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Research Article

A Hybrid Multiple Criteria Decision Making Model for Selecting the Location of Women's Fitness Centers

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Location selection is a critical problem for businesses that can determine the success of an organization. Selecting the optimal location from a pool of alternatives belongs to a multiple criteria decision making (MCDM) problem. This study employed a hybrid MCDM technique to select locations for women's fitness centers in Taiwan. In the beginning, the fuzzy Delphi method was utilized to obtain selection criteria from interviewed senior executives. In the second stage, the decision making trial and evaluation laboratory (DEMATEL) was employed to extract interdependencies between the selection criteria within each perspective. On the basis of interdependencies between the selection criteria, the analytic network process (ANP) was used to get respective weights of each criterion. Finally, the technique for order preference by similarity to ideal solution (TOPSIS) was ranking the alternatives. To demonstrate application of the proposed model and illustrate a location selection problem, a case was conducted. The capabilities and effectiveness of the proposed model are revealed.

1. Introduction

Location selection is a vital issue in service industries. The quality of location decisions could be improved by a comprehensive location selection model, thereby attracting consumers and positively influencing market share and profitability [1]. The sports industry has been growing in Taiwan, and many organizations now provide sports facilities. In 2015, the government of Taiwan proposed a series of policies to promote female sports participation [2]. Female sports awareness and demand have risen, and female consumers have become a notable potential market. Female consumers are a particularly vital target for sports and fitness centers [3].

Past studies related to location selection problem by using MCDM approaches suffer from several limitations, including (1) not clearly describing how to screen the criteria, (2) not considering the interdependencies among perspectives or criteria in the hierarchy, (3) not applying any quantitative methods to specifically identify the interdependent relations between perspectives or criteria, and (4) not enhancing an optimal solution in a shorter time. To overcome the drawbacks of past studies, this research developed a new hybrid MCDM model including the fuzzy Delphi method, DEMATEL, ANP, and TOPSIS in order to support location selection decisions for women's fitness centers in Taiwan.

A suitable process can help decision makers reduce poor decisions. The fuzzy Delphi method can generate favorable selection criteria [4, 5] and more objective selection criteria can be screened through the fuzzy Delphi method. In this study, we first used the fuzzy Delphi method, which gathers expert opinions, to investigate constructive means of modifying selection criteria. When making decisions, it is important to properly address whether the criteria are dependent on or independent of each other. Many researchers have applied DEMATEL to solve complicated system problems. DEMATEL can make better decisions because it can confirm interdependencies between criteria and help develop a map reflecting their relative relationships [6]. ANP, an extension of the analytic hierarchy process (AHP), is a comprehensive decision making approach that is appropriate to use for both

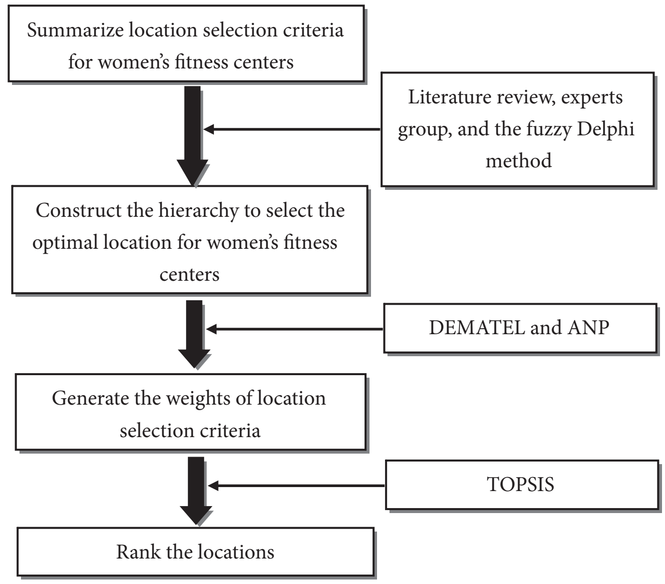

Figure 1: Steps of the proposed selection model.

quantitative and qualitative data and can also overcome the interdependent problems [7]. Several conventional MCDM methods are based on the independence assumption, but ANP accounts for the dependence assumption between criteria, and it is more adapted to applications [8].

