International Journal of Strategic Property Management
ISSN: 1648-715X / eISSN: 1648-9179
2022 Volume 26 Issue 4: 258–271
https://doi.org/10.3846/ijspm.2022.17168

# EXPLORING HOTEL APPRAISAL DETERMINANTS AMID SALES TREND DURING COVID-19 PANDEMIC: USING A DANP-mV MODEL

Chui-Hua LIU[1,*], Bochner LIU[2]

[1] *Department of Tourism & Hospitality, Kainan University, Taoyuan, Taiwan*
[2] *Antai College of Economics and Management, Shanghai Jiao Tong University, Shanghai, China*

Received 10 July 2021; accepted 14 June 2022

**Abstract.** In the current hotel sales trend due to COVID-19 pandemic, few empirical studies have discussed hotel appraisal determinants and prioritization in terms of operational efficiency. This paper presents an innovative approach for appraisal practice efficiency based on hotel appraisal approach and the multiple criteria decision making (MCDM). The DANP-mV model is used to identify the determinants related to actual hotel appraisal practices, including the techniques of the decision-making trial and evaluation laboratory (DEMATEL), DEMATEL-based ANP (DANP), and modified VIKOR. The result of influential network relationship map (INRM) and the gaps of determinants to the aspiration level may contribute to improving hotel appraisal efficacy. In practice, the "discounted cash flow" becomes the most influential determinant (dimension) and the "market survey" is the most manageable one. More findings together with an action plan are presented and useful in the real world. Therefore, this innovative approach could help hotel appraisers and related parties, such as hospitality managers, investors, lenders, and decision makers, better manage the evaluation determinants of hotel appraisal efficacy.

**Keywords:** hotel appraisal, hotel appraisal approach, DANP-mV model, human problem solving theory, hotel evaluation determinants.

## Introduction

Taiwanese tourism has suffered a downturn (Liu, 2020; Liu & Liu, 2021). The COVID-19 pandemic has aggravated this situation (World Travel & Tourism Council, 2020). Consequently, several hotels in Taiwan are up for sale due to the financial distress caused by the pandemic (Good Earth CPA, 2017) (Figure 1). Some currently active buyers may be opportunistic. These buyers, such as High Wealth Construction in Taiwan, seek a high discount for hotel properties in financial distress (China Times, 2021; Hotel Business, 2020). In 2011, international tourists in Taiwan spent the most on lodging, approximately 35.06% of total tourist expenditure (Taiwan Tourism Bureau, 2020a). Some investors may gamble on tourism recovery expecting market rebound benefits.

However, the uncertainties and associated risks concern hospitality managers, investors, lenders, and other decision-makers in the lodging market (Singh & Schmidgall, 2005). Hotel appraisers have received criticism for reporting inaccurate evaluation values (Dalbor & Andrew, 2000). This problem seems particularly challenging for new hotel appraisers in the hospitality evaluation business with limited experience in Taiwan, where the valuation of lodging real estate has gained recent popularity.

An efficient hotel appraisal could confirm the liability of an investment project or reduce its cost, but an inefficient appraisal causes misjudgment or even the breakdown of the financial structure, resulting in the project's complete failure (Lin, 2006). An efficient appraisal practice is crucial for all related parties in hotel investment (Dalbor & Andrew, 2000), particularly for the less mature appraisal market (Liu et al., 2012a). Taiwanese appraisers follow the Real Estate Appraisal Techniques Guide while making rational adjustments based on facts (Chen, 2011).

Nevertheless, few studies have addressed hotel appraisals and offered empirical results, particularly about lodging appraisals. Dalbor and Andrew (2000) focused on hotel agency problems; Corgel and deRoos (1993) used a multi-regression model to determine the effects of sellers

*Corresponding author. E-mail: *liu32lee@mail.knu.edu.tw*


Figure 1. Some tourist hotels in Taiwan disclosed online for sale by real estate agents (photos by authors)

and buyers on the accuracy of hotel appraisal prices. Singh and Schmidgall (2005) predicted key events and impacts on hotel investments. Although Liu et al. (2012a) reported the elements influencing efficiency hotel appraisal efficiency, they did not examine the appraisal determinants and their prioritizations for decision-makers in the real world.

Thus, the following research queries have been raised, particularly regarding the sales trend due to the COVID-19 pandemic. What determinants require typical/rational consideration of Taiwanese appraisers while conducting lodging appraisers? What is the prioritization of these determinants? What is their ranking? What models can be developed to manage these determinants and improve appraisal efficiency?

This study addresses the abovementioned questions by identifying the determinants of hotel evaluation in the current Taiwanese hotel sales trend. The DANP-mV model was used because it is based on the mature multiple criteria decision making (MCDM) theory (Fontela & Gabus, 1976; Gabus & Fontela, 1973) while having a well-modified calculation efficacy (Lin et al., 2019; Liu, 2020b; Liu & Liu, 2021). Furthermore, the MCDM model is superior in providing alternatives to human problems. MCDM techniques have worked appropriately for inherently intricate and complicated issues in the real world (Lin et al., 2021). Therefore, the DANP-mV model applies to actual appraisal assignments and determines the relationships associated with determinants. Thus, the research purpose is achieved by the following. (1) using DEMATEL to sort out the interrelated criteria of hotel appraisal; (2) commanding DEMATEL-based ANP (DANP) to derive the influential values of hotel appraisal criteria; (3) employing the modified VIKOR (mV) to calculate the gap values for identifying performance of hotel appraisal determinants; and (4) integrating DANP-mV model with a prioritized action plan to help decision makers better manage the evaluation determinants of lodging real estate.

The following section contains a literature review on hotel appraisal in Taiwan, hotel appraisal theory, and the DANP-mV model human problem-solving theory. Section 2 outlines and discusses the methodology of the DANP-mV model. Section 3 presents the results, and the conclusions are drawn in final section.

## 1. Literature review

A review of the literature identified the hotel appraisal determinants. First, the most prevalent hotel property categories in Taiwan, the overall hotel appraisal approach, and practices, were defined. Moreover, the human problem-solving theory of DANP-mV was integrated. Thus, a conceptualized theoretical framework was constructed.

### 1.1. Hotel property categories in Taiwan

Taiwan classifies hotels using a single public standard, having laws defining hotel categories or ratings. Taiwanese hotels are divided into two formal categories based on Hotel Regulation: international tourist hotels and general hotels. Tourist hotels are larger than general hotels, and each accounted for 70 hotels with 20,361 rooms and 38 hotels/

properties with 5178 rooms, respectively (Taiwan Tourism Bureau, 2020b). Their main differences lie in construction standards, facilities, and service quality. These hotels have been rated under a star rating scheme since 2008. The Taiwan Tourism Bureau operates this scheme to unify the world star rating lines and adopt service quality as the rating criterion. Higher star ratings indicated more luxury (Taiwan Tourism Bureau, 2020a). Finally, some hotels were classified as real estate investment trusts (REITs). There are only two REIT hotel properties in Taiwan; Sheraton Taipei and Green World Hotels. It reveals the infancy of Taiwanese hotel appraisals (Liu et al., 2012a). Hotel REITs were recognized as a significant asset class in the equity investment marketplace (Jackson, 2009).

These hotels were the research targets because they represented the current main property classifications of the Taiwanese lodging industry. Due to a lack of formal appraisal records, this research excluded other subcategories of hotel properties in Taiwan, ranging from resorts and motels supervised by local governments to bed and breakfast (B&B) accommodations.

### 1.2. Hotel appraisers in Taiwan

An appraisal is a professional appraiser's opinion of property value. According to Appraisal Institute, the preparation of an appraisal involves following aspects: researching into appropriate markets, collecting and analysing the information pertinent to a property; and the professional judgment of the appraiser (Appraisal Institute [AI], 2014). Based on information about the asset or property, these appraisal aspects determine its value based on several econometric indices (Lee et al., 2016). Thus, the profession is limited to experts, known as appraisers (Chang, 2019; Lin, 2006).

According to AI (2014), the appraiser provides objective, impartial, and unbiased opinions about a property's value. They are expected to assist those who own, manage, sell, invest in, and/or lend money to real-estate security. In the US, only licensed or certified appraisers can provide appraisals to federally regulated lenders (AI, 2014). However, some appraisers exceed these minimum requirements by participating in continuing education and following a code of professional ethics to obtain membership and designation certificates from leading professional organizations. The American Appraisal Institute (AMI) and the American Society of Appraisers are two such organizations (American Society of Appraisers [ASA], 2020; AI, 2014). This accreditation system has been used in the US for decades. However, several specialized hotel appraisers and appraisal firms (e.g., Hotel and Lodging Valuation Advisors [HLVA] and US Hotel Appraisals [USHA]) are unavailable in Taiwan.

The law governing real estate appraisers was initiated in Taiwan in 2000. A qualified real estate appraiser must adhere to the following. (1) Obtain a qualification certificate after passing a national examination; (2) possess a real estate appraiser license issued by the Department of Land Administration of the Ministry of Interior Affairs; (3) have a practice license issued by local governments with at least two years of experience; and (4) join the Real Estate Appraisers Association, following which the appraiser can operate an appraisal business independently. As of 2019, 726 people had passed the National Examination of Real Estate Appraisers. However, only 440 were practicing appraisers (Department of Land Administration, Ministry of Interior Affairs, 2020). Although both Taiwan and the US have professional real estate appraisers, Taiwanese appraisers are comparatively rarer, and only a few have conducted hotel appraisals. Therefore, an expert approach is necessary for hotel appraisals.

