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An ANP based TOPSIS approach for Taiwanese service apartment location selection

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ABSTRACT

The fuzzy Delphi method, analytic network process (ANP), and technique for order preference by similarity to ideal solution (TOPSIS) are integrated in this paper to help Taiwanese service apartments to effectively select the optimal locations. The fuzzy Delphi method, which can lead to better criteria selection, is used to modify previous studies to construct the hierarchy. Considering the interdependence among the selection criteria in the hierarchy, ANP is then used to obtain the weights of the criteria. To avoid calculation and additional pairwise comparisons of ANP, TOPSIS is used to rank the alternatives. According to the hierarchy based on three perspectives and 12 important criteria, optimal locations for Taiwanese service apartments can be more effectively selected. Moreover, by integrating the fuzzy Delphi method, ANP, and TOPSIS, this study can make better decisions for optimal locations. To illustrate how the fuzzy Delphi method, ANP, and TOPSIS are applied in the location selection problem, their application to a real case is also performed.

1. Introduction

Location decisions have attracted much attention from the academic and business communities (Chou, Hsu, & Chen, 2008). The decision to select a location has become increasingly vital (Kapoor, Tak, & Sharma, 2008). For the hotel industry, optimal location not only helps increase market share and profit, but may also enhance the convenience of passenger lodging. Satisfying customer needs or enhancing the convenience of customer lodging will directly increase customer loyalty (Chou et al., 2008). In recent years, service apartments providing long-term hotel services for business persons have become a growing industry in Taiwan. The service apartment is a good choice for a comfortable, homelike, and economical residence. In order to decrease the cost to the business person of finding accommodations and to improve operating performance, location selection has become one of the most important issues for service apartments.

Hsu and Yang (2000) applied a triangular fuzzy number to encompass expert opinions and establish a fuzzy Delphi method. The maximum and minimum value of expert opinions are taken as the two terminal points of triangular fuzzy numbers, and the geometric mean is taken as the membership degree of triangular fuzzy numbers to derive the statistical unbiased effect and avoid the impact of extreme values. The advantage of the fuzzy Delphi method is its simplicity. All of the expert opinions can be encompassed in one investigation. Hence, this method can create more effective criteria selection (Ma, Shao, Ma, & Ye, 2011). ANP produces more accurate weighting of criteria, since it enables consideration of the dependence among factors in decision-making problems. Unfortunately, ANP requires many pairwise comparisons depending on the number and interdependence of factors and alternatives. This disadvantage of ANP is eliminated via the use of the (TOPSIS). Thus, the selection process is shortened (Dağdeviren, 2010).

By combining the fuzzy Delphi method, ANP, and TOPSIS, this study can make better decisions in selecting locations for Taiwanese service apartments within a shorter time, by considering the

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dependence among factors, which distinguishes this study from others in the literature. We first present a literature review of the location selection. Next, the ANP and TOPSIS as selection tools are described. The integrated method within the context of selecting the optimal location for a Taiwanese service apartment is shown in Section 5. The conclusion is given in Section 6.