Horng et al. [9] concluded that combining DEMATEL and ANP creates a helpful tool. Pai [10] identified the advantages of DEMATEL and ANP. DEMATEL is a useful approach for analyzing cause-effect relationships between criteria. However, DEMATEL cannot generate the weights of criteria. By contrast, ANP can provide criteria priorities. Büyüközkan and Güleryüz [11] described how DEMATEL can be utilized to determine the dependencies of criteria. Integrating ANP and DEMATEL yields successful results in strategic decision making. However, ANP takes more time. This is because interdependent relationships between criteria may increase the number of pairwise comparisons [11]. On the basis of relevant research, we utilized DEMATEL in this study to identify the interdependencies between the criteria within each perspective. According to the interdependencies between the selection criteria, ANP was then applied to get the weights of each. Bongo and Ocampo [12] pointed out that TOPSIS, which ranks alternatives based on both positive and negative ideal solutions, was an appropriate ranking method. Nie et al. [13] also concluded that TOPSIS give a reasonable alternative ranking. Abdel-Basset et al. [14] pointed that ANP needs many pairwise comparison matrices on the basis of the interdependence of the selection criteria. To overcome this drawback, TOPSIS was for ranking alternatives. The selection procedure is shown in Figure 1.

Combining the fuzzy Delphi method, DEMATEL, ANP, and TOPSIS, this study sought to achieve better location selection decisions in a shorter time; this distinguishes this study from others in the literature. The rest of this study is organized as follows. The literature is briefly reviewed. Next, the use of the fuzzy Delphi method, DEMATEL, ANP, and TOPSIS is proposed. Section 7 presents the integrated method for selecting the optimal location. Section 8 concludes the paper.

2. MCDM for Location Selection

Several literature review studies have been presented to examine the location selection problem. Chang et al. [15] applied the fuzzy Delphi method, ANP, and TOPSIS to help managers to select the locations for Taiwanese service apartments. Chen and Tsai [1] proposed a data mining framework using the rough set theory (RST) to support location selection decisions. Aksoy and Yetkin Ozbuk [16] employed the preference selection index (PSI) to rank hotels by location. Chen et al. [17] used the preference ranking organization method for enrichment evaluations (PROMETHEE) based on the cloud model and AHP to select location for a large charging power station. Komchornrit [18] used the confirmatory factor analysis (CFA), the measuring attractiveness by a categorical based evaluation technique (MACBETH), and PROMETHEE to select a dry port location. Lee et al. [19] integrated the interpretive structural modeling (ISM), fuzzy ANP, and the vlsekriterijumska optimizacija i kompromisno resenje (VIKOR) to select the photovoltaic solar plant locations. Nie et al. [20] applied an extended weighted aggregated sum product assessment (WASPAS) to select solar-wind power station locations. Pamučar et al. [21] applied the geographical information systems (GIS), the best worst method (BWM), and the multiattributive ideal-real comparative analysis (MAIRCA) to select the locations for wind farms. Cheng [22] offered a new autocratic multiattribute group decision making approach to select locations for hotels. Deveci et al. [23] proposed a WASPAS based on TOPSIS with an interval type-2 fuzzy MCDM model for selecting a car sharing station location. Sennaroglu and Varlik Celebi [24] employed AHP, PROMETHEE, and VIKOR to select location for a military airport. Stević et al. [25] used rough BWM and rough WASPAS to select potential locations for roundabout construction.

Although main studies have examined finding ideal locations, the literature does not have useful guidance for creating a decision making model for selecting locations for women's fitness centers. There is a lack of published paper in this field. Moreover, past studies related to location selection problem suffer from many limitations. Firstly, some of them did not clearly describe how to screen the criteria. Some authors treat perspectives or criteria as independent but they are often dependent on each other in real world. Although some authors consider the perspectives or criteria as interdependent, they did not utilize quantitative methods to clearly identifying the cause-effect relationships. Lastly, some studies did not enhance an optimal solution in a shorter time.

To address this, we used the fuzzy Delphi method to modify the selection criteria. Then, DEMATEL was applied to identify the interdependencies among the criteria within each perspective. ANP, which captures the interdependencies, was applied to obtain the weights of the selection criteria. TOPSIS was for ranking the alternatives. Based on the fuzzy Delphi method, DEMATEL, ANP, and TOPSIS, this study achieved more favorable location selection decisions. No similar research has combined these methodologies. Therefore, this study introduces an integrated model to fill the gap in this area.

3. Fuzzy Delphi Method

The Delphi method, a traditional forecasting approach, does not require large samples and is employed to generate a professional consensus [26]. Consensus is obtained by conducting up to four consultation rounds and deriving information such as medians, averages, and deviations from the previous rounds [27]. However, the Delphi method was criticized for low convergence of expert opinions and high execution costs [28]. Hsu et al. [29] described how the Delphi method is an expert opinion survey approach that also exposes weaknesses. In some situations, expert judgments cannot be properly reflected in quantitative terms. Some ambiguity results because of differences in meanings or interpretations of expert opinions. Dong et al. [30] also identified the shortcomings of the traditional Delphi method, namely long feedback time, high cost, and low convergence rate, as well as the possibility of distorting expert opinions.