### 1.3. Hotel appraisal approaches

An appraisal is a professional opinion about the value of a property. It is frequently used to obtain financing and establish a market value for sale. An appraiser must collect and analyze all the necessary information (business enterprise or intangible assets) to develop an appraisal of credible assignment results (ASA, 2020). The first step in any real estate appraisal is gathering all the relevant data. The data may include evaluation documents (e.g., the estimation of the lender's report, the owner's estimate of the asset's value, or an investor's estimate), evaluation conditions (e.g., any affiliated conditions to hotel appraisal), and property data (e.g., recent financial reports, rents, or property information) (Liu et al., 2012a).

Market surveys are considered crucial because valuation aims to provide the most accurate estimate of a property's transaction price (Chang, 2019; Maliene, 2011). For lodging appraisal, a hotel's revenue is measured with the average daily rate (ADR), occupancy, and the estimated number of tourists (Taylor, 2003), which must be surveyed and compared with new, under-constructed, and rival hotels to gain a comprehensive picture of the market supply and demand. A hotel's operation is management-sensitive (Taylor, 2003), affected by its regional conditions (e.g., location, traffic system, public facilities, and large development projects) (Kisilevich et al., 2013) and individual conditions (e.g., interior maintenance, managerial system, and the use of the property) (Rushmore, 1992). A market survey must consider all these factors.

The traditional hotel valuation model has three commonly recognized approaches: (1) the sales comparison approach, (2) the cost approach, and (3) the income capitalization approach (Hinton, 2008). However, the sales comparison method is susceptible due to the following: (1) the lack of recent sales data, (2) numerous necessary insupportable adjustments, and (3) the general inability to determine the true financial terms and human motivations for comparable transactions. Thus, this technique renders frequent unreliable results (Deroos & Rushmore, 1995), and Taiwanese hotel appraisers seldom use it (Liu et al., 2012a).

The cost approach requires highly subjective depreciation estimates for buildings and other improvements or maintenance, including the costs of rebuilding or relocating. Consequently, accurately quantifying the resultant loss in value becomes increasingly difficult (Deroos & Rushmore, 1995). Whether estimating the land cost via the comparison or land development technique, this approach is susceptible to subjective human judgment. Therefore, Taiwanese appraisers prefer using the income-capitalization approach with minimal weight on the cost approach. The land, building, and maintenance costs are all considered while using the cost approach.

Generally, the income capitalization approach is considered the most persuasive and supportable conclusion for lodging facilities (Rushmore, 1984) because it includes the present worth of future benefits.

Thus, Roubi (2004) suggests assuming direct capitalization methods of the income approach rather than discounted cash flow models. Among the future benefits, a hotel is a typical income-producing property. Forecasting income and expenses estimate the net income of the hotel property. It results in anticipated proceeds from future sales. However, the discounted cash flow technique is considered superior for providing a more realistic estimate of a hotel firm's value (Fu et al., 2013). These benefits can be converted into an indication of market value through a capitalization process using a discounted cash flow analysis (Deroos & Rushmore, 1995; Hinton, 2008). It is particularly useful for managing international tourist hotel appraisals (Chang, 1995; Chang, 2019; Lung, 2010). The total income, expenses, and capitalization rate are all accounted for while calculating the discounted cash flow (Liu et al., 2012a). Table 1 lists the determinants integrated into the dimensions and criteria and considered in actual hotel evaluation practices.

### 1.4. MCDM human problem solving theory and hotel appraisal

The MCDM human problem-solving theory simultaneously considers multiple criteria to help estimate the best alternatives. It resolves complex human problems according to the criteria for each available case. It means using a compromise solution tool for problems tangled in conflict, complex, and unpredictable criteria in actual human life. MCDM, combined with several methods such as DEMATEL, DANP, and mV, has proven useful in solving human problems in various domains (e.g., Liu, 2020; Zhu et al., 2017; Liu et al., 2012b, 2012c; Yang & Tzeng, 2011).

The DEMATEL technique was developed by the Battelle Memorial Institute of Geneva between 1972 and 1976 (Fontela & Gabus, 1976; Gabus & Fontela, 1973). Since human thoughts are too complicated to manage using tables only, the DEMATEL technique uses a visual model to depict complex relations via matrices of mathematical theories. This method assumes that the criteria are independent and hierarchical in structure. They keep releasing the feedback effects simultaneously. These effects can

Table 1. The dimensions of influence and criteria associated with hotel appraisal practice

| Code | Dimensions/criteria | Context of criteria | Sources |
|---|---|---|---|
| $D_1$ | Evaluation premise | | Liu et al. (2012a); Maliene (2011); Taylor (2003); Kisilevich et al. (2013); Rushmore (1992); Lee et al. (2011, 2016) |
| $C_1$ | Evaluation purposes | Lender's report, owner's estimation of asset value, or investor's estimation | |
| $C_2$ | Evaluation conditions | Any affiliated conditions to hotel appraisal | |
| $C_3$ | Property data | Recently financial report, rents, property information | |
| $D_2$ | Market survey | | Liu et al. (2012a); Rushmore (1984, 1992); Taylor (2003); Lee et al. (2011, 2016) |
| $C_4$ | Supply-demand | Analysing the current supply and demand of hotels, e.g., new hotels, rivals, occupancy rate, averaged room rates, incomes, tourist estimation. | |
| $C_5$ | Regional conditions | Location, traffic system, public facilities, large development project | |
| $C_6$ | Individual conditions | Interior maintenances, management, and utilisation of the property | |
| $D_3$ | Cost analysis | | Deroos and Rushmore (1995); Hinton (2008); Liu et al. (2012a); Lee et al. (2016) |
| $C_7$ | Land cost | Using the Comparison approach or Land Development technique to analyse land cost | |
| $C_8$ | Building cost | Rebuilding cost or reallocating cost | |
| $C_9$ | Maintenances | Listing the recent maintenance expenses | |
| $D_4$ | Discounted cash flow | | Chang (1995); Deroos and Rushmore (1995); Hinton (2008); Liu et al. (2012a); Lung (2010); Rubi (2004); Fu and Lang (2013); Lee et al. (2016) |
| $C_{10}$ | Total income | Business income or room revenue the owner received | |
| $C_{11}$ | Total expense | All the related expenses of the property | |
| $C_{12}$ | Capitalisation rate | A stabilised estimate of net income capitalised rate considering all the management risks involved | |

be calculated and converted into an intelligible structural model using a visual map through matrices. It is technically termed an "influential network relation map (INRM)," presenting network relations between criteria in a map and depicting solutions for human problems (Lin et al., 2019; Liu, 2020; Qu et al., 2019; Zhu et al., 2017).

DEMATEL is more efficient in calculating the influential weights of each criterion as it is combined with Saaty's ANP (Saaty, 1996). It is known as the ANP-based technique (DANP). Similar to AHP's pairwise comparisons (Zhuang et al., 2018), DANP further avoids tediousness, resulting in repeated pair comparisons (Liu et al., 2019). In the DEMATEL procedure, the influence weight of the criteria can be obtained and used to calculate the gap to the optimal level (in the mV method) (Liu et al., 2013a, 2013b).

The VIKOR method was modified because of the drawback of choosing the best among inferiors (Opricovic & Tzeng, 2004, 2007). The mV method was the first to establish the baseline of the best choice (optimal level). The mean group utility is the sum of all individual regrets (i.e., an average of performance values and gap of each dimension/criterion) and maximum regret (i.e., maximum gap). Therefore, an individual criterion's value can be calculated more reasonably using the baseline. Each criterion's priority can be ranked according to the gap values. Therefore, mV can choose the best among the superior alternatives and solve human problems more efficiently (Lin et al., 2019; Liu, 2020; Qu et al., 2019; Zhu et al., 2017).

Accordingly, this intelligent joint method is called the DANP-mV model. The model was proven useful for solving human problems in many domains, such as the TFT-LCD industry (Lu et al., 2016), quality life in rural residences (Qu et al., 2019), health care system (Lin et al., 2019), public space planning of elderly people (Zhu et al., 2017), and managing coach driver job stress (Liu, 2020b). Since hotel appraisal is inherently multidimensional and requires expertise (Corgel & deRoos, 1993), we supposed an expert survey using the DANP-mV model would be appropriate for our current study.

## 2. Methodology

Considering the superiority of MCDM in solving human problems, this research used the DANP-mV model to identify the determinants and prioritization of hotel appraisals. The research methodology was designed within the DANP-mV process as follows.

### 2.1. Building a DANP-mV model evaluation system for hotel appraisal efficacy

Research construction of the DANP-mV model was initiated. Furthermore, an evaluation system in a hierarchical layout with multiple criteria based on MCDM theory was established (Lin et al., 2019; Liu, 2020; Qu et al., 2019; Zhu et al., 2017). This study addresses hotel appraisal determinants (derived from the literature review in Section 1), including four dimensions and 12 criteria with 28 items (Table 1, Figure 2).

