisfaction score of each hostel. The satisfaction score of each hostel and their ranking are summarized in Table 10.

4.10. Proposed Hybrid MADM Model versus Classical SWA Operator. In this section, the same hostel satisfaction problem was evaluated using a classical, additive aggregation operator or to be precise, by only employing the common SWA operator and the obtained result was compared with the result generated by the proposed model. The motive of choosing classical SWA was to mainly demonstrate the implication of discounting the interactions between attributes in hostel satisfaction analysis.

As SWA assumes independency between attributes, it is crucial to assure the sum of weights of the 22 attributes is being additive (or equal to one). To derive the weights for SWA, firstly, the nonadditive individual weights of attributes within each factor (refer to Table 7) were normalized to ensure the sum of the weights is equal to one. These normalized weights were just represented the contribution of attributes towards their respective factor. Hence, the final additive weight of each attribute (contribution of attributes towards overall satisfaction) was then computed by multiplying an attribute's normalized weight with the weight of its respective factor. Note that the weights of factors do not demand any normalization as they were already in the additive state. Table 11 recapitulates the process involved in determining the required additive weights of attributes for applying SWA operator.

The identified additive weights and the performance scores as presented in Table 3 were then swapped into SWA model (6) to compute the overall satisfaction score of each hostel. Table 12 shows the disparities on the overall satisfaction scores and ranking of the hostels resulting from the proposed model and conventional SWA.

It can be concluded that there was a significant variation between the result generated through the proposed model and classical SWA as the latter model ignores the usual interactions that exist between hostel attributes. Besides, the additive weights used for SWA failed to express the interactions shared by the attributes and thus could lead to the implementation of inefficient satisfaction enhancement strategies.

4.11. Discussion on the Result. Through the proposed model, with the help of factor analysis, it was discovered that the actual determinants of the students' satisfaction towards the hostels are service, facility, convenience, value for money, and precaution aspects. However, it was understood that the prioritization on these determinants is as follows: service (0.374) ≻ facility (0.309) ≻ convenience (0.147) ≻ precaution (0.106) ≻ value for money (0.065) where ≻ means "is preferred or superior to." Therefore, in order to enhance the students' satisfaction, a hostel can simply focus on the four crucial aspects; service, facility, convenience, and precaution aspects which are independent of each other.

The interaction parameter, $\lambda = -0.956$, indicates that in order to improve a hostel's performance in term of service, it is enough to simultaneously enhance some of the attributes which have higher individual weights; management and maintenance. In other words, by only enhancing management and maintenance attributes, a significant improvement in the aspect of service can be achieved. The experts involved in the analysis accepted this fact by stating that a good management and maintenance team can ensure the other attributes within the factor are being at the satisfactory level. According to them, a good management team often monitors the cleanliness level of the hostel and motivates the students' representative committee (SRC) to frequently organize fruitful activities for the students. Besides, a caring management and effective maintenance team timely ensure the washrooms and toilets are being in good condition.

Meanwhile, $\lambda = 0.035$ implies that in order to improve a hostel's performance with respect to facility factor, all the attributes within the factor need to be enhanced simultaneously regardless of their individual weights; TV, laundry, ATM, sports amenities, and study room. The similar strategy applies for improving the precaution level of a hostel as it has a positive interaction parameter ($\lambda = 0.140$).

The value, $\lambda = -0.943$, shows that in order to attain drastic improvement in convenience aspect, it is sufficient to simultaneously enhance some of the attributes which have higher individual weights; physical condition of the room and Wi-Fi accessibility. According to the experts, a good furniture arrangement, ventilation, paint colours, and lighting have the capability to form spacious and comforting in-room environment even if the room is small (refers to "room size" attribute) or crowded (refers to "room population" attribute). Besides, in current trend of education which largely relies on internet facility, a fine Wi-Fi accessibility would enable

Table 7: Identification of individual weights of attributes within each factor.