Recognizing the drawbacks of the traditional Delphi method, several researchers [4, 31, 32] have improved it in a fuzzy environment. Kuo and Chen [28] concluded that the fuzzy Delphi method reduced the cost and time of the investigation. Chao and Kao [33] claimed that the main advantage of the fuzzy Delphi method was saving time by reducing the number of surveys while including the opinions of experts. This present study used the fuzzy Delphi method proposed by Klir and Yuan [34] to screen the selection criteria. We first collected expert opinions from questionnaires and established the triangular fuzzy number T_i. Y_{ij} was the evaluation value of expert j for criterion i. On the basis of the work of Hsu et al. [29], we used the simple center of gravity method to calculate the defuzzified value of each criterion S_i. Last, selection criteria were screened out by setting the threshold. In this study, the threshold value was set by experts through discussion.

$$T_i = (L_i, M_i, U_i) \tag{1}$$

$$L_i = \min_j \{Y_{ij}\} \tag{2}$$

$$U_i = \max_j \{Y_{ij}\} \tag{3}$$

$$M_i = \left(\prod_{j=1}^{n} Y_{ij}\right)^{1/n} \tag{4}$$

$$S_i = \frac{L_i + M_i + U_i}{3} \tag{5}$$

4. DEMATEL

DEMATEL is applied to identify the interdependent relationships between various criteria. It is executed as detailed herein [35–38].

Step 1 (gather expert opinions). Experts are designated the task of completing pairwise comparisons to determine the relative influence of pairs of criteria on a scale of 0 (no influence) to 4 (very high influence). Let x_{ij} denote the extent to which expert evaluation criterion i influences criterion j. When i=j, all elements existing on the diagonal become 0. For each expert, we establish an $n{\times}n$ positive matrix in the form $X^k = [X^k_{ij}]$ for $1 \le k \le H$; here, k and n are the number of experts and criteria, respectively, yielding $X^1, X^2, \ldots, X^H$ as the H experts' individual matrixes. To integrate these distinct matrixes, we construct the average matrix $A = [a_{ij}]$:

$$a_{ij} = \frac{1}{H}\sum_{k=1}^{H} x^k_{ij} \tag{6}$$

Step 2 (normalize the generated initial direct relation matrix). We normalize the generated initial direct relation matrix D as $A \times S$, and $S = 1/\max_{1\le i\le n}\sum_{j=1}^{n} a_{ij}$. All elements in D take a value in the 0-1 range.

Step 3 (obtain the total relation matrix). We can determine the total relation matrix T to be given by $T = D(I - D)^{-1}$, with I being the identity matrix. Let c and r, respectively, be the $1 \times n$ and $n \times 1$ vectors denoting the sums of columns and rows of T. If r_i is the sum of row i in T, r_i captures the indirect effects and direct effects exerted by criterion i on other criteria. Similarly, if c_j is the sum of column j in T, c_j represents the indirect effects and direct effects exerted by criterion j from the other criteria. For j=i, $(r_i$+$c_j)$ expresses the net effect—that is, both exerted and received—by criterion i. This means that $(r_i$+$c_j)$ is a measure of the influence of criterion i on the system. Conversely, $(r_i - c_j)$ expresses the total effect criterion i adds to the system. Thus, when $(r_i$−$c_j)$ is larger (smaller) than 0, criterion i is a net cause (net receiver) [39, 40].

Step 4 (establish the threshold). T clarifies the influence of various criteria on each other. Decision makers must therefore establish a threshold to exclude negligible influence relationships. In this study, this threshold was established by experts through discussion [41].

5. ANP

ANP comprises the following four important steps [7].

Step 1 (construct the hierarchy as well as problem structure). On the basis of the goals, perspectives, criteria, and alternatives, the process can create the problem structure within a hierarchy containing multiple levels of elements and connections. This step can be realized on the basis of appropriate methods, for example, brainstorming by decision makers and a literature survey.

Step 2 (establish the perspectives and criteria weights). Through the application of pairwise comparisons, the decision makers determine the interdependency of perspectives and criteria by using Saaty 1-9 as the relative scale. To establish a pairwise comparison, Saaty [7] recommended that all decision makers' preferences be integrated as the geometric mean and proposed consistency ratio (CR) as a measure of the pairwise comparison matrix's consistency [42]:

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \quad \text{with } \mathrm{CI} = \frac{\lambda_{\max} - n}{n-1} \tag{7}$$

Here, CI and RI are the consistency index and random index, respectively, and n and $\lambda_{\max}$ are the number of criteria in the matrix and the maximum (or principal) eigenvalue of the matrix, respectively. The matrix consistency is deemed acceptable if CR < 0.1.