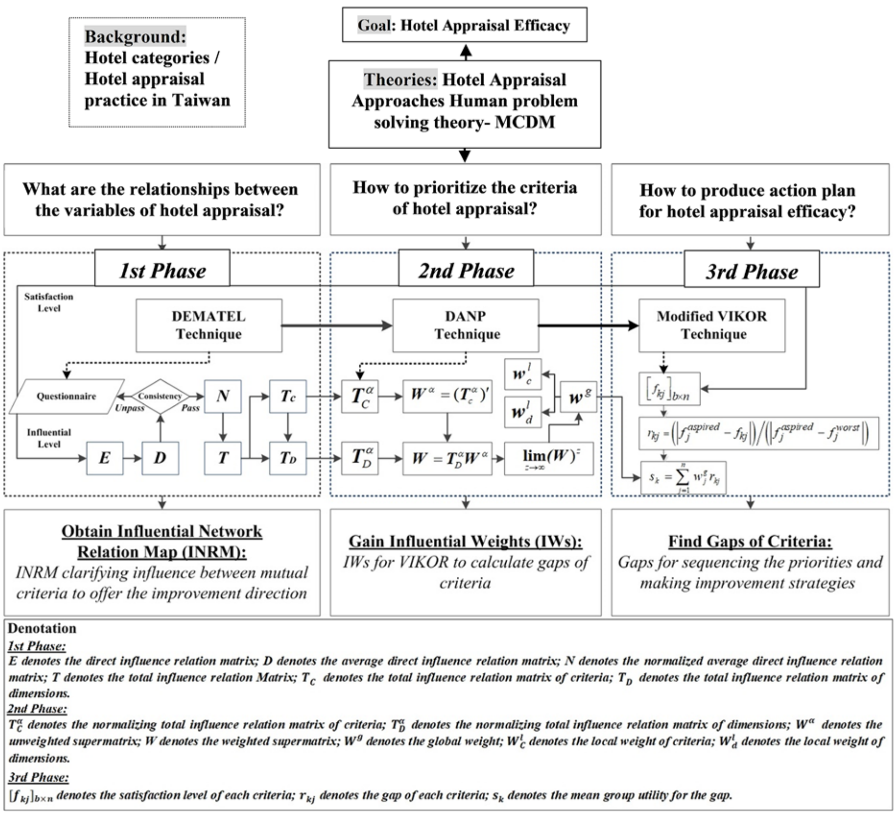


Figure 2. Conceptual framework and research layout and procedures of DANP-mV

### 2.2. Sampling and data collection

The initial expert questionnaire was developed based on a literature review. Since hotel appraisal is inherently multi-dimensional and requires expertise (Corgel & deRoos, 1993), data collection is required a "group decision-making method". A content survey was distributed to a panel of five content experts, including three real estate appraisers with ten or more years of experience, besides two who had conducted hotel appraisals and taught part-time at universities in Taipei. The α values were greater than 0.8, verifying the content reliability of the tool (DeVellis, 2016).

Furthermore, a formal survey was conducted with an expert group of 20 real estate appraisers having a minimum of five years of experience in hotel appraisal. The survey was sent via email or social media (to avoid face-to-face interviews during the pandemic). A 5-point scale, ranging from 0 (no effect) to 4 (extremely influential), was used to collect responses for each criterion. The results of the consistency test showed a significant confidence level of 95.94% (larger than 95%). The gap error was 4.06% (<5%). It indicated a strong consensus among experts (Table 2).

$$\frac{1}{n^2}\sum_{i=1}^{n}\sum_{j=1}^{n}\frac{\left|t_{ij}^{n}-t_{ij}^{n-1}\right|}{t_{ij}^{n}}\times 100\% = 4.06\% < 5\%, \text{ where } t_{ij}^{p}$$

and $t_{ij}^{p-1}$ denote the average influence of $i$ criterion to $j$ by $p$ = 20 (appraisers); $n$ = 12 denotes the numbers of criteria.

### 2.3. Research procedure

The DANP-mV model used in this study was processed in three phases (Figure 2).

Phase 1: To develop the INRM using DEMATEL

Through the questionnaire survey (from 0/ no influence to 4/extreme influence), the opinions of experts were obtained. Further, DEMATEL was used to develop initial matrix and calculate the relation matrix of the total influence of dimensions $\boldsymbol{T}_D$ and criteria $\boldsymbol{T}_C$. The calculations are as follows (Liu et al., 2019; Liu, 2020; Liu et al., 2013a, 2013b; Liu & Liu, 2021; Zhu et al., 2017).

Step 1: Form the initial influence matrix $\boldsymbol{E}$

Pairwise comparison was used to obtain the initial influence matrix $\boldsymbol{E}=[E_{ij}]_{n\times n}$, where $E_{ij}$ represents the degree of effect of factor $i$ on factor $j$.

$$\boldsymbol{E}=\begin{bmatrix} E_{11} & \cdots & E_{1j} & \cdots & E_{1n} \\ \vdots & & \vdots & & \vdots \\ E_{i1} & \cdots & E_{ij} & \cdots & E_{in} \\ \vdots & & \vdots & & \vdots \\ E_{n1} & \cdots & E_{nj} & \cdots & E_{nn} \end{bmatrix}. \quad (1)$$

Step 2: Calculate the direct influence relationship matrix $\boldsymbol{D}$

Average values were used to integrate expert opinions to obtain the direct influence relationship matrix $\boldsymbol{D}=[D_{ij}]_{n\times n}$ shown in Eq. (2).

$$\boldsymbol{D}=\begin{bmatrix} D_{11} & \cdots & D_{1j} & \cdots & D_{1n} \\ \vdots & & \vdots & & \vdots \\ D_{i1} & \cdots & D_{ij} & \cdots & D_{in} \\ \vdots & & \vdots & & \vdots \\ D_{n1} & \cdots & D_{nj} & \cdots & D_{nn} \end{bmatrix}. \quad (2)$$

Step 3: Calculate the normalized direct influence relationship matrix $\boldsymbol{N}$

Matrix was normalized using Eqs (3) and (4), respectively. Its diagonal is 0, and the maximum sum of the rows or columns is 1.

$$\boldsymbol{N}=\Omega\boldsymbol{D}=\begin{bmatrix} N_{11} & \cdots & N_{1j} & \cdots & N_{1n} \\ \vdots & & \vdots & & \vdots \\ N_{i1} & \cdots & N_{ij} & \cdots & N_{in} \\ \vdots & & \vdots & & \vdots \\ N_{n1} & \cdots & N_{nj} & \cdots & N_{nn} \end{bmatrix}. \quad (3)$$

Table 2. Total influential effect matrix $T$ of criteria

| $T$ | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ | $C_8$ | $C_9$ | $C_{10}$ | $C_{11}$ | $C_{12}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_1$ | 0.492 | 0.531 | 0.562 | 0.610 | 0.556 | 0.560 | 0.491 | 0.499 | 0.509 | 0.533 | 0.524 | 0.536 |
| $C_2$ | 0.540 | 0.429 | 0.522 | 0.559 | 0.515 | 0.529 | 0.458 | 0.466 | 0.477 | 0.499 | 0.492 | 0.501 |
| $C_3$ | 0.628 | 0.593 | 0.544 | 0.664 | 0.594 | 0.630 | 0.512 | 0.547 | 0.586 | 0.610 | 0.598 | 0.567 |
| $C_4$ | 0.628 | 0.581 | 0.629 | 0.604 | 0.651 | 0.642 | 0.555 | 0.550 | 0.574 | 0.614 | 0.587 | 0.608 |
| $C_5$ | 0.530 | 0.488 | 0.513 | 0.613 | 0.467 | 0.532 | 0.481 | 0.466 | 0.474 | 0.518 | 0.492 | 0.505 |
| $C_6$ | 0.627 | 0.596 | 0.646 | 0.698 | 0.634 | 0.576 | 0.562 | 0.581 | 0.605 | 0.624 | 0.614 | 0.600 |
| $C_7$ | 0.580 | 0.538 | 0.553 | 0.643 | 0.599 | 0.594 | 0.428 | 0.492 | 0.504 | 0.524 | 0.518 | 0.524 |
| $C_8$ | 0.577 | 0.542 | 0.574 | 0.611 | 0.568 | 0.603 | 0.481 | 0.441 | 0.536 | 0.531 | 0.545 | 0.523 |
| $C_9$ | 0.601 | 0.566 | 0.631 | 0.643 | 0.592 | 0.637 | 0.505 | 0.555 | 0.492 | 0.585 | 0.588 | 0.562 |
| $C_{10}$ | 0.677 | 0.629 | 0.694 | 0.747 | 0.686 | 0.694 | 0.556 | 0.580 | 0.625 | 0.565 | 0.626 | 0.633 |
| $C_{11}$ | 0.655 | 0.606 | 0.674 | 0.707 | 0.646 | 0.673 | 0.562 | 0.580 | 0.625 | 0.623 | 0.539 | 0.606 |
| $C_{12}$ | 0.631 | 0.577 | 0.604 | 0.680 | 0.620 | 0.617 | 0.511 | 0.529 | 0.559 | 0.585 | 0.568 | 0.500 |

$$\boldsymbol{\Omega} = \min\left[\frac{1}{\max_i \sum_{j=1}^{n}|D_{ij}|}, \frac{1}{\max_j \sum_{i=1}^{n}|D_{ij}|}\right],\ i,j = 1,2,\ldots,n\,. \tag{4}$$