2. Location selection

Many approaches for location selection have been developed. Cheng, Li, and Yu (2007) used geographic information systems to select a location for shopping malls. Wu, Lin, and Chen (2007) used the modified Delphi method, analytic hierarchy process (AHP), and sensitivity analysis, to select the optimal location for a regional hospital in Taiwan. Anagnostopoulos, Doukas, and Psarras (2008) proposed a fuzzy multicriteria algorithm to solve the distribution center location selection problem. Chou, Chang, and Shen (2008) present a new fuzzy multiple attributes decision-making method to answer facility location selection problems. Chou et al. (2008) apply fuzzy AHP to select international tourist hotel locations. Kapoor et al. (2008) used fuzzy cluster analysis for the location selection problem. Tabari, Kaboli, Aryanezhad, Shahanaghi, and Siadat (2008) selected the optimal location based on the concept of fuzzy AHP. Guneri, Cengiz, and Seker (2009) applied fuzzy ANP to select a suitable location for a shipyard. Hsu (2010) utilized ANP to select the optimal location for an international business office center in China. Kayikci (2010) combined fuzzy AHP and artificial neural networks for location selection. Lin and Tsai (2010) integrated ANP and TOPSIS to select locations for foreign direct investments in new hospitals in China. Önüt, Efendigil, and Kara (2010) used fuzzy AHP and fuzzy TOPSIS to select a shopping center site. Bottero and Ferretti (2011) applied ANP to rank sites for the location of a waste incinerator plant for the Province of Torino in Italy. Li, Liu, and Chen (2011) selected a logistic center location on the basis of the axiomatic fuzzy set (AFS) clustering approach and TOPSIS. Athawale, Chatterjee, and Chakraborty (2012) applied the preference ranking organization method for enrichment evaluation (PROMETHEE II) to solve facility location selection problems. Choudhary and Shankar (2012) used fuzzy AHP and TOPSIS to select locations for a thermal power plant. Ishizaka, Nemery, and Lidouh (2013) selected the location of casinos in the Greater London region using the weighted sum method, TOPSIS, and PROMETHEE.

Several previous studies treat the selection criteria as independent. After discussions with senior executives, we find that selection criteria are not independent in actual selection situations. To address this issue, this paper combines ANP with TOPSIS to make better decisions in selecting optimal locations for Taiwanese service apartments. ANP, which captures the interdependence, is applied to generate the weights of the selection criteria. TOPSIS is used to rank the alternatives.

3. ANP

ANP (Saaty, 1996) is a comprehensive decision-making technique that captures the outcome of dependency between criteria. AHP serves as a starting point for ANP. Priorities are established in the same way that they are in AHP using pairwise comparisons. The weight assigned to each perspective and criterion may be estimated either from the data, or subjectively by decision makers. It is desirable to measure the consistency of the decision makers' judgment. AHP provides a measure through the consistency ratio (C.R.) which is an indicator of the reliability of the model. This ratio is designed in such a way that the values of the ratio exceeding 0.1 indicate inconsistent judgment (Saaty, 1980). ANP comprises four major steps (Saaty, 1996).

Step 1. Construct hierarchy and structure problem

The problem should be clearly stated and hierarchy structure constructed. The hierarchy can be determined by the decision makers' opinion via brainstorming or other appropriate methods, such as literature reviews.

Step 2. Determine the perspectives and criteria weights

In this step, the decision-making committee makes a series of pairwise comparisons to establish the relative importance of perspectives and criteria. In these comparisons, a 1–9 scale is applied to compare two perspectives or criteria according to the interdependency of perspectives and criteria. The eigenvector of the observable pairwise comparison matrix provides the perspectives and criteria weights at this level, which will be used in the supermatrix.

Step 3. Construct and solve the supermatrix

The perspectives and criteria weights derived from Step 2 are used to obtain the column of the supermatrix. Finally, the supermatrix will be steady by multiplying the supermatrix by itself until the row values of the supermatrix converge to the same value for each column of the matrix. We call that the limiting matrix.

Step 4. Select the best alternative

Based on the limiting matrix and the weights of alternatives with respect to the criteria, we can aggregate the total weight of each alternative. We rank the alternatives according to their total weights.