Step 3 (build the supermatrix and solve it). ANP utilizes a supermatrix to account for the outer and inner dependencies among criteria and perspectives. The weights of the criteria and perspectives derived in Step 2 are applied to form the supermatrix column. Then, the supermatrix is multiplied by itself until all the row elements converge to the same value in each column of the matrix, thus ensuring matrix stability. The resulting matrix is termed the limiting matrix.

$$W_{limit} = \lim_{x\longrightarrow\infty} \left(W_{weighted}\right)^{x} \cong \left(W_{weighted}\right)^{2k+1} \tag{8}$$

Here, k is an arbitrarily large number.

Step 4 (choose the optimal alternative). On the basis of the built limiting matrix and the weights of the alternatives (vs. the criteria), the net weight of each alternative can be summed. Then, the identified alternatives are ranked per their weights.

6. TOPSIS

In TOPSIS, which was developed by Hwang and Yoon in 1981 [43], the optimal alternative is the one that is the closest to and farthest from the positive ideal solution (A^*) and negative ideal solution (A^-), respectively. TOPSIS is executed as detailed herein.

Step 1 (build the standardized appraisal matrix).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{9}$$

Here, i, x_{ij}, and j represent the alternatives, ith alternative under the jth criterion to be assessed, and selection criteria, respectively.

Step 2 (build the weighted standardized appraisal matrix). The product of the weights of the selection criterion $w = (w_1, w_2, \ldots, w_n)$ and the standardized appraisal matrix is expressed as follows:

$$\begin{aligned} v &= \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ v_{m1} & v_{m2} & \cdots & v_{nm} \end{bmatrix} \\ &= \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \cdots & w_n r_{1n} \\ w_1 r_{21} & w_2 r_{22} & \cdots & w_n r_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ w_1 r_{m1} & w_2 r_{m2} & \cdots & w_n r_{mn} \end{bmatrix} \end{aligned} \tag{10}$$

Step 3 (determine both the positive and negative ideal solutions).

$$\begin{aligned} A^* &= \left\{v_1^*, v_2^*, \ldots, v_j^*, \ldots, v_n^*\right\} \\ &= \left\{\left(\max_i v_{ij} \mid j \in J\right) \mid i = 1, \ldots, m\right\}, \\ A^- &= \left\{v_1^-, v_2^-, \ldots, v_j^-, \ldots, v_n^-\right\} \\ &= \left\{\left(\min_i v_{ij} \mid j \in J\right) \mid i = 1, \ldots, m\right\}. \end{aligned} \tag{11}$$

Step 4 (for all alternatives, estimate the Euclidean distance separating the positive (S_i^*) and negative (S_i^-) ideal solutions).

$$\begin{aligned} S_i^* &= \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_i^*\right)^2}, \quad i = 1, \ldots, m, \\ S_i^- &= \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_i^-\right)^2}, \quad i = 1, \ldots, m. \end{aligned} \tag{12}$$

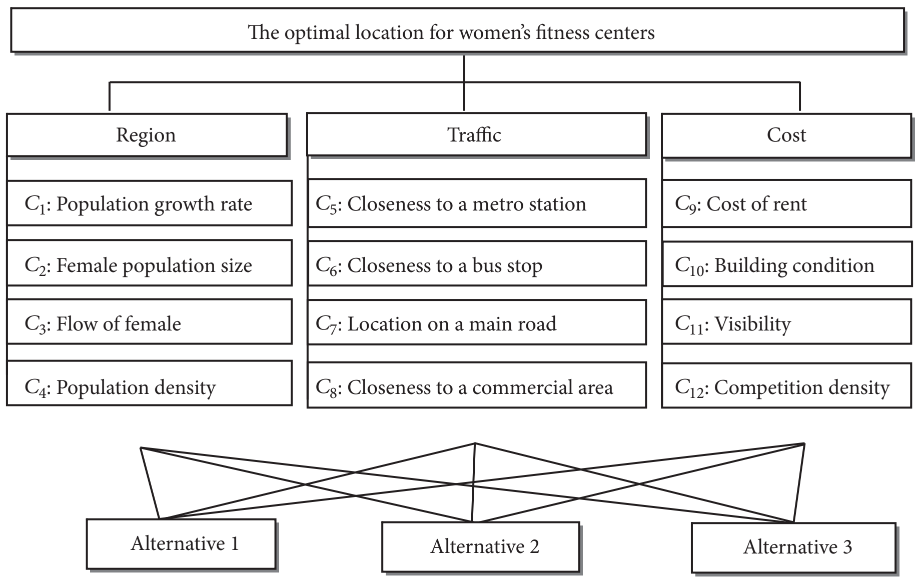

Figure 2: Hierarchy to select optimal location for women's fitness centers.

