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# An ANP based TOPSIS approach for Taiwanese service apartment location selection

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A B S T R A C T

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