Step 4: Calculate the total influence relationship matrix $\boldsymbol{T}$

Matrix can be calculated using Eq. (5), where $\boldsymbol{I}$ is the identity matrix. Eq. (5) can be deduced from Eq. (6), which can be obtained using $\boldsymbol{T} = \boldsymbol{N} + \boldsymbol{N}^2 + \cdots + \boldsymbol{N}^h$ when $\lim_{h\to\infty} \boldsymbol{N}^h = [0]_{n\times n}$.

$$\boldsymbol{N}(\boldsymbol{I} - \boldsymbol{N})^{-1}; \tag{5}$$

$$\begin{aligned}\boldsymbol{T} &= \boldsymbol{N} + \boldsymbol{N}^2 + \cdots + \boldsymbol{N}^h \\ &= \boldsymbol{N}(I + \boldsymbol{N} + \boldsymbol{N}^2 + \cdots + \boldsymbol{N}^{h-1})\left[(\boldsymbol{I} - \boldsymbol{N})(\boldsymbol{I} - \boldsymbol{N})^{-1}\right] \\ &= \boldsymbol{N}(\boldsymbol{I} - \boldsymbol{N}^h)(\boldsymbol{I} - \boldsymbol{N})^{-1} \\ &= \boldsymbol{N}(\boldsymbol{I} - \boldsymbol{N})^{-1}, \text{when } h \to \infty, \boldsymbol{N}^h = \left[0\right]_{n\times n}.\end{aligned} \tag{6}$$

Step 5: Obtain the evaluation system influence relationship ($\boldsymbol{r}, \boldsymbol{s}, r_i + s_i, r_i - s_i$).

Obtain prominence and relation by totaling. Sum each row and column of the total influence matrix $\boldsymbol{T} = [t_{ij}]$ to obtain the sum of all rows (vector $\boldsymbol{r} = [r_i]_{n\times 1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} = (r_1,\ldots,r_i,\ldots,r_n)'$) and the sum of all columns (vector $\boldsymbol{s} = [s_j]_{1\times n} = \left[\sum_{i=1}^{n} t_{ij}\right]_{1\times n} = (s_1,\ldots,s_j,\ldots,s_n)$). "$r_i + s_i$" refers to the total degree of influence, "$r_i - s_i$" refers to the degree of net influence.

Phase 2: To obtain influence weights using DANP

DANP has the basic concept of ANP. The first is to develop a relation matrix of the total influence derived from the first phase. Subsequently, the total influence is used to calculate the influential weights (IWs) or global weights of the criteria (vector). The IWs were obtained by multiplying the weighted supermatrix $\boldsymbol{W}^{\alpha}$ until $\boldsymbol{W}^{\alpha}$ converged (Table 4). These influence weights can be reused for the mV calculations. DANP was processed as follows (Liu & Liu, 2021; Liu, 2018, 2020; Liu et al., 2013a, 2013b; Zhu et al., 2017).

Step 1: Develop the unweighted supermatrix

Develop the unweighted supermatrix and normalize each level with the total influence degree from the total influence matrix $\boldsymbol{T}$ of DEMATEL as shown in Eq. (7).

$$\boldsymbol{T}_c = \begin{array}{c} D_1\ c_{11}\ c_{12} \cdots c_{1m_1} \\ \vdots \\ D_i\ c_{i1}\ c_{i2} \cdots c_{im_i} \\ \vdots \\ D_n\ c_{n1}\ c_{n2} \cdots c_{nm_n} \end{array} \overset{\begin{array}{ccc} D_1 & D_j & D_n \\ c_{11}\ldots c_{1m_1} \cdots & c_{j1}\ldots c_{jm_j} \cdots & c_{n1}\ldots c_{nm_n} \end{array}}{\begin{bmatrix} T_c^{11} & \cdots & T_c^{1j} & \cdots & T_c^{1n} \\ \vdots & & \vdots & & \vdots \\ T_c^{i1} & \cdots & T_c^{ij} & \cdots & T_c^{in} \\ \vdots & & \vdots & & \vdots \\ T_c^{n1} & \cdots & T_c^{nj} & \cdots & T_c^{nn} \end{bmatrix}}. \tag{7}$$

Step 2: Normalize $\boldsymbol{T}_c$ with the total degree of effect and obtain $\boldsymbol{T}_c^{\alpha}$, as shown in Eq. (8).

$$\boldsymbol{T}_C^{\alpha} = \begin{array}{c} D_1\ c_{11}\ c_{12} \cdots c_{1m_1} \\ \vdots \\ D_i\ c_{i1}\ c_{i2} \cdots c_{im_i} \\ \vdots \\ D_n\ c_{n1}\ c_{n2} \cdots c_{nm_n} \end{array} \overset{\begin{array}{ccc} D_1 & D_j & D_n \\ c_{11}\ldots c_{1m_1} \cdots & c_{j1}\ldots c_{jm_j} \cdots & c_{n1}\ldots c_{nm_n} \end{array}}{\begin{bmatrix} T_c^{\alpha 11} & \cdots & T_c^{\alpha 1j} & \cdots & T_c^{\alpha 1n} \\ \vdots & & \vdots & & \vdots \\ T_c^{\alpha i1} & \cdots & T_c^{\alpha ij} & \cdots & T_c^{\alpha in} \\ \vdots & & \vdots & & \vdots \\ T_c^{\alpha n1} & \cdots & T_c^{\alpha nj} & \cdots & T_c^{\alpha nn} \end{bmatrix}}. \tag{8}$$

Then, normalize $\boldsymbol{T}_c^{\alpha 11}$ using Eqs (9) and (10), and repeat to obtain $\boldsymbol{T}_c^{\alpha nn}$.

$$d_i^{11} = \sum_{j=1}^{m_1} t_{c\,ij}^{11},\ i = 1,2,\ldots,m_1; \tag{9}$$

$$\boldsymbol{T}_C^{\alpha 11} = \begin{bmatrix} t_{c11}^{11}/d_1^{11} & \cdots & t_{c1j}^{11}/d_1^{11} & \cdots & t_{c1m_1}^{11}/d_1^{11} \\ \vdots & & \vdots & & \vdots \\ t_{ci1}^{11}/d_i^{11} & \cdots & t_{cij}^{11}/d_i^{11} & \cdots & t_{cim_1}^{11}/d_i^{11} \\ \vdots & & \vdots & & \vdots \\ t_{cm_11}^{11}/d_{m_1}^{11} & \cdots & t_{cm_1j}^{11}/d_{m_1}^{11} & \cdots & t_{cm_1m_1}^{11}/d_{m_1}^{11} \end{bmatrix} = \begin{bmatrix} t_{c11}^{\alpha 11} & \cdots & t_{c1j}^{\alpha 11} & \cdots & t_{c1m_1}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_{ci1}^{\alpha 11} & \cdots & t_{cij}^{\alpha 11} & \cdots & t_{cim_1}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_{cm_11}^{\alpha 11} & \cdots & t_{cm_1j}^{\alpha 11} & \cdots & t_{cm_1m_1}^{\alpha 11} \end{bmatrix}. \tag{10}$$

The total effect matrix is normalized into the supermatrix. Then it goes further to obtain the unweighted supermatrix, as shown in Eq. (11).

$$\boldsymbol{W} = (\boldsymbol{T}_c^{\alpha})' = \begin{array}{c} D_1\ c_{11}\ c_{12} \cdots c_{1m_1} \\ \vdots \\ D_j\ c_{j1}\ c_{j2} \cdots c_{jm_j} \\ \vdots \\ D_n\ c_{n1}\ c_{n2} \cdots c_{nm_n} \end{array} \overset{\begin{array}{ccc} D_1 & D_i & D_n \\ c_{11}\ldots c_{1m_1} \cdots & c_{i1}\ldots c_{im_i} \cdots & c_{n1}\ldots c_{nm_n} \end{array}}{\begin{bmatrix} W^{11} & \cdots & W^{i1} & \cdots & W^{n1} \\ \vdots & & \vdots & & \vdots \\ W^{1j} & \cdots & W^{ij} & \cdots & W^{nj} \\ \vdots & & \vdots & & \vdots \\ W^{1n} & \cdots & W^{in} & \cdots & W^{nn} \end{bmatrix}}. \tag{11}$$

Both matrices $\boldsymbol{W}^{11}$ and $\boldsymbol{W}^{12}$ can be obtained by Eq. (12). A blank space or 0 in the matrix implies that the group or criterion is independent. Similarly, the matrix $\boldsymbol{W}^{nn}$ is calculated.