In the literature on the application of ANP, Ertay, Büyüközkan, Kahraman, and Ruan (2005) tried to implement quality function deployment (QFD) under a fuzzy environment. Moreover, ANP is used to prioritize design requirements. Kahraman, Ertay, and Büyüközkan (2006) combined ANP and a fuzzy logic approach to incorporate the customer needs and the product technical requirements systematically into the product design phase in QFD. Chang, Wey, and Tseng (2009) used the fuzzy Delphi method, ANP, and zero one goal programming to select revitalization strategy projects for the historic Alishan forest railway. Chen, Huang, and Cheng (2009) used ANP and the balanced scorecard (BSC) for measuring knowledge management (KM) performance. Guneri et al. (2009) applied fuzzy ANP to select a suitable location for a shipyard. Hsu and Hu (2009) used ANP to select suppliers by adding the concept of hazardous substance management. Lee, Tzeng, Guan, Chien, and Huang (2009) established an investment decision model based on the Gordon model. ANP is applied to generate the weight of criteria because of interrelations and self-feedback relationships among the criteria. Liao and Chang (2009a) used ANP to measure the performance of hospitals. Liao and Chang (2009b) applied ANP to select television sportscasters for the Olympic Games. Liao and Chang (2009c) combined ANP with BSC to select the key capabilities of Taiwanese TV shopping companies. Liao and Chang (2009d) applied ANP to choose public relations personnel for Taiwanese hospitals. Lin (2009) combined ANP with fuzzy preference programming to select suppliers and then allocated orders among the selected suppliers using multi-objective linear programming. Oh, Suh, Hong, and Hwang (2009) applied ANP and BSC to evaluate the feasibility of a new telecom service. They point out that ANP can obtain more realistic results. Wu, Lin, and Peng (2009) combined ANP with conjoint analysis to simplify ANP for hospital policymakers making appropriate management policies. Aznar, Ferrís-Oñate, and Guijarro (2010) used ANP for property pricing. Chen and Chen (2010) applied decision-making trial and evaluation laboratory (DEMATEL), fuzzy ANP, and TOPSIS to develop a new innovation support system. Dağdeviren (2010) employed ANP and modified TOPSIS to select personnel. Hsu (2010) utilized ANP to select optimal location for an international business office center in China. Liao and Chang (2010) combined ANP with BSC for measuring the managerial performance of TV companies. Liao, Chang, and Tseng (2010) selected program suppliers for TV companies using ANP. Lin and Tsai (2010) integrated ANP and TOPSIS to select locations for foreign direct investments in new hospitals in China. Tseng (2010) used ANP, DEMATEL, and fuzzy set theory to obtain the relative weight of BSC factors for a university performance measurement. Yang, Hui, Leung, and Chen (2010) applied ANP to select logistics service providers for air cargo. Yüksel and Dağdeviren (2010) integrated fuzzy ANP and BSC to measure the performance of a manufacturing firm in Turkey. Bottero and Ferretti (2011) applied ANP to rank sites for the location of a waste incinerator plant for the Province of Torino in Italy. Ertay, Akyol, and Araz (2011) applied fuzzy ANP to rank engineering characteristics for implementing QFD. Liao, Chen, Chang, and Tseng (2011) used ANP and TOPSIS for assessing the performance of Taiwanese tour guides. Fazli and Jafari (2012) applied DEMATEL, ANP, and VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) to select the best alternative for investment in stock exchange. Hu, Wang, and Hung (2012a) utilized ANP to evaluate e-service quality of microblogging. Hu, Wang, and Wang (2012b) used ANP to evaluate the performance of Taiwan homestay industry.

ANP, widely applied in decision making, is more accurate and feasible under interdependent situations. However, after discussions with senior executives, we found that the selection criteria for locations are interrelated. ANP, which captures the interdependence, appears to be one of the more feasible and accurate solutions for generating the weights of the selection criteria.

4. TOPSIS

TOPSIS, proposed by Hwang and Yoon (1981), enables decision makers to determine the positive ideal solution (A^*) and negative ideal solution (A^-). On the basis of TOPSIS, the chosen alternative should have the shortest distance from the positive ideal solution and the farthest from the negative ideal solution. The computing process is presented as follows.

Step 1. Construct the standardized appraisal matrix

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

where i indicates the alternatives, j denotes the selection criteria, and x_{ij} means the i alternative under the j criterion to be assessed.