Step 5 (for all alternatives, calculate the relative distance to the positive ideal solution).

$$C_i^* = \frac{S_i^-}{S_i^* + S_i^-} \tag{13}$$

For C_i^* approaching 1, alternative A_i becomes closer to A^* and farther from A^-.

Step 6 (rank the alternatives on the basis of C_i^*). Larger index values (C_i^*) signify higher performance.

7. Empirical Application

We employed the fuzzy Delphi method, DEMATEL, ANP, and TOPSIS to select the optimal locations for women's fitness centers in Taiwan. The steps of the selection process were as follows.

Step 1 (construct the hierarchy as well as problem structure). The selection criteria for the location were collected from other relevant studies and discussions with executives of women's fitness centers. Using a purposive sampling method, the executives were contacted and asked to recommend other professionals with sufficient experience in selecting locations. Using the fuzzy Delphi method, questionnaires were distributed regarding selection criteria based on a 9-point Likert scale (1=most unimportant and 9=most important). A semistructured questionnaire was used to screen criteria for location selection and assess their importance. The questionnaire also provided space for the executives to suggest additional criteria. Questionnaires were received from 48 senior executives. The data were converted into triangular fuzzy numbers to calculate defuzzified values and screen the criteria for the purpose of assuring content validity.

Based on discussion with senior executives, top 12 criteria were obtained: population growth rate [1], female population size (executive proposed), flow of female (executive proposed), population density [1, 19], closeness to a metro station [1, 15, 16, 22, 23], closeness to a bus stop [1, 15, 16, 22, 23], location on a main road [1], closeness to a commercial area [15], cost of rent [23], building condition (executive proposed), visibility [1], and competition density [1, 15]. Based on past research [1, 15] and discussions with senior executives, the hierarchy was constructed as shown in Figure 2.

Step 2 (identify the relationships within each perspective through DEMATEL). DEMATEL was used to identify the relationships between the selection criteria within each perspective and their influence on each other. The members of the decision making committee, including two managers of a women's fitness center, were interviewed to determine the influential relationships to use for ranking each criterion. The initial direct relation matrix A was obtained from equation (6) as depicted in Tables 1–3. The total relation matrix T is illustrated in Tables 4–6.

To obtain an appropriate relationship, threshold values were chosen after discussion with the same two senior executives. Thus, the interdependencies between the selection criteria within each perspective were developed as shown in Figures 3–5.

Step 3 (establish the perspectives and criteria weights). Each perspective's priority weight is depicted in Table 7. The CR of each pairwise comparison was < 0.1; the consistency is acceptable.

Pairwise comparisons are applied based on the interdependencies of the selection criteria. A pairwise comparison within the Region perspective with respect to Population growth rate is presented in Table 8. Following this method,

Table 1: The initial direct relation matrix within Region perspective.

Criteria	Population growth rate	Female population size	Flow of female	Population density
Population growth rate	0.0000	4.0000	3.0000	3.5000
Female population size	3.5000	0.0000	4.0000	4.0000
Flow of female	3.5000	4.0000	0.0000	4.0000
Population density	3.0000	4.0000	4.0000	0.0000

Table 2: The initial direct relation matrix within Traffic perspective.

Criteria	Closeness to a metro station	Closeness to a bus stop	Location on a main road	Closeness to a commercial area
Closeness to a metro station	0.0000	3.5000	3.0000	4.0000
Closeness to a bus stop	4.0000	0.0000	3.5000	4.0000
Location on a main road	3.0000	3.0000	0.0000	4.0000
Closeness to a commercial area	4.0000	4.0000	3.5000	0.0000

Table 3: The initial direct relation matrix within Cost perspective.

Criteria	Cost of rent	Building condition	Visibility	Competition density
Cost of rent	0.0000	4.0000	3.5000	3.0000
Building condition	4.0000	0.0000	3.0000	3.5000
Visibility	3.5000	1.5000	0.0000	2.5000
Competition density	2.5000	2.0000	4.0000	0.0000

Table 4: The total relation matrix within Region perspective.

Criteria	Population growth rate	Female population size	Flow of female	Population density
Population growth rate	6.6667	**7.9140**	**7.4194**	**7.6667**
Female population size	**7.3840**	**8.2121**	**7.9938**	**8.2320**
Flow of female	**7.3840**	**8.4701**	**7.7357**	**8.2320**
Population density	7.1367	**8.2149**	**7.7544**	**7.7266**
The threshold value is 7.3000				

Table 5: The total relation matrix within Traffic perspective.