$$\boldsymbol{W}^{11} = (\boldsymbol{T}^{11})' = \begin{array}{c} \\ c_{11} \\ \vdots \\ c_{1j} \\ \vdots \\ c_{1m_1} \end{array} \begin{array}{c} \begin{array}{ccccc} c_{11} & \cdots & c_{1i} & \cdots & c_{1m_1} \end{array} \\ \begin{bmatrix} t_{c11}^{\alpha 11} & \cdots & t_{ci1}^{\alpha 11} & \cdots & t_{cm_1 1}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_{c1j}^{\alpha 11} & \cdots & t_{cij}^{\alpha 11} & \cdots & t_{cm_1 j}^{\alpha 11} \\ \vdots & & \vdots & & \vdots \\ t_{c1m_1}^{\alpha 11} & \cdots & t_{cim_1}^{\alpha 11} & \cdots & t_{cm_1 m_1}^{\alpha 11} \end{bmatrix} \end{array}. \quad (12)$$

Step 3: Obtain the weighted supermatrix by deriving the matrix of the total effect of dimensions $\boldsymbol{T}_D$ using Eq. (13). Then, $\boldsymbol{T}_D$ is normalized to obtain $\boldsymbol{T}_D^{\alpha}$, as shown in Eq. (14). $d_i = \sum_{j=1}^{n} t_D^{ij}$, $i = 1,2,...,n$.

$$\boldsymbol{T}_D = \begin{bmatrix} t_D^{11} & \cdots & t_D^{1j} & \cdots & t_D^{1n} \\ \vdots & & \vdots & & \vdots \\ t_D^{i1} & \cdots & t_D^{ij} & \cdots & t_D^{in} \\ \vdots & & \vdots & & \vdots \\ t_D^{n1} & \cdots & t_D^{nj} & \cdots & t_D^{nn} \end{bmatrix}, \quad (13)$$

$$\boldsymbol{T}_D^{\alpha} = \begin{bmatrix} t_D^{11}/d_1 & \cdots & t_D^{1j}/d_1 & \cdots & t_D^{1n}/d_1 \\ \vdots & & \vdots & & \vdots \\ t_D^{i1}/d_2 & \cdots & t_D^{ij}/d_2 & \cdots & t_D^{in}/d_2 \\ \vdots & & \vdots & & \vdots \\ t_D^{n1}/d_n & \cdots & t_D^{nj}/d_n & \cdots & t_D^{nn}/d_n \end{bmatrix} = \begin{bmatrix} t_D^{\alpha 11} & \cdots & t_D^{\alpha 1j} & \cdots & t_D^{\alpha 1n} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha i1} & \cdots & t_D^{\alpha ij} & \cdots & t_D^{\alpha in} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha n1} & \cdots & t_D^{\alpha nj} & \cdots & t_D^{\alpha nn} \end{bmatrix}. \quad (14)$$

The normalized $\boldsymbol{T}_D^{\alpha}$ is transformed into the unweighted supermatrix $\boldsymbol{W}$ ready for calculating the weighted supermatrix $\boldsymbol{W}^{\alpha}$. It is shown in Eq. (15).

$$\boldsymbol{W}^{\alpha} = \boldsymbol{T}_D^{\alpha}\boldsymbol{W} = \begin{bmatrix} t_D^{\alpha 11} \times W^{11} & \cdots & t_D^{\alpha i1} \times W^{i1} & \cdots & t_D^{\alpha n1} \times W^{n1} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha 1j} \times W^{1j} & \cdots & t_D^{\alpha ij} \times W^{ij} & \cdots & t_D^{\alpha nj} \times W^{nj} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha 1n} \times W^{1n} & \cdots & t_D^{\alpha in} \times W^{in} & \cdots & t_D^{\alpha nn} \times W^{nn} \end{bmatrix}. \quad (15)$$

Step 4: Obtain the limit supermatrix. Let the weighted supermatrix $\boldsymbol{W}^{\alpha}$ multiply itself multiple times to obtain the limit supermatrix. The DANP weights of each criterion can then be obtained by $\lim_{z \to \infty} (\boldsymbol{W}^{\alpha})^z$, where $z$ represents any number for power.

Phase 3: To calculate the performance/gap values using mV

The mV method is used to calculate the values of performance and gap of each criterion/determinants to the optimal level. The mV process is simplified as follows (Liu, 2018, 2020; Liu & Liu, 2021; Opricovic, 1998; Opricovic & Tzeng, 2002; Tzeng et al., 2005; Tzeng & Huang, 2011; Zhu et al., 2017).

Step 1: Set the optimal level and the worst value.

We define the best value (optimal level) as $f_j^{aspired}$ for $j$ criterion and the worst value $f_j^{worst}$ for all criteria to fit the real-world. The performance scores ranged from 0 to 10 (strongly disagree ← 0, 1, 2, ⋯, 9, 10 → strongly agree) with natural language in this research besides a linguistic/semantic questionnaire.

The optimal level: $f^{aspired} = (f_1^{aspired}, ..., f_j^{aspired}, ..., f_n^{aspired})$, where $f_j^{aspired}$ is labeled "the best value".

Hence, $f_j^{aspired} = 10$ is defined as the optimal level.

The worst values: $f^{worst} = (f_1^{worst}, ..., f_j^{worst}, ..., f_n^{worst})$, where $f_j^{worst}$ is labeled "the worst value".

So $f_j^{worst} = 0$ as the worst value. It avoids choosing the best among inferiors.

Step 2: Determine the mean group utility for the gap.

These values can be calculated using Eq. (16):

$$s_k = \sum_{j=1}^{n} w_j r_{kj} = \sum_{j=1}^{n} w_j (|f_j^{aspired} - f_{kj}|)/(|f_j^{aspired} - f_j^{worst}|), \quad (16)$$

where $s_k$ is defined as the normalized ratio (%) of the distance to the optimal level. Synthesized gap of the criteria. $w_j$ is the IWs for the criteria and obtained from DANP.

## 3. Empirical case analysis for hotel appraisal practice

An empirical case study was conducted using expert hotel appraisers in Taiwan. The collected data were analyzed using the DANP-mV model, including the DEMATEL, DANP, and mV techniques. The results were twofold: the INRM by DEMATEL and Gap values by mV based on DANP. These are discussed below.

### 3.1. INRM of hotel appraisal determinants by DEMATEL

The opinions of expert appraisers were analysed by the DEMATEL technique. Based upon the initial matrix $\boldsymbol{E}$, the total effect matrix $\boldsymbol{T}$ of criteria (Table 2) showing the overall influential effect was calculated and tested of the significant confidence (4.06% < 5%), implying the reliability of the survey. Moreover, it was further used to derive the influence relation $(r_i - s_i)$ in Table 3. Among the dimensions, the discounted cash flow ($D_4$) with the largest influence value of 0.225 has the strongest direct effect to impact, followed by cost analysis ($D_3$) (0.115) and market survey ($D_2$) (–0.170). Contrarily, the evaluation premise ($D_1$) is most vulnerable to impact with the smallest influence value of –0.171. Figure 3 illustrates these interrelated effects in network interactions, INRM. Each dimension with several criteria forms sub-network within the network, demonstrating the overall interactions between criteria. According to the influence relations, from large (to impact) to small (to be impacted), the influences of dimensions can be prioritized as: $D_4 \succ D_3 \succ D_2 \succ D_1$. The criteria can also be ranked using this rule.

Table 3. Result of dimensions/criteria analysis

| Code | Dimensions/criteria | $r$ | $s$ | $r_i + s_i$ | $r_i - s_i$ / ranking |
|---|---|---|---|---|---|
| $D_1$ | Evaluation premise | 2.162 | 2.332 | 4.494 | –0.171 (4) |
| $C_1$ | Evaluation purposes | 1.585 | 1.661 | 3.246 | –0.076 |
| $C_2$ | Evaluation conditions | 1.491 | 1.553 | 3.044 | –0.062 |
| $C_3$ | Property data | 1.765 | 1.628 | 3.393 | 0.137 |
| $D_2$ | Market survey | 2.296 | 2.466 | 4.762 | –0.170 (3) |
| $C_4$ | Supply-demand | 1.897 | 1.915 | 3.812 | –0.018 |
| $C_5$ | Regional conditions | 1.613 | 1.752 | 3.365 | –0.139 |
| $C_6$ | Individual conditions | 1.907 | 1.75 | 3.658 | 0.157 |
| $D_3$ | Cost analysis | 2.221 | 2.106 | 4.327 | 0.115 (2) |
| $C_7$ | Land cost | 1.423 | 1.415 | 2.838 | 0.009 |
| $C_8$ | Building cost | 1.459 | 1.488 | 2.947 | –0.029 |
| $C_9$ | Maintenances | 1.552 | 1.532 | 3.084 | 0.02 |
| $D_4$ | Discounted cash flow | 2.465 | 2.241 | 4.706 | 0.225 (1) |
| $C_{10}$ | Total income | 1.823 | 1.773 | 3.596 | 0.051 |
| $C_{11}$ | Total expense | 1.767 | 1.733 | 3.5 | 0.035 |
| $C_{12}$ | Capitalisation rate | 1.653 | 1.738 | 3.391 | –0.085 |