Step 2. Construct the weighted standardized appraisal matrix

Weights of selection criteria, $w = (w_1, w_2, \ldots, w_n)$, multiplied by the standardized appraisal matrix, may be expressed as:

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

Step 3. Identify the positive ideal solution and negative ideal solution

$$A^* = \left\{v_1^*, v_2^*, \ldots, v_j^*, \ldots, v_n^*\right\} = \left\{\left(\max_i v_{ij} | j \in J\right) | i = 1, \ldots, m\right\}, \tag{3}$$

$$A^- = \left\{v_1^-, v_2^-, \ldots, v_j^-, \ldots, v_n^-\right\} = \left\{\left(\min_i v_{ij} | j \in J\right) | i = 1, \ldots, m\right\}.$$

Step 4. Calculate the Euclidean distance between the positive ideal solution (S_i^*) and negative ideal solution (S_i^-) for each alternative

$$S_i^* = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_i^*\right)^2}, i = 1, \ldots, m, \tag{4}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_i^-\right)^2}, i = 1, \ldots, m.$$

Step 5. Calculate the relative closeness to the positive ideal solution for each alternative

$$C_i^* = \frac{S_i^-}{S_i^* + S_i^-} \tag{5}$$

An alternative A_i is closer to A^* and farther from A^- asC_i^* approaches 1.

Step 6. Rank the preference order by C_i^*

According to C_i^*, larger index values indicate better performance of the alternatives.

TOPSIS has been widely explored in the literature. Dağdeviren, Yavuz, and Kılınç (2009) used AHP and fuzzy TOPSIS to select weapons. Gumus (2009) employed fuzzy AHP and TOPSIS to evaluate hazardous transportation firms. Saremi, Mousavi, and Sanayei (2009) applied fuzzy TOPSIS to select an external total quality management (TQM) consultant. Sun and Lin (2009) used fuzzy TOPSIS to generate the weight of each criterion and rank four shopping websites. Wang, Cheng, and Huang (2009) developed a fuzzy hierarchical TOPSIS that improves the idea of Chen (2000) for selecting a lithium-ion battery protection integrated circuit (LIBPIC) supplier. Chen and Chen (2010) applied DEMATEL, fuzzy ANP, and TOPSIS to develop a new innovation support system for Taiwanese higher education. Dağdeviren (2010) employed ANP and modified TOPSIS to select personnel. Kelemenis and Askounis (2010) proposed a new approach on the basis of fuzzy TOPSIS to select information technology professionals. Lin and Tsai (2010) integrated ANP and TOPSIS to select locations for foreign direct investments in new hospitals in China. Önüt et al. (2010) used fuzzy AHP and fuzzy TOPSIS to select a shopping center site. Liao et al. (2011) used ANP and TOPSIS for assessing the performance of Taiwanese tour guides. Li et al. (2011) selected a logistic center location based on the AFS clustering approach and TOPSIS. Choudhary and Shankar (2012) used fuzzy AHP and TOPSIS to select locations for thermal power plants. Ishizaka et al. (2013) selected the location of a casino in the Greater London region using the weighted sum method, TOPSIS, and PROMETHEE. The authors found that PROMETHEE and the weighted sum method are more suitable than TOPSIS.

Although TOPSIS is comprehensible and the computations are uncomplicated, it suffers from the inherent problem of assigning reliable subjective preferences to criteria (Shyur, 2006). Due to the interdependent criteria, ANP is applied in this paper to generate the weights for the selection criteria. TOPSIS is used to rank the alternatives.

5. A case study

We employ the fuzzy Delphi method, ANP, and TOPSIS in a case study of a real-life firm to select optimal locations. The company is the first electronic business platform in Taipei established to provide professional service apartment chain services. It has several service apartments in Taipei City, Taiwan, which are all located in well-to-do residential communities. In addition to modern room facilities, professional housekeeping services, and a secure and comfortable residence environment, all services can be customized according to customers' requirements. The decision committee includes two managers. There are three locations as alternatives. We depict the selection process as follows.