Factors	Criteria	Degree of Importance (in linguistic terms)					Importance (in crisp values after defuzzyfying fuzzy numbers)					Aggregated individual weights
		E_1	E_2	E_3	E_4	E_5	E_1	E_2	E_3	E_4	E_5	
Service	Cleaning	VH	AA	A	BA	A	0.745	0.59	0.5	0.41	0.5	0.549
	Washroom	BA	A	VL	A	ExL	0.41	0.5	0.255	0.5	0.135	0.360
	Maintenance	H	A	H	A	H	0.665	0.5	0.665	0.5	0.665	0.599
	Management	H	EH	ExH	A	L	0.665	0.955	0.865	0.5	0.335	0.664
	SRC	ExL	EL	ExL	ExL	EL	0.135	0.045	0.135	0.135	0.045	0.099
Facility	TV	EL	VL	EL	ExL	ExL	0.045	0.255	0.045	0.135	0.135	0.123
	Laundry	VL	VL	VL	ExL	VL	0.255	0.255	0.255	0.135	0.255	0.231
	ATM	ExL	VL	EL	ExL	ExL	0.135	0.255	0.045	0.135	0.135	0.141
	Sports	VL	BA	VL	L	A	0.255	0.41	0.255	0.335	0.5	0.351
	Study room	ExL	ExL	VL	EL	ExL	0.135	0.135	0.255	0.045	0.135	0.141
Convenience	Population	ExL	L	A	L	ExL	0.135	0.335	0.5	0.335	0.135	0.288
	Size	A	BA	BA	A	H	0.5	0.41	0.41	0.5	0.665	0.497
	Physical	VH	H	A	AA	BA	0.745	0.665	0.5	0.59	0.41	0.582
	Lab	ExL	L	VL	L	VL	0.135	0.335	0.255	0.335	0.255	0.263
	Wi-Fi	H	A	A	H	H	0.665	0.5	0.5	0.665	0.665	0.599
Value for money	Bus	ExH	A	AA	BA	A	0.865	0.5	0.59	0.41	0.5	0.573
	Distance	BA	BA	L	L	A	0.41	0.41	0.335	0.335	0.5	0.398
	Cafeteria	H	A	A	AA	A	0.665	0.5	0.5	0.59	0.5	0.551
	Exterior	L	ExL	AA	AA	BA	0.335	0.255	0.59	0.59	0.41	0.436
	Fees	H	A	VH	H	AA	0.665	0.5	0.745	0.665	0.59	0.633
Precaution	Security	H	H	AA	A	AA	0.665	0.665	0.59	0.5	0.59	0.602
	Safety	A	BA	L	L	VL	0.5	0.41	0.335	0.335	0.255	0.367

the students to access the required information from any corners of the hostel and reduces the students' dependency on computer lab and also ensures them not to concern too much about the quality of the lab service.

According to the proposed model, the ranking of the residential halls based on global satisfaction score is as follows: SME ≻ Petronas ≻ Bank Rakyat ≻ EON ≻ Perwaja ≻ YAB ≻ Tradewinds ≻ TM ≻ TNB ≻ Muamalat ≻ Sime Darby ≻ Proton ≻ MAS ≻ MISC.

SME, Petronas, Bank Rakyat, EON, and Perwaja ruled the top five positions as they had satisfactory scores on service, facility, and convenience aspects which are the main determinants of students' satisfaction towards a hostel. Petronas has the potential to be in the top in the future if the hostel's administration put major effort on improving its service level by simultaneously enhancing the management and maintenance efficiency while retaining its performance in both facility and convenience aspects. Perwaja also has the opportunity to be in the lead if the administration simultaneously improves all the attributes within facility factor (TV, laundry, ATM, sports, and study room), regardless of their individual weights as they shared superadditive effect.

Tradewinds which obtained the lowest precaution score certainly can be in top 5 positions in future if the hostel tightens its security system and adds more safety equipment or features while maintaining its performance on service, facility, and convenience aspects.

Muamalat, Sime Darby, Proton, MAS, and MISC which are being at the bottom five positions attained poor scores mainly on service and facility aspects; thus, appropriate strategies should be planned to achieve perfection in these two aspects. They need to assure the management and maintenance doing their job effectively in fulfilling the students' needs. Besides, they should offer better TV, laundry, ATM, sports, and study room facilities to their students. However, it was discovered that MISC needs to take an extra effort where it should also focus on stepping up the precaution measures which can be achieved by simultaneously enhancing the existing security system and safety features.

The same evaluation is also carried out by only using the additive SWA operator and a different set of scores and ranking was obtained. This shows that neglecting interactions between hostel attributes could offer flawed information which consequently leads to wrong decisions. Therefore,

Table 8: λ-measure weights for each factor.