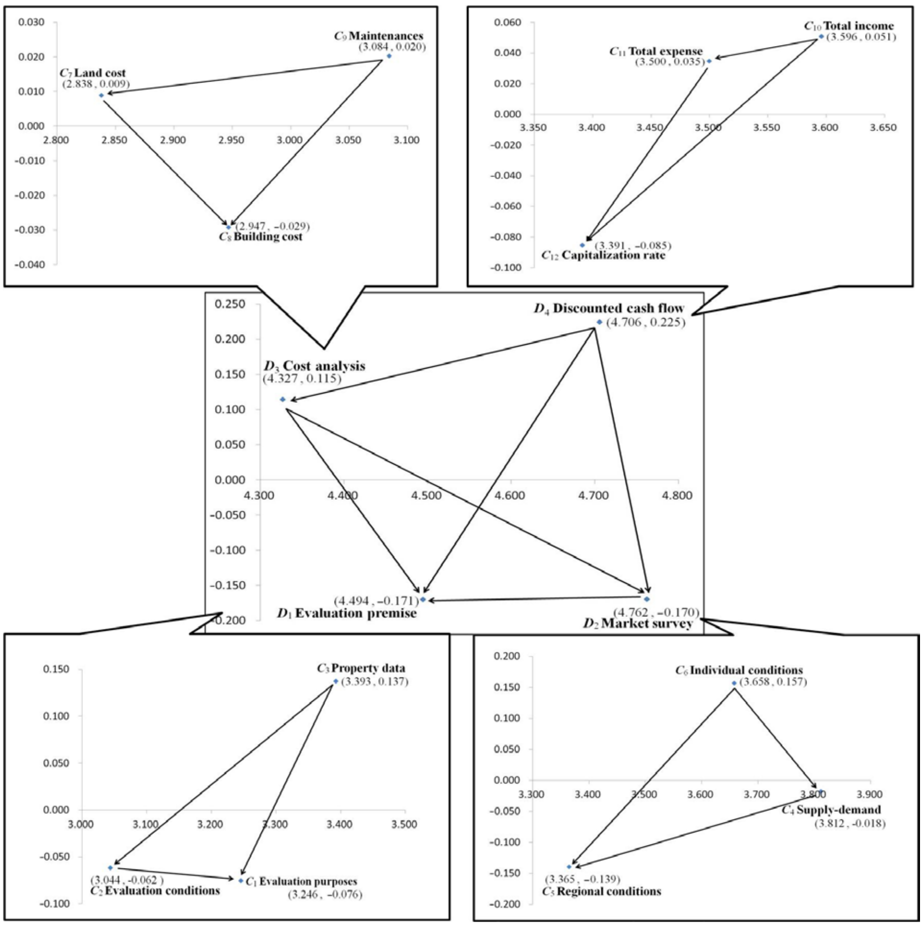


Figure 3. The influential network relationship map (INRM) of hotel appraisal criteria

All expert appraisers regarded income capitalization as the most important while conducting a hotel appraisal. They believed that the discounted cash flow ($D_4$) is the priority, which can influence the remaining dimensions, namely, cost analysis ($D_3$), market survey ($D_2$) and evaluation premise ($D_1$). Moreover, it suggests that appraisers' primary concern is a hotel's cash flow, including the total income, total expenses, and estimated capitalization rate. Expert responses suggested that delineating these relationships would directly affect cost analysis and speed of market surveys and evaluations.

Furthermore, these influential relationships can be identified from the individual dimensions. For example, the direct influential relationships from ($D_4$) can be further pinpointed as $D_4 \succ D_3, D_4 \succ D_1, D_4 \succ D_2, D_3 \succ D_1, D_3 \succ D_2, D_2 \succ D_1, D_4 \succ D_2 \succ D_1$ and $D_3 \succ D_2 \succ D_1$. The discounted cash flow ($D_4$) should receive the maximum attention as the most influential dimension.

A network relationship can also be observed in each dimension. For example, in discounted cash flow $D_4$, total income ($C_{10}$) has a direct effect on the remaining criteria; total expenses ($C_{11}$) and capitalization rate ($C_{12}$). Appraisers agree that that initially considering the total income a hotel can generate is must while conducting discounted cash flow. Thus, the practice priority in this dimension is $C_{10} \succ C_{11} \succ C_{12}$. The most influential criterion can be identified in the individual dimension using this rule, such as maintenance ($C_9$) in cost analysis ($D_3$), individual conditions ($C_6$) in market survey $D_2$), and property data ($C_3$) in evaluation premise ($D_4$). This solution makes hotel appraisal determinants and prioritization easily identifiable in the complex criteria (Figure 3).

### 3.2. Gap values of hotel appraisal determinants by mV based on DANP

A DANP was used to obtain the influential weights of the criteria. A stable matrix showing the weight of each criterion (Table 4) emerged through pairwise comparisons of the unweighted supermatrix and weighted supermatrix, $\lim_{z \to \infty} (\boldsymbol{W}^{\alpha})^{z}$. These weights can further be used by mV in next phase to calculate the performances and cap values of criteria and dimensions.

Thus, the performance/gap values of the overall practice (appraisal) toward the optimal level were obtained by mV (Table 5). Table 5 lists the local weights, global weights, performance values and gap values (to the aspiration level). Accordingly, it can show the overall achievable degrees of criteria according to the performance values, from high to low, and the gap value, from low to high. Among the overall dimensions, for instance, Market survey ($D_2$) is ranked as first to be improved to reach the optimal level because of its high-performance value of 7.439 (out to 10) and a low gap value of 0.256 (with 0 being ideal). Expert appraisers were most satisfied with market survey ($D_2$), followed by evaluation premise ($D_1$), cost analysis ($D_3$) and discounted cash flow ($D_4$). Comparatively, appraisers had the least confidence in discounted cash flow ($D_4$) because of its lowest performance value (6.071) and the largest gap value (0.393). Decision-makers may order a strategic sequence as $D_2 \succ D_1 \succ D_3 \succ D_4$ for practicing hotel appraisal priority to reach the optimal level.

This strategic sequence rule can also be used for the individual criterion. For instance, regional condition ($C_5$) would be the first criterion to be improved to reach the optimal level. It has a high-performance value of 8.300 and a low gap value of 0.170, followed by evaluation purpose ($C_1$) and evaluation conditions ($C_2$). Comparatively, the capitalization rate ($C_{12}$) with a low performance value (5.300) and the largest gap value (0.470) is the last criterion to improve. The expert appraisers indicated that managing and investigating the regional conditions was easier among all the determinants than any other criteria. Estimating precise capitalization rates is challenging, particularly with the downturn in tourism during the COVID-19 pandemic. The result provides an efficacy rule for hotel evaluation determinants if the decision-makers strategize reaching an optimal level (Table 5).

Table 4. The stable matrix of DANP

| $W^*$ | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ | $C_8$ | $C_9$ | $C_{10}$ | $C_{11}$ | $C_{12}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_1$ | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 |
| $C_2$ | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 |
| $C_3$ | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 |
| $C_4$ | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 | 0.094 |
| $C_5$ | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 | 0.086 |
| $C_6$ | 0.088 | 0.088 | 0.088 | 0.088 | 0.088 | 0.088 | 0.088 | 0.088 | 0.088 | 0.088 | 0.088 | 0.088 |
| $C_7$ | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 |
| $C_8$ | 0.076 | 0.076 | 0.076 | 0.076 | 0.076 | 0.076 | 0.076 | 0.076 | 0.076 | 0.076 | 0.076 | 0.076 |
| $C_9$ | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 | 0.080 |
| $C_{10}$ | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 | 0.083 |
| $C_{11}$ | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 |
| $C_{12}$ | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 | 0.081 |

The abovementioned suggests that network influence or gap values of performance efficiently identify appraisal determinants and their prioritizations for appraisal efficiency. This innovative plan of two formulations for efficacy priority can influence the network or the optimal/desired level, from each perspective or the overall operation (Table 6). For instance, using the network influence **(F1)**, the decision maker may initially grasp discounted cash flow ($D_4$). In this dimension, total income ($C_{10}$) should be the first priority to manage and accelerate the achievement of the remaining criteria. To reach the aspiration level **(F2)**, the decision maker may use the market survey ($D_2$) and prioritize regional conditions ($C_5$), which seems closest to the optimal level. Such determinants for hotel appraisal efficacy can be unique and integral, and they are illustrated in this case study in Table 6.