Step 1. Construct hierarchy and structure problem

The fuzzy Delphi method can create better criteria selection (Ma et al., 2011). We apply the concept of the fuzzy Delphi method to revise the hierarchy of Chou et al. (2008) and select optimal locations for service apartments. Firstly, based on Chou et al. (2008b), we obtain the selection criteria. Then, questionnaires based on a 9-point Likert scale, with 1 as the most unimportant and 9 as the most important, are sent to 31 senior executives to obtain their opinions about the importance of the criteria. In this paper, the geometric mean of each criterion is used to denote the consensus of the experts' evaluation value of the criteria. According to the geometric mean, we retain the top 12 criteria as shown in Table 1 to structure the hierarchy for Taiwanese service apartment location selection (Fig. 1).

Step 2. Determine the perspectives and criteria weights

In this step, the decision-making committee makes a series of pairwise comparisons to establish the relative importance of perspectives. In these comparisons, a 1–9 scale is applied to compare the two perspectives. The pairwise comparison matrix and the development of each perspective priority weight are shown in Table 2.

Table 1
Descriptions of the selection criteria.

Criteria	Definition
Public facilities	Distance to public facilities
Competitiveness	Regional competitiveness
Security	Regional public security
Airport	Distance to the airport
Downtown	Distance to the downtown
Traffic facilities	Easy to travel main traffic facilities
Traffic routes	Extensiveness of traffic routes
Indoor facilities	Variety of indoor facilities
Human resources	Sufficient human resources
Quality	Quality of manpower
Cost	Rent cost
Regulations	Regulation restrictions

Based on the interdependency of criteria, we apply pairwise comparisons again to establish the criteria relationships within each perspective. The eigenvector of the observable pairwise comparison matrix provide the criteria weights at this level, which will be used in the supermatrix. With respect to airport, for example, a pairwise comparison within the traffic perspective can be shown in Table 3. In this way, we can derive the weight of each criterion to obtain the supermatrix.

Step 3. Construct and solve the supermatrix

The criteria weights derived in Step 2 are used to obtain the column of the supermatrix as shown in Table 4. Finally, the system solution is derived by multiplying the supermatrix of model variables by itself, which accounts for the variable interaction, until the system's row values converge to the same value for each column of the matrix, as shown in Table 5. According to Tables 2 and 5, we can aggregate the total weight of each criterion, as shown in Table 6.

Step 4. Construct the standardized and weighted standardized appraisal matrix.

The decision-making committee is asked to establish the appraisal matrix by comparing three alternatives with respect to each criterion. After the appraisal matrix Eq. (1) is used to obtain