Criteria	Closeness to a metro station	Closeness to a bus stop	Location on a main road	Closeness to a commercial area
Closeness to a metro station	**4.2651**	**4.3533**	**4.1566**	**4.7913**
Closeness to a bus stop	**4.8174**	**4.4040**	**4.4551**	**5.1048**
Location on a main road	**4.3058**	**4.1669**	3.7961	**4.6153**
Closeness to a commercial area	**4.8174**	**4.6620**	**4.4551**	**4.8468**
The threshold value is 4.0000				

Table 6: The total relation matrix within Cost perspective.

Criteria	Cost of rent	Building condition	Visibility	Competition density
Cost of rent	**1.8757**	**1.7803**	**2.2064**	**1.9404**
Building condition	**2.1534**	**1.5081**	**2.1855**	**1.9717**
Visibility	**1.6792**	1.2828	**1.4985**	**1.5022**
Competition density	**1.7346**	1.3903	**1.8934**	**1.4098**
The threshold value is 1.4000				

Table 7: The pairwise comparisons of perspectives.

	Region	Traffic	Cost	Priority weights
	$\lambda_{\max}$=3.0099	C.R.=0.0075		
Region	1.0000	2.6458	7.3485	0.6491
Traffic	0.3780	1.0000	3.7417	0.2709
Cost	0.1361	0.2673	1.0000	0.0800

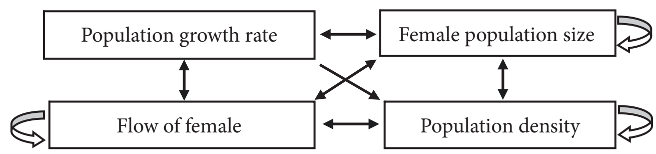

Figure 3: The interdependencies between the selection criteria within the Region perspective.

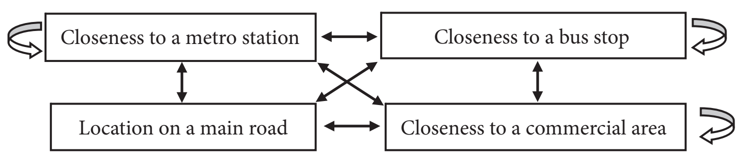

Figure 4: The interdependencies between the selection criteria within the Traffic perspective.

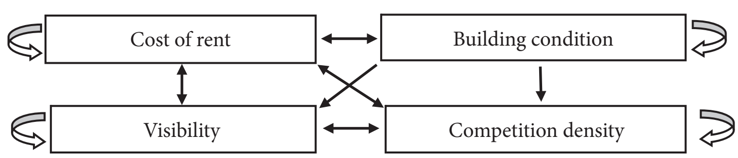

Figure 5: The interdependencies between the selection criteria within the Cost perspective.

we derived every criterion weight and obtained the supermatrix.

Step 4 (build the supermatrix and solve it). The criteria weights derived in Step 3 were used to obtain the column of the supermatrix as depicted in Table 9. The limiting matrix is indicated in Table 10. On the basis of the data presented in Tables 7 and 10, we aggregated the total weight of each criterion as presented in Table 11.

Step 5 (build the standardized and weighted standardized appraisal matrix). We used equation (9) to obtain the standardized appraisal matrix, as displayed in Table 12. The weighted standardized appraisal matrix is depicted in Table 13.

Step 6 (determine both the positive and negative ideal solutions). The positive ideal solution and negative ideal solution were defined according to equation (11) as

$$A^{*} = (0.0625, 0.1787, 0.0784, 0.0921, 0.0400, 0.0686, 0.0239, 0.0396, 0.0179, 0.0072, 0.0090, 0.0060)\,,$$
$$A^{-} = (0.0625, 0.1246, 0.0784, 0.0647, 0.0400, 0.0467, 0.0207, 0.0323, 0.0303, 0.0056, 0.0070, 0.0060)\,. \tag{14}$$

Step 7 (for all alternatives, estimate the Euclidean distance separating the positive and negative ideal solutions). By equation (12), the Euclidean distance for each alternative can be measured.

Step 8 (for all alternatives, calculate the relative distance to the positive ideal solution). The C_i^* value of each alternative was calculated by equation (13).

Step 9 (choose the optimal alternative). According to the results presented in Table 14, the preferred location was selected. Alternative 2 was clearly the optimal location, followed by Alternatives 1 and 3. We provided the results to the case company, and they selected the location as per our suggestion.

8. Conclusion

Location selection is a MCDM problem. In this study, a novel hybrid MCDM model effectively selected the optimal location for women's fitness centers in Taiwan through the fuzzy Delphi method, DEMATEL, ANP, and TOPSIS with

Table 8: The pairwise comparisons within Region perspective with respect to Population growth rate.