Table 5. Gap value of hotel appraisal criteria by modified VIKOR

| Code | Dimensions/criteria | Local weight | Global weight | Performance | Gap/ranking |
|---|---|---|---|---|---|
| $D_1$ | Evaluation premise | 0.255 | | 7.412 | 0.259 (2) |
| $C_1$ | Evaluation purposes | 0.087 | 0.342 | 8.250 | 0.175 |
| $C_2$ | Evaluation conditions | 0.081 | 0.318 | 7.650 | 0.235 |
| $C_3$ | Property data | 0.087 | 0.340 | 6.350 | 0.365 |
| $D_2$ | Market survey | 0.269 | | 7.439 | 0.256 (1) |
| $C_4$ | Supply-demand | 0.094 | 0.351 | 7.250 | 0.275 |
| $C_5$ | Regional conditions | 0.086 | 0.321 | 8.300 | 0.170 |
| $C_6$ | Individual conditions | 0.088 | 0.328 | 6.800 | 0.320 |
| $D_3$ | Cost analysis | 0.231 | | 6.971 | 0.303 (3) |
| $C_7$ | Land cost | 0.074 | 0.322 | 7.400 | 0.260 |
| $C_8$ | Building cost | 0.076 | 0.331 | 7.150 | 0.285 |
| $C_9$ | Maintenances | 0.08 | 0.346 | 6.400 | 0.360 |
| $D_4$ | Discounted cash flow | 0.245 | | 6.071 | 0.393 (4) |
| $C_{10}$ | Total income | 0.083 | 0.338 | 6.700 | 0.330 |
| $C_{11}$ | Total expense | 0.081 | 0.332 | 6.200 | 0.380 |
| $C_{12}$ | Capitalisation rate | 0.081 | 0.330 | 5.300 | 0.470 |
| | Total performance | | | 6.987 | |
| | Total gap | | | | 0.301 |

*Note:* The weights calculation uses DANP method.

Table 6. Innovative action plan for hotel appraisal efficacy

| Formulation for solution | Perspective/method | Priority for improvement |
|---|---|---|
| F1: Sequence to rise to network influence (by influential weights from high to low) | Dimensions/DEMATEL | $D_4 \succ D_3 \succ D_2 \succ D_1$ |
| | Criteria within individual Dimensions/DEMATEL | $D_1 : C_3 \succ C_2 \succ C_1$ |
| | | $D_2 : C_6 \succ C_4 \succ C_5$ |
| | | $D_3 : C_9 \succ C_7 \succ C_8$ |
| | | $D_4 : C_{10} \succ C_{11} \succ C_{12}$ |
| F2: Sequence to rise to aspired level (by gap value from low to high) | Dimensions/VIKOR | $D_2 \succ D_1 \succ D_3 \succ D_4$ |
| | Criteria within individual Dimensions/VIKOR | $D_1 : C_1 \succ C_2 \succ C_3$ |
| | | $D_2 : C_5 \succ C_4 \succ C_6$ |
| | | $D_3 : C_7 \succ C_8 \succ C_9$ |
| | | $D_4 : C_{10} \succ C_{11} \succ C_{12}$ |

## Conclusions

In this study, we modeled a DANP-mV approach to identify hotel determinants and improve hotel appraisal efficacy during sales trends due to the COVID-19 pandemic in Taiwan. The identified appraisal determinants and their prioritizations help all parties involved, such as hotel appraisers, managers, investors, lenders, and decision-makers. Theoretically, DANP-mV converts human thoughts into visual results, presenting an advanced solution to hotel appraisals in the real world. This DANP-mV result of an innovative plan of appraisal determinants would practically direct appraisers and all related parties in hotel selling and buying. It has significant contributions to both practitioners and academics concerning hotel appraisals. Our managerial implications are as follows:

1. The most influential determinant while conducting hotel appraisals is the "discounted cash flow." Improving this determinant produces network effects on the impacted dimensions, such as analyzing cost, market, and property information. It may spontaneously resolve multiple issues in a single shot. Furthermore, it confirms that hotels are income-producing, and hotel appraisals are inherent in net income estimations (Hinton, 2008; Rushmore, 1984; Taylor, 2003). Among the appraisal determinants, total income ($C_{10}$), maintenance ($C_9$), individual conditions ($C_6$), and property data ($C_3$) were more influential in their dimensions. These determinants yield double results with half the effort for appraisers or related parties.
2. The most straightforward and achievable method for reaching the desired level is conducting the determinant of an overall market condition analysis. It is due to the market survey ($D_2$) with the smallest gap value (0.256) and the regional conditions ($C_5$) with the smallest gap value (0.170). Contrarily, discounted cash flow ($D_4$) had the largest gap value (0.393), being the least achievable dimension.
3. The capitalization rate ($C_{12}$) is the most unachievable determinant (criterion), with the largest gap value (0.470). Consistently, accurately quantifying the forecasts of income, expenses, and anticipated proceeds from future benefits are challenging. It implies that estimating the risks associated with running a business and deriving a precise capitalization rate are the most challenging and unattainable tasks for appraisers. Therefore, while appraising hotels, the determinants that require a subjective judgment of current conditions appear to be more achievable at the desired level than those requiring an objective calculation or prediction.

Therefore, the research purpose was fulfilled with the DANP-mV model to identify hotel appraisal determinants and provide an action plan for hotel appraisal. The findings have the following contribution. (1) Producing INRM by converting human thoughts into a visual map to indicate more influential appraisal determinants than linear relationships (Figure 3); (2) demonstrating the aspiration gap of appraisal determinants for appraisal efficacy (Table 5); (3) assisting appraisers and related parties to use the DANP-mV model (Table 6) for identifying appraisal determinants; and (4) improving hotel appraisal efficacy for the burgeoning hospitality market in Taiwan during the COVID-19 pandemic.

Finally, we propose future research directions concerning the determinants of hotel appraisal efficacy. The content and focus of the present study were essentially hotel appraisal oriented. A comparison between lodging types, such as motels, resorts, limited-service hotels, historic properties, luxury boutique hotels, and hotel REITs, would have expanded the discussion. Besides, our action plan may guide efficient appraisal practices, particularly for appraisers or related parties with limited hotel experience. However, various factors influence hotel appraisal efficiency or accuracy, such as appraiser morals, approaches, and market impact. Future studies should focus on these variables and manage the linguistic ambiguity using the techniques, such as IF-MADM (Zhuang et al., 2018) and Fuzzy MCDM (Hosseini et al., 2021).

## References


American Society of Appraisers. (2020). *Join ASA*. https://www.appraisers.org/education

Appraisal Institute. (2014). *Commonly asked questions about real estate appraisers and appraisals*. https://www.appraisalinstitute.org/assets/1/7/commonly_asked_questions.pdf

Chang, C. C. (1995). *The study of hotel appraisal approach* [Unpublished master thesis]. Feng-Chia University.

Chang, K. C. (2019). *A study on the real estate capitalization rate – the analysis of market extract method*. Chengchi University.

Chen, F. H. (2011). Are appraisers rational? *Journal of Housing Study*, *20*(2), 47–60.

China Times. (2021, July 3). *Taiwanese hotels are on sale*. https://www.chinatimes.com/newspapers/20210703000165-260202?chdtv

Corgel, J. B., & deRoos, J. A. (1993). The ADR rule-of-thumb as predictor of lodging property values. *International Journal of Hospitality Management*, *12*(4), 353–365. https://doi.org/10.1016/0278-4319(93)90051-A

Dalbor, M. C., & Andrew, W. P. (2000). Agency problems and hotel appraisal accuracy. An exploratory study. *International Journal of Hospitality Management*, *19*(4), 353–360. https://doi.org/10.1016/S0278-4319(00)00014-1

Department of Land Administration, Ministry of Interior Affairs. (2020). *Real-estate appraiser database*. https://www.land.moi.gov.tw/

DeRoos, J., & Rushmore, S. (1995). Investment values of lodging property: modeling the effects of income taxes and alternative lender criteria. *The Cornell Hotel and Restaurant Administration Quarterly*, *36*(6), 62–69. https://doi.org/10.1177/001088049503600619

DeVellis, R. F. (2016). *Scale development: theory and applications*. Sage Publications.

Fontela, E., & Gabus, A. (1976). *The DEMATEL observer* (DEMATEL 1976 report). Battelle Geneva Research Center.

Fu, J., Sheel, A., & Lang, J. (2013). A reexamination of current hotel valuation techniques – which approach is more realistic? *The Journal of Hospitality Financial Management*, *21*, 17–30. https://doi.org/10.1080/10913211.2013.820074

Gabus, A., & Fontela, E. (1973). *Perceptions of the world problematique: communication procedure, communicating with those bearing collective responsibility* (DEMATEL report No. 1). Battelle Geneva Research Center.

Good Earth CPA. (2017, September 26). *600 hotels throughout Taiwan are looking for sale? A shuffle in the hotel market is just on the go*. http://www.goodearth.com.tw/blog/?p=781

Hinton, B. B. (2008). Valuing limited-service hotels: a pragmatic framework from a broker's perspective. *The Appraisal Journal*, *76*(1), 47–53.

Hosseini, A., Pourahmad, A., Ayashi, A., Tzeng, G.-H., Banaitis, A., & Pourahmad, A. (2021). Improving the urban heritage based on a tourism risk assessment using a hybrid fuzzy MADM method: the case study of Tehran's central district. *Journal of Multi-Criteria Decision Analysis*, *28*(5–6), 248–268. https://doi.org/10.1002/mcda.1746

Hotel Business. (2020). *Buying and selling hotels during the pandemic: factors to consider for hotel owners and investors.* https://www.hotelbusiness.com/buying-and-selling-hotels-during-the-pandemic-factors-to-consider-for-hotel-owners-and-investors/

Jackson, L. A. (2009). Lodging REIT performance and comparison with other equity REIT returns. *International Journal of Hospitality & Tourism Administration*, *10*(4), 296–325. https://doi.org/10.1080/15256480903202383

Kisilevich, S., Keim, D., & Rokach, L. (2013). A GIS-based decision support system for hotel room rate estimation and temporal price prediction: the hotel brokers' context. *Decision Support Systems*, *54*(2), 1119–1133. https://doi.org/10.1016/j.dss.2012.10.038

Lee, C. S., Lee, C. W., & Chen, C. W. (2011). A study of the tourist hotel development indicators. *Journal of Architecture*, *77*, 107–118.