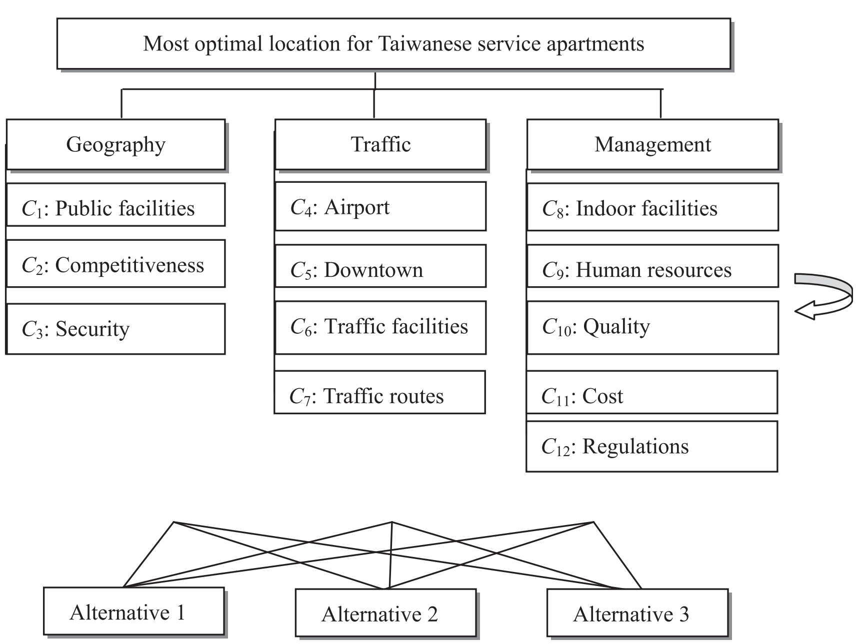

Figure 1. Hierarchy for Taiwanese service apartments to select optimal locations.

Table 2
The pairwise comparisons of perspectives.

	Geography	Traffic	Management	Priority weights
	$\lambda_{max} = 3.0536$	C.R. = 0.0406		
Geography	1.0000	1.4142	0.7071	0.3319
Traffic	0.7071	1.0000	1.0000	0.2956
Management	1.4142	1.0000	1.0000	0.3725

C.R. = consistency ratio.

Table 3
The pairwise comparisons within traffic perspective with respect to airport.

	Downtown	Traffic facilities	Traffic routes	Priority weights
	$\lambda_{max} = 3.0377$	C.R. = 0.0286		
Downtown	1.0000	1.4142	1.1180	0.3853
Traffic facilities	0.7071	1.0000	1.4142	0.3308
Traffic routes	0.8944	0.7071	1.0000	0.2839

C.R. = consistency ratio.

the standardized appraisal matrix, shown in Table 7. The criteria weights derived from ANP shown in Table 6 are multiplied by the standardized appraisal matrix to obtain the weighted standardized appraisal matrix.

Step 5. Identify the positive ideal solution and negative ideal solution

The positive ideal solution and negative ideal solution are defined according to Eq. (3) as:

$A^* = (0.0666, 0.0168, 0.0679, 0.0299, 0.0358, 0.0558, 0.0587, 0.0734, 0.0374, 0.0362, 0.0357, 0.0481),$

Table 6
The total weight of each criterion.

	Weights from perspectives	Weights from supermatrix after convergence	Total weights of criteria
C_1	0.3319	0.3843	0.1275
C_2	0.3319	0.2929	0.0972
C_3	0.3319	0.3228	0.1071
C_4	0.2956	0.2057	0.0608
C_5	0.2956	0.2208	0.0653
C_6	0.2956	0.2821	0.0834
C_7	0.2956	0.2914	0.0861
C_8	0.3725	0.2305	0.0858
C_9	0.3725	0.1618	0.0603
C_{10}	0.3725	0.1481	0.0552
C_{11}	0.3725	0.2358	0.0878
C_{12}	0.3725	0.2238	0.0834

$A^- = (0.0822, 0.0756, 0.0485, 0.0399, 0.0413, 0.0372, 0.0367, 0.0315, 0.0321, 0.0271, 0.0667, 0.0481).$

Step 6. Calculate the Euclidean distance between the positive ideal solution and negative ideal solution for each alternative

The Euclidean distance between the positive ideal solution and negative ideal solution for each alternative can be measured by Eq. (4).

Step 7. Calculate the relative closeness to the positive ideal solution for each alternative

The C_i^* value of each alternative can be obtained by Eq. (5).