	Female population size $\lambda_{\max}$=3.0260	Flow of female C.R.=0.0197	Population density	Priority weights
Female population size	1.0000	2.6458	2.8284	0.5731
Flow of female	0.3780	1.0000	1.7321	0.2544
Population density	0.3536	0.5774	1.0000	0.1725

Table 9: The supermatrix before convergence.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
C_1	0.0000	0.2750	0.2532	0.0000								
C_2	0.5731	0.3795	0.3977	0.3725								
C_3	0.2544	0.1684	0.1677	0.2956								
C_4	0.1725	0.1771	0.1814	0.3319								
C_5					0.2617	0.2617	0.2318	0.2550				
C_6					0.3966	0.3966	0.1840	0.4044				
C_7					0.1672	0.1672	0.0000	0.1667				
C_8					0.1745	0.1745	0.5842	0.1739				
C_9									0.4758	0.6586	0.6436	0.6386
C_{10}									0.2332	0.0893	0.0000	0.0000
C_{11}									0.1355	0.1246	0.2740	0.2806
C_{12}									0.1555	0.1275	0.0825	0.0807

Table 10: The supermatrix after convergence (Limiting matrix).

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
C_1	0.1669	0.1669	0.1669	0.1669								
C_2	0.4141	0.4141	0.4141	0.4141								
C_3	0.2093	0.2093	0.2093	0.2093								
C_4	0.2097	0.2097	0.2097	0.2097								
C_5					0.2559	0.2559	0.2559	0.2559				
C_6					0.3679	0.3679	0.3679	0.3679				
C_7					0.1432	0.1432	0.1432	0.1432				
C_8					0.2330	0.2330	0.2330	0.2330				
C_9									0.5524	0.5524	0.5524	0.5524
C_{10}									0.1414	0.1414	0.1414	0.1414
C_{11}									0.1772	0.1772	0.1772	0.1772
C_{12}									0.1290	0.1290	0.1290	0.1290

Table 11: The total weight of each selection criterion.

	Weights from perspectives	Weights from supermatrix after convergence	Total weights
C_1	0.6491	0.1669	0.1083
C_2	0.6491	0.4141	0.2688
C_3	0.6491	0.2093	0.1358
C_4	0.6491	0.2097	0.1361
C_5	0.2709	0.2559	0.0693
C_6	0.2709	0.3679	0.0997
C_7	0.2709	0.1432	0.0388
C_8	0.2709	0.2330	0.0631
C_9	0.0800	0.5524	0.0442
C_{10}	0.0800	0.1414	0.0113
C_{11}	0.0800	0.1772	0.0142
C_{12}	0.0800	0.1290	0.0103

Table 12: The standardized appraisal matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	0.5774	0.5861	0.5774	0.5625	0.5774	0.5541	0.5345	0.5867	0.6860	0.6332	0.5970	0.5774
A_2	0.5774	0.6646	0.5774	0.6765	0.5774	0.4683	0.5774	0.6273	0.6050	0.5970	0.6332	0.5774
A_3	0.5774	0.4634	0.5774	0.4754	0.5774	0.6882	0.6172	0.5121	0.4042	0.4925	0.4925	0.5774

Table 13: The weighted standardized appraisal matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
A_1	0.0625	0.1576	0.0784	0.0766	0.0400	0.0552	0.0207	0.0370	0.0303	0.0072	0.0085	0.0060
A_2	0.0625	0.1787	0.0784	0.0921	0.0400	0.0467	0.0224	0.0396	0.0267	0.0068	0.0090	0.0060
A_4	0.0625	0.1246	0.0784	0.0647	0.0400	0.0686	0.0239	0.0323	0.0179	0.0056	0.0070	0.0060

Table 14: The results of TOPSIS.

	S_i^*	S_i^-	C_i^*	Rank
A_1	0.0322	0.0365	0.5310	2
A_2	0.0237	0.0612	0.7209	1
A_3	0.0611	0.0254	0.2937	3

group decision making. The fuzzy Delphi method was used to gather information, which effectively addressed the vagueness and imprecision of the expert judgments to identify the location selection criteria. DEMATEL was then employed to identify the interrelationships between criteria within each perspective. On the basis of DEMATEL results, ANP was used to build the criteria weights. To avoid the excessive calculation and additional pairwise comparisons characteristic of ANP, TOPSIS was used to rank the alternatives. TOPSIS eliminated procedures that are typically performed in ANP, enabling the system to achieve a conclusion in a shorter time.