Service ($\lambda = -0.956$)		Facility ($\lambda = 0.035$)		Convenience ($\lambda = -0.943$)		Value for money ($\lambda = -0.972$)	
Subsets	Weights	Subsets	Weights	Subsets	Weights	Subsets	Weights
$\{\}$	0.000	$\{\}$	0.000	$\{\}$	0.000	$\{\}$	0.000
$\{c_{11}\}$	0.549	$\{c_{17}\}$	0.123	$\{c_4\}$	0.288	$\{c_3\}$	0.573
$\{c_{21}\}$	0.360	$\{c_{18}\}$	0.231	$\{c_7\}$	0.497	$\{c_2\}$	0.398
$\{c_{11}, c_{21}\}$	0.720	$\{c_{17}, c_{18}\}$	0.355	$\{c_4, c_7\}$	0.650	$\{c_3, c_2\}$	0.749
$\{c_{10}\}$	0.599	$\{c_{16}\}$	0.141	$\{c_{12}\}$	0.582	$\{c_9\}$	0.551
$\{c_{11}, c_{10}\}$	0.834	$\{c_{17}, c_{16}\}$	0.265	$\{c_4, c_{12}\}$	0.712	$\{c_3, c_9\}$	0.817
$\{c_{21}, c_{10}\}$	0.753	$\{c_{18}, c_{16}\}$	0.373	$\{c_7, c_{12}\}$	0.806	$\{c_2, c_9\}$	0.736
$\{c_{11}, c_{21}, c_{10}\}$	0.907	$\{c_{17}, c_{18}, c_{16}\}$	0.498	$\{c_4, c_7, c_{12}\}$	0.875	$\{c_3, c_2, c_9\}$	0.899
$\{c_{20}\}$	0.664	$\{c_{19}\}$	0.351	$\{c_{14}\}$	0.263	$\{c_1\}$	0.436
$\{c_{11}, c_{20}\}$	0.865	$\{c_{17}, c_{19}\}$	0.476	$\{c_4, c_{14}\}$	0.480	$\{c_3, c_1\}$	0.766
$\{c_{21}, c_{20}\}$	0.795	$\{c_{18}, c_{19}\}$	0.585	$\{c_7, c_{14}\}$	0.637	$\{c_2, c_1\}$	0.665
$\{c_{11}, c_{21}, c_{20}\}$	0.927	$\{c_{17}, c_{18}, c_{19}\}$	0.710	$\{c_4, c_7, c_{14}\}$	0.752	$\{c_3, c_2, c_1\}$	0.868
$\{c_{10}, c_{20}\}$	0.883	$\{c_{16}, c_{19}\}$	0.494	$\{c_{12}, c_{14}\}$	0.701	$\{c_9, c_1\}$	0.753
$\{c_{11}, c_{10}, c_{20}\}$	0.968	$\{c_{17}, c_{16}, c_{19}\}$	0.619	$\{c_4, c_{12}, c_{14}\}$	0.798	$\{c_3, c_9, c_1\}$	0.907
$\{c_{21}, c_{10}, c_{20}\}$	0.939	$\{c_{18}, c_{16}, c_{19}\}$	0.729	$\{c_7, c_{12}, c_{14}\}$	0.869	$\{c_2, c_9, c_1\}$	0.860
$\{c_{11}, c_{21}, c_{10}, c_{20}\}$	0.995	$\{c_{17}, c_{18}, c_{16}, c_{19}\}$	0.855	$\{c_4, c_7, c_{12}, c_{14}\}$	0.921	$\{c_3, c_2, c_9, c_1\}$	0.954
$\{c_{22}\}$	0.099	$\{c_{15}\}$	0.141	$\{c_{13}\}$	0.599	$\{c_8\}$	0.633
$\{c_{11}, c_{22}\}$	0.596	$\{c_{17}, c_{15}\}$	0.265	$\{c_4, c_{13}\}$	0.724	$\{c_3, c_8\}$	0.853
$\{c_{21}, c_{22}\}$	0.425	$\{c_{18}, c_{15}\}$	0.373	$\{c_7, c_{13}\}$	0.815	$\{c_2, c_8\}$	0.786
$\{c_{11}, c_{21}, c_{22}\}$	0.751	$\{c_{17}, c_{18}, c_{15}\}$	0.498	$\{c_4, c_7, c_{13}\}$	0.882	$\{c_3, c_2, c_8\}$	0.921
$\{c_{10}, c_{22}\}$	0.641	$\{c_{16}, c_{15}\}$	0.283	$\{c_{12}, c_{13}\}$	0.852	$\{c_9, c_8\}$	0.845
$\{c_{11}, c_{10}, c_{22}\}$	0.854	$\{c_{17}, c_{16}, c_{15}\}$	0.407	$\{c_4, c_{12}, c_{13}\}$	0.909	$\{c_3, c_9, c_8\}$	0.947
$\{c_{21}, c_{10}, c_{22}\}$	0.781	$\{c_{18}, c_{16}, c_{15}\}$	0.516	$\{c_7, c_{12}, c_{13}\}$	0.950	$\{c_2, c_9, c_8\}$	0.916
$\{c_{11}, c_{21}, c_{10}, c_{22}\}$	0.920	$\{c_{17}, c_{18}, c_{16}, c_{15}\}$	0.641	$\{c_4, c_7, c_{12}, c_{13}\}$	0.980	$\{c_3, c_2, c_9, c_8\}$	0.979
$\{c_{20}, c_{22}\}$	0.762	$\{c_{19}, c_{15}\}$	0.494	$\{c_{14}, c_{13}\}$	0.713	$\{c_1, c_8\}$	0.801
$\{c_{11}, c_{20}, c_{22}\}$	0.882	$\{c_{17}, c_{19}, c_{15}\}$	0.619	$\{c_4, c_{14}, c_{13}\}$	0.808	$\{c_3, c_1, c_8\}$	0.928
$\{c_{21}, c_{20}, c_{22}\}$	0.819	$\{c_{18}, c_{19}, c_{15}\}$	0.729	$\{c_7, c_{14}, c_{13}\}$	0.876	$\{c_2, c_1, c_8\}$	0.889
$\{c_{11}, c_{21}, c_{20}, c_{22}\}$	0.938	$\{c_{17}, c_{18}, c_{19}, c_{15}\}$	0.855	$\{c_4, c_7, c_{14}, c_{13}\}$	0.926	$\{c_3, c_2, c_1, c_8\}$	0.967
$\{c_{10}, c_{20}, c_{22}\}$	0.898	$\{c_{16}, c_{19}, c_{15}\}$	0.637	$\{c_{12}, c_{14}, c_{13}\}$	0.904	$\{c_9, c_1, c_8\}$	0.923
$\{c_{11}, c_{10}, c_{20}, c_{22}\}$	0.976	$\{c_{17}, c_{16}, c_{19}, c_{15}\}$	0.763	$\{c_4, c_{12}, c_{14}, c_{13}\}$	0.946	$\{c_3, c_9, c_1, c_8\}$	0.982
$\{c_{21}, c_{10}, c_{20}, c_{22}\}$	0.949	$\{c_{18}, c_{16}, c_{19}, c_{15}\}$	0.873	$\{c_7, c_{12}, c_{14}, c_{13}\}$	0.977	$\{c_2, c_9, c_1, c_8\}$	0.964
$\{c_{11}, c_{21}, c_{10}, c_{20}, c_{22}\}$	1.000	$\{c_{17}, c_{18}, c_{16}, c_{19}, c_{15}\}$	1.000	$\{c_4, c_7, c_{12}, c_{14}, c_{13}\}$	1.000	$\{c_3, c_2, c_9, c_1, c_8\}$	1.000
Safety ($\lambda = 0.140$)							
Subsets	Weights						
$\{\}$	0.000						
$\{c_5\}$	0.602						
$\{c_6\}$	0.367						
$\{c_5, c_6\}$	1.000						