Table 4
The supermatrix prior to 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	0.6667	0.5858									
C_2	0.4142	0.0000	0.4142									
C_3	0.5858	0.3333	0.0000									
C_4				0.0000	0.2679	0.2997	0.2128					
C_5				0.3853	0.0000	0.2379	0.2556					
C_6				0.3308	0.2679	0.0000	0.5316					
C_7				0.2839	0.4641	0.4624	0.0000					
C_8								0.0000	0.2210	0.1927	0.3028	0.4234
C_9								0.3141	0.0000	0.1344	0.1547	0.1475
C_{10}								0.1078	0.1233	0.0000	0.2879	0.1585
C_{11}								0.3141	0.3100	0.3557	0.0000	0.2705
C_{12}								0.2641	0.3458	0.3172	0.2546	0.0000

Table 5
The supermatrix after 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	0.3843	0.3843	0.3843									
C_2	0.2929	0.2929	0.2929									
C_3	0.3228	0.3228	0.3228									
C_4				0.2057	0.2057	0.2057	0.2057					
C_5				0.2208	0.2208	0.2208	0.2208					
C_6				0.2821	0.2821	0.2821	0.2821					
C_7				0.2914	0.2914	0.2914	0.2914					
C_8								0.2305	0.2305	0.2305	0.2305	0.2305
C_9								0.1618	0.1618	0.1618	0.1618	0.1618
C_{10}								0.1481	0.1481	0.1481	0.1481	0.1481
C_{11}								0.2358	0.2358	0.2358	0.2358	0.2358
C_{12}								0.2238	0.2238	0.2238	0.2238	0.2238

Table 7
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	0.5583	0.6047	0.4527	0.4915	0.6325	0.4460	0.4256	0.8552	0.6211	0.4915	0.7598	0.5774
A_2	0.5222	0.1728	0.6273	0.5735	0.5477	0.5946	0.5959	0.3665	0.5751	0.5735	0.5077	0.5774
A_3	0.6447	0.7775	0.6338	0.6554	0.5477	0.6690	0.6810	0.3665	0.5324	0.6554	0.4061	0.5774

Table 8
Results of technique for order preference by similarity to ideal solution (TOPSIS).

	S_i^*	S_i^-	C_i^*	Rank
A_1	0.0638	0.0479	0.4288	2
A_2	0.0446	0.0706	0.6132	1
A_3	0.0747	0.0478	0.3900	3

Step 8. Rank the alternatives

According to Table 8, the optimal location is selected. Therefore, it is obvious that the ranking for the optimal locations is Alternative 2, Alternative 1, and Alternative 3.

The case company takes this result to operate service apartments in Alternative 1 and Alternative 2. After interviewing the two managers, they point out that a service apartment operated in Alternative 2 is better based on their survey and annual performance evaluation data.

6. Conclusion

This study presents an effective framework applying the fuzzy Delphi method, ANP, and TOPSIS to select the optimal locations for Taiwanese service apartments. The fuzzy Delphi method is used to revise the work of previous studies and construct a hierarchy. Questionnaires based on a 9-point Likert scale are sent to 31 senior executives to obtain their rankings of the importance of the criteria. The top 12 criteria are selected and taken into three perspectives, namely, geography, traffic, and management, to structure the hierarchy for selecting the optimal locations. To solve the problem of selection criteria interdependency, ANP is used to obtain the weights of the criteria. To prevent excessive calculation and additional pairwise comparisons of ANP, TOPSIS is used to rank the locations. By combining the fuzzy Delphi method, ANP, and TOPSIS, this study can make better decisions in selecting the optimal locations for Taiwanese service apartments. The proposed framework has increased the efficiency of the decision-making process in location selection. The fuzzy Delphi method can create a better criteria selection. TOPSIS eliminates many procedures that are performed in ANP and enables the system to reach a conclusion in a shorter time. Additionally, this model can assist managers of Taiwanese service apartments in performing similar multiple criteria tasks objectively and systematically during optimal location selection. In this paper, the C.R. of each pairwise comparison is <0.1, which means that the reliability of the data is acceptable.

We only retain 12 important criteria in this paper to structure the hierarchy for selecting the optimal locations. We suggest that future research studies incorporate more criteria in order to make more accurate estimates. Additionally, ANP and TOPSIS ignore the fuzziness of the executives' judgment during the decision-making process. We suggest that follow-up researchers analyze this topic with the concept of fuzzy sets.

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