No known study has previously combined the fuzzy Delphi method, DEMATEL, ANP, and TOPSIS. This study therefore contributes to the literature by combining these four approaches for the first time to develop a novel selection model to assist with the location selection process. To validate the effectiveness of the proposed model, two managers of the case company were interviewed. They selected the location per our suggestion and the performance of the new branch is better than expected. In practice, it takes about two and half years to recoup the costs of starting up a branch. In this case company, managers recouped the amount their invested in two years. The results confirmed that the proposed model can help managers improve their decision making processes. This study provided reliable and validated selection criteria on which women's fitness center managers can make optimal location selections. The criteria identified in this study should be considered as comprising guidelines on which managers can make optimal location decisions.

This study had several limitations. First, respondents were senior executives of women's fitness centers in Taiwan. Further studies should be conducted in different countries to account for cultural variation. However, some criteria have a qualitative structure that could not be measured precisely. The fuzzy extensions of DEMATEL or ANP can be considered in the proposed model for dealing with vagueness or imprecision. Lastly, comparative analyses with different MCDM approaches on the same example are not conducted in this paper.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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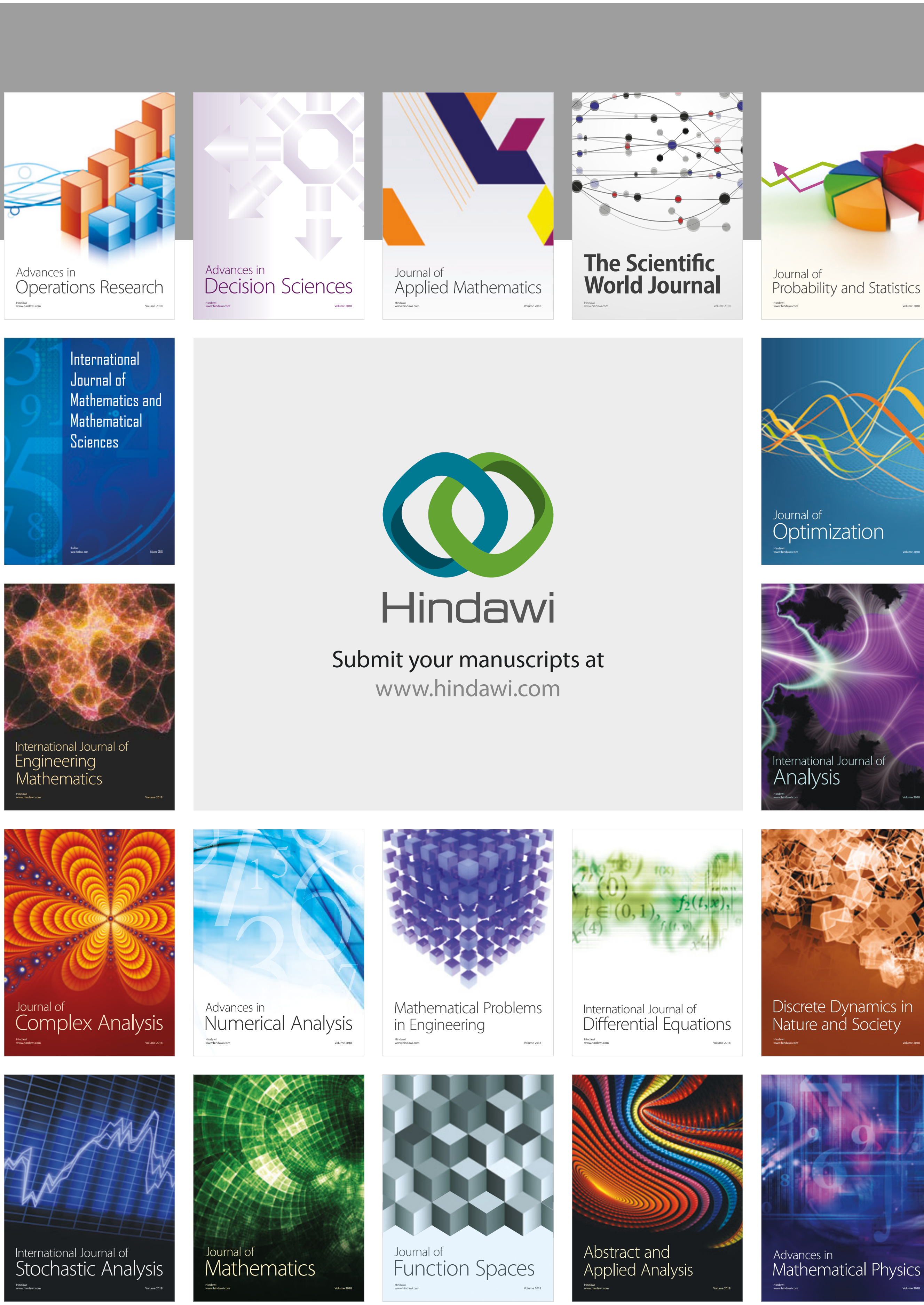
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