Lee, S., O'Neill, J. W., & McGinley, S. (2016). Effects of economic conditions and other factors on hotel sale prices. *International Journal of Contemporary Hospitality Management*, *28*(10), 2267–2284. https://doi.org/10.1108/IJCHM-07-2014-0363

Lin, P. J., Shiue, Y. C., Tzeng, G. H., & Huang, S. L. (2019). Developing a sustainable long-term ageing health care system using the DANP-mV model: empirical case of Taiwan. *International Journal of Environmental Research and Public Health*, *16*(8), 1349. https://doi.org/10.3390/ijerph16081349

Lin, S. H., Hsu, C. C., Zhong, T., He, X., Li, J. H., Tzeng, G. H., & Hsieh, J. C. (2021). Exploring location determinants of Asia's unique beverage shops based on a hybrid MADM model. *International Journal of Strategic Property Management*, *25*(4), 291–315. https://doi.org/10.3846/ijspm.2021.14796

Lin, Y. Y. (2006). *Real estate appraisal* (11th ed.). Wen-sheng Book Store.

Liu, C. H. (2018). Schemes for enhancing Taiwanese cruise PAK relationships using the hybrid MADM model. *Tourism Management*, *69*, 510–522. https://doi.org/10.1016/j.tourman.2018.06.029

Liu, C. H. (2020). Strategies of managing coach driver job stress for sustainable coach tourism industry—the use of DANP-V model. *Sustainability*, *12*(9), 3690. https://doi.org/10.3390/su12093690

Liu, C. H., & Liu, B. (2021). Using DANP-mV model to improve the paid training measures for travel agents amid the COVID-19 pandemic. *Mathematics*, *9*(16), 1924. https://doi.org/10.3390/math9161924

Liu, C. H., Lee, M. H., & Lian, L. Y. (2012a, March 17). *Examining hotel appraisal: using DEMATEL model* [Conference presentation]. MCU Tourism International Conference, Taipei.

Liu, C. H., Tzeng, G. H., & Lee, M. H. (2012b). Improving tourism policy implementation – the use of hybrid MCDM models. *Tourism Management*, *33*, 413–426. https://doi.org/10.1016/j.tourman.2011.05.002

Liu, C. H., Tzeng, G. H., & Lee, M. H. (2013a). Strategies for improving cruise product sales using hybrid 'multiple criteria decision making' models. *The Service Industries Journal*, *33*(5), 542–563. https://doi.org/10.1080/02642069.2011.614342

Liu, C. H., Tzeng, G. H., & Lee, P. Y. (2019). Combined CFPR and VIKOR model for enhancing the competencies of domestic chain hotel groups. *International Journal of Information Technology & Decision Making*, *18*(03), 901–927. https://doi.org/10.1142/S0219622019500184

Liu, C. H., Tzeng, G. H., Lee, M. H., & Lee, P. Y. (2013b). Improving metro–airport connection service for tourism development: using hybrid MCDM models. *Tourism Management Perspectives*, *6*, 95–107. https://doi.org/10.1016/j.tmp.2012.09.004

Liu, C. H., Tzeng, G. H., Lee, M. H., Tseng, H. L., & Lee, P. Y. (2012c). Using a hybrid MCDM model combining fuzzy DEMATEL Technique to examine the job stress of coach driver. In J. Watada, T. Watanabe, G. Phillips-Wren, R. J. Howlett, & L. C. Jain (Eds.), *Intelligent decision technologies* (Vol. 16, pp. 149–156). Springer. https://doi.org/10.1007/978-3-642-29920-9_16

Lu, I. Y., Kuo, T., Lin, T. S., Tzeng, G. H., & Huang, S. L. (2016). Multicriteria decision analysis to develop effective sustainable development strategies for enhancing competitive advantages: case of the TFT-LCD industry in Taiwan. *Sustainability*, *8*(7), 646. https://doi.org/10.3390/su8070646

Lung, C. I. (2010). *The whole values evaluate study of real estate possessed superficies* [Thesis, Graduate of Industry Economics]. National Central University. http://ir.lib.ncu.edu.tw/handle/987654321/25887#.XxQNUZ4zZPY

Maliene, V. (2011). Specialised property valuation: multiple criteria decision analysis. *Journal of Retail and Leisure Property*, *9*, 443–450. https://doi.org/10.1057/rlp.2011.7

Opricovic, S. (1998). *Multicriteria optimization of civil engineering systems* [PhD thesis]. Faculty of Civil Engineering, Belgrade.

Opricovic, S., & Tzeng, G. H. (2002). Multicriteria planning of post-earthquake sustainable reconstruction. *Computer-Aided Civil and Infrastructure Engineering*, *17*(3), 211–220. https://doi.org/10.1111/1467-8667.00269

Opricovic, S., & Tzeng, G. H. (2007). Extended VIKOR method in comparison with outranking methods. *European Journal of Operational Research*, *178*(2), 514–529. https://doi.org/10.1016/j.ejor.2006.01.020

Opricovic, S., & Tzeng, G.-H. (2004). Compromise solution by MCDM methods: a comparative analysis of VIKOR and TOPSIS. *European Journal of Operational Research*, *156*(2), 445–455. https://doi.org/10.1016/S0377-2217(03)00020-1

Qu, G. B., Zhao, T. Y., Zhu, B. W., Tzeng, G. H., & Huang, S. L. (2019). Use of a modified DANP-mV model to improve quality of life in rural residents: the empirical case of Xingshisi village, China. *International Journal of Environmental Research and Public Health*, *16*(1), 153. https://doi.org/10.3390/ijerph16010153

Roubi, S. (2004). The valuation of intangibles for hotel investments. *Property Management*, *22*(5), 410–423. https://doi.org/10.1108/02637470410570761

Rushmore, S. (1984). The appraisal of lodging facilities—update. *Cornell Hotel and Restaurant Administration Quarterly*, *25*(3), 35–46. https://doi.org/10.1177/001088048402500313

Rushmore, S. (1992). Seven current hotel-valuation techniques. *Cornell Hotel and Restaurant Administration Quarterly*, *33*(4), 49–56. https://doi.org/10.1177/001088049203300407

Saaty, T. L. (1996). *Decision making with dependence and feedback: the Analytic Network Process*. RWS Publications.

Singh, A., & Schmidgall, R. (2005). Future events and their impact on financial management in the US lodging industry: Delphi study to predict changes in 2007 and 2027. *Journal of Retail & Leisure Property*, *4*. https://doi.org/10.1057/palgrave.rlp.5090221

Taiwan Tourism Bureau. (2020a). *Taiwan Tourism Bureau (Spending)*. Tourism Statistics Database. https://stat.taiwan.net.tw/

Taiwan Tourism Bureau. (2020b). *Taiwan Tourism Bureau (room)*. Tourism Statistics Database. https://admin.taiwan.net.tw/FileUploadCategoryListC003330.aspx?CategoryID=3d2faec1-39d0-4a48-8b90-bc34e1330b18&appname=FileUploadCategoryListC003330

Taylor, S. (2003). What is your hotel worth? *Lodging Hospitality*, 43–50.

Tzeng, G. H., & Huang, J. J. (2011). *Multiple attribute decision making: methods and applications*. Chapman and Hall/CRC. https://doi.org/10.1201/b11032

Tzeng, G. H., Lin, C. W., & Opricovic, S. (2005). Multi-criteria analysis of alternative-fuel buses for public transportation. *Energy Policy*, *33*(11), 1373–1383. https://doi.org/10.1016/j.enpol.2003.12.014

World Travel & Tourism Council. (2020). *Monthly economic impact—March 2020*. https://wttc.org/Research/Economic-Impact/moduleId/1236/itemId/69/controller/DownloadRequest/action/QuickDownload

Yang, J. L., & Tzeng, G. H. (2011). An integrated MCDM technique combined with DEMATEL for a novel cluster-weighted with ANP method. *Expert Systems with Applications*, *38*(3), 1417–1424. https://doi.org/10.1016/j.eswa.2010.07.048

Zhu, B. W., Zhang, J. R., Tzeng, G. H., Huang, S. L., & Xiong, L. (2017). Public open space development for elderly people by using the DANP-V model to establish continuous improvement strategies towards a sustainable and healthy aging society. *Sustainability*, *9*(3), 420. https://doi.org/10.3390/su9030420

Zhuang, Z. Y., Lin, C. C., Chen, C. Y., & Su, C. R. (2018). Rank-based comparative research flow benchmarking the effectiveness of AHP–GTMA on aiding decisions of shredder selection by reference to AHP–TOPSIS. *Applied Sciences*, *8*(10), 1974. https://doi.org/10.3390/app8101974