Table 9: Fuzzy pairwise comparison matrix between hostel factors.

	Service	Facility	Convenience	Value for money	Precaution
Service	(1, 1, 1)	(1, 2, 3)	(2, 3, 4)	(4, 5, 6)	(3, 4, 5)
Facility	—	(1, 1, 1)	(1, 2, 3)	(3, 4, 5)	(2, 3, 4)
Convenience	—	—	(1, 1, 1)	(2, 3, 4)	(1, 2, 3)
Value for money	—	—	—	(1, 1, 1)	—
Precaution	—	—	—	(1, 2, 3)	(1, 1, 1)

Table 10: Overall satisfaction score of each hostel and their ranking.

Factors/hostels	Service (w_1 = 0.374)	Facility (w_2 = 0.309)	Convenience (w_3 = 0.147)	Value for money (w_4 = 0.065)	Precaution (w_5 = 0.106)	Final scores	Ranking
Bank Rakyat	5.337	4.870	6.105	4.991	5.044	5.257	3
SME	5.860	4.789	6.679	5.385	5.652	5.602	1
Sime Darby	4.751	3.765	5.981	5.373	4.663	4.663	11
EON	5.536	4.732	6.086	5.404	4.464	5.252	4
Muamalat	4.883	4.680	4.890	5.629	4.259	4.809	10
YAB	5.275	4.699	5.409	5.127	4.193	4.998	6
Proton	4.414	4.285	6.068	5.136	4.181	4.644	12
MAS	4.627	3.647	6.406	5.036	4.757	4.631	13
Petronas	5.091	5.479	6.261	5.867	4.962	5.425	2
TNB	5.091	3.764	5.998	5.437	4.899	4.822	9
Tradewinds	5.002	4.972	5.763	5.024	3.885	4.993	7
Perwaja	5.508	4.128	6.626	5.998	4.594	5.186	5
MISC	5.004	3.304	6.021	5.384	3.953	4.546	14
TM	5.159	4.008	6.651	5.247	4.302	4.943	8

Table 11: Identification of additive weights of attributes for SWA operator.

Factors	Attributes	Individual weights	Normalized weights	Final weights
Service (0.374)	Cleaning	0.549	0.242	0.090
	Washroom	0.360	0.159	0.059
	Maintenance	0.599	0.264	0.099
	Management	0.664	0.292	0.109
	SRC	0.099	0.044	0.016
	SUM	**2.271**	**1.000**	
Facility (0.309)	TV	0.123	0.125	0.039
	Laundry	0.231	0.234	0.072
	ATM	0.141	0.143	0.044
	Sports	0.351	0.356	0.110
	Study room	0.141	0.143	0.044
	SUM	**0.987**	**1.000**	
Convenience (0.147)	Population	0.288	0.129	0.019
	Size	0.497	0.223	0.033
	Physical	0.582	0.261	0.038
	Lab	0.263	0.118	0.017
	Wi-Fi	0.599	0.269	0.039
	SUM	**2.229**	**1.000**	
Value for money (0.065)	Bus	0.573	0.221	0.014
	Distance	0.398	0.154	0.010
	Cafeteria	0.551	0.213	0.014
	Exterior	0.436	0.168	0.011
	Fees	0.633	0.244	0.016
	SUM	**2.591**	**1.000**	
Precaution (0.106)	Security	0.602	0.621	0.066
	Safety	0.367	0.379	0.040
	SUM	**0.969**	**1.000**	
SUM				**1.000**

Table 12: Proposed model versus classical SWA operator.

Hostels	Proposed model		Classical SWA	
	Overall scores	Ranking	Overall scores	Ranking
Bank Rakyat	5.257	3	5.024	4
SME	5.602	1	5.369	1
Sime Darby	4.663	11	4.473	11
EON	5.252	4	5.098	3
Muamalat	4.809	10	4.680	9
YAB	4.998	6	4.825	6
Proton	4.644	12	4.412	13
MAS	4.631	13	4.470	12
Petronas	5.425	2	5.290	2
TNB	4.822	9	4.595	10
Tradewinds	4.993	7	4.821	7
Perwaja	5.186	5	4.983	5
MISC	4.546	14	4.296	14
TM	4.943	8	4.741	8

the proposed model is recommended in order to identify more practical ranking and to develop the optimal strategies for enhancing students' satisfaction towards each hostel as the hostel attributes are normally interacted to each other.

5. Conclusion and Recommendation

This paper has finally introduced a new hybrid MADM model which considers the interactions between hostel attributes while evaluating the students' satisfaction towards a set of hostels. The execution of the model can be simplified into following steps: identifying hostel evaluation attributes, data collection using simple random stratified sampling approach, constructing the performance matrix by averaging data on satisfaction, factor analyzing the data on importance of attributes to reduce the attributes into independent factors, exemplifying the evaluation problem via simpler hierarchical system diagram, identifying the interaction parameter and monotone measure within each factor, aggregating the interactive scores within each factor using Choquet integral, assigning weights on each independent factors using MFAHP, and finally the overall satisfaction score of each hostel is by aggregating the independent factor scores using SWA operator.

Apart from dealing with the interactions between attributes, the model is able to discover the main determinants of hostel satisfaction together with their weights and also reduces the actual number of λ-measure weights which need to be determined prior to using Choquet integral from 2^n to $\sum_{p=1}^{q} 2^{|f_p|}$ where n represents the number of attributes, $f_p = (f_1, f_1, \ldots, f_q)$ represents the set of extracted factors, q is the total number of factors, and $|f_p|$ denotes the number of attributes within factor, p.

The feasibility of the model was verified by carrying out a real evaluation problem involving fourteen UUM hostels where some potential strategies for enhancing the students' satisfaction towards certain hostels were proposed. The same hostel evaluation problem was assessed by only using the additive SWA operator which simply assumes independency between attributes and a different set of satisfaction scores and ranking of hostels were obtained. Therefore, it is advisable to use the proposed model for analyzing hostel satisfaction problem in order to identify more practical hostel rankings and to develop strategies with better efficiency for enhancing the students' satisfaction towards each hostel as in reality most of the hostels attributes hold interactive characteristics.

In future, besides analyzing students' satisfaction towards hostels, the proposed model can be also applied in other domains where the ranking of alternatives and the enhancement strategies need to be identified by considering multiple interactive attributes. However, the sampling approach may vary based on the objective of the evaluation problem or target population.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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