Decision-making in the commercial space service design of transportation architecture

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Abstract. Transportation architecture is common globally. The design of rest areas, which allow travelers to rest and refuel, is crucial in such architecture. The design focus of rest areas in Taiwan has shifted from function-oriented features to that meet travelers’ diverse needs. Space planning in such areas can be used to integrate highway information, dining services, and leisure activities for travelers; design spaces with local characteristics; and improve service design and innovative service models. This study analyzed the effect of evaluation criteria weights used in highway rest area design tendering in Taiwan on the selection of space designers. The modified Delphi method was used to conduct interviews with experts and select criteria for commercial service space design from a consensus. Subsequently, an analytic hierarchy process was adopted to determine the relative weight of each criterion, and a consistency analysis was conducted. These design criteria were deemed essential by the experts and are thus beneficial for future designers in understanding the aspects in the spatial planning for highway rest areas and acquiring transportation architecture tenders. The results of this study can facilitate identification of highway rest area design criteria, which can serve as a reference for space designers to make related decisions.

Keywords: transportation architecture, commercial space, modified Delphi method, hierarchical analysis, design decision-making

1. Introduction

Highways are a primary means of transportation in Taiwan and feature service areas for travelers to rest and refuel. In addition to providing “affective services,” highway rest areas have experienced diverse development, with some even transforming into tourist attractions [1]. This study used “transportation architecture” to describe highway rest areas because it more closely reflects the meaning of such areas and encompasses their hardware and software components. In addition to introducing international brands to shops, highway rest areas incorporate services such as providing local tourism information and selling local souvenirs. The interior and exterior design of highway rest areas also integrates local cultural elements to drive local industry development. Regarding shop management in highway rest areas, training of retail staff members and food safety management have become stricter.

In Taiwan, old buildings at highway rest areas are met with challenges concerning maintenance and upgrade design. When designing a highway rest area, shop managers and space designers must account for travelers’ needs, the amount of investment funds, and related costs. Identifying key design factors is time and cost intensive. Therefore, design decision makers are particularly crucial to the renovation of highway rest areas. Such designers must work under the premise of old building maintenance and
innovative design and also account for the design concepts of complex expert systems and circular business models for sustainable development.

The planning of commercial spaces in transportation architecture differs from that of general shopping malls in terms of user purposes and length of stay. Such commercial spaces excel in disseminating local tourism information compared with other media. Therefore, space planning must entail specific objectives and criteria and also incorporate local cultural elements to showcase local characteristics (Figure 1). This promotes local marketing and tourism activities and is considerably affected by innovative space design. Figure 1a presents the interior space of the mall at the Southbound Rende Service Area. The theme of this rest area is “tradition and innovation;” hence, retro elements such as wooden farming boxes are used to decorate the ceiling, and bamboo furniture is used in the dining area. Figure 1b presents the northbound rest area with the theme of “technology takeoff.” Hence, interactive projection technology is used to introduce local attractions, and the ceiling features astronomical elements of the Tainan Astronomical Education Area. The rapid development of the Taiwanese design industry has prompted various industries to invest in design-related operations. Design criteria in planning commercial space enable professional designers to improve their evaluation scores when competing for tender opportunities, thus helping them acquire tenders.

The research motivation of this study originated from the authors’ experiences in encountering various difficulties when devising design plans. This study focused on the design criteria for planning commercial space in transportation architecture (i.e., highway rest areas) to achieve the following objectives: (1) identify design criteria while considering various factors related to design, management, and profit, (2) combine the modified Delphi method (MDM) and hierarchical analysis to explore the adequacy of the devised comprehensive research framework, and (3) determine the weighted ranking of design criteria according to the opinions of relevant experts, space designers, and managers. The study results can serve as a reference for the design and planning of commercial service space.

![Figure 1. (a) Combining space design with theme display (simulation image of space inside the Southbound Rende Service Area). (b) Combining space design with innovation design and local revitalization (simulation image of space inside the Northbound Rende Service Area).](image)

2. Literature review
Transportation architecture refers to any structure that facilitates passenger or freight transportation and encompasses various facilities, including airports, harbors, roads, and railroads. In Taiwan, highway rest areas are comprehensive civil engineering buildings that not only have diverse transportation and service functions but also ensure smooth traffic and road safety. Since 1980, the Freeway Bureau of Taiwan has commissioned private companies to manage highway rest areas. The selection of such companies is based on the assessment method of the most advantageous tender. Currently, the selection focus has shifted from profit oriented to service oriented. Moreover, the Bureau has conducted user satisfaction surveys for several years to implement improvement measures. Companies selected to plan highway rest areas are now required to design affective services instead of basic services [1]. In recent years, the environmental planning of highway service areas has integrated aesthetic concepts and created a new
trend of transforming such areas into tourist attractions [2]. Because of its popularity among younger citizens, social media check-ins has become an effective marketing strategy. In response to overall user needs, highway rest areas should enhance their recreational functions and integrate multifunctional malls, food courts, multimedia services, book-sharing stands, Sunday markets, and various live performances that promote local culture.

Design- or innovation-oriented corporations or services can establish environments that are conducive to creativity and innovation. These environments provide such corporations advantages over their competitors and enhance corporate performance and strategies [3]. Innovation in space design encourages consumption behavior and helps managers achieve their profit goals [4].

Space design in malls entails various methods of incorporating local characteristics and creating empathetic links with local people. Through space design, local features and social consciousness are realized. Therefore, mall spaces must be adjustable and modularized to enable flexible and dynamic spatial adjustment [5].

In the analysis of design elements in mall space planning, mall designers and managers must agree on the rationality of line planning. Facility convenience and refined space allocation affect consumers’ willingness to visit a mall [6]. The aforementioned literature review indicated that the various dimensions of space planning in malls must be weighted. Organizing or executing a design project requires the interdisciplinary integration of expert systems in various fields. These expert systems are assigned to various stages of the development process for multidimensional assessment. However, due to budget and scheduling limitations, crucial design elements must be prioritized in the planning and construction of transportation architecture. Experts from various professional fields, academics, and related brand managers agree that space design entails various essential criteria dimensions, namely hardware design, local feature design, service design, and management strategies. Key factors must be identified for each dimension in a hierarchical framework and serve as an effective reference for devising the overall design plan.

3. Research methods
The research procedures of this study were as follows: (1) Data related to the development of and construction white papers on Taiwanese highway rest areas were collected to compile relevant theories and discourses, thereby establishing the overall research framework. (2) Key design criteria were proposed on the basis of literature, theories, design elements, and strategies for planning commercial space. (3) According to the competitive advantages of commercial space design and literature related to highway rest areas, the MDM was used to invite experts, who shared their experience, knowledge, and opinions, to reach a consensus and identify competitiveness criteria for planning commercial spaces in transportation architecture. The validity and reliability of each criterion were verified, and factor analysis was performed. (4) An analytical hierarchy process (AHP) questionnaire was distributed for professional assessment, to evaluate consistency in the expert opinions, and determine relative weights of essential design criteria. The results can serve as a reference for space designers to acquire tenders for designing highway rest areas.

3.1. MDM application
The MDM originated from the conventional Delphi method, also known as the expert judgement method. It is a group decision-making approach mostly used in qualitative research. In the MDM, the knowledge and experience of experts are compiled by using inquiries and feedback to minimize variance in opinions. The MDM retains the concept and advantages of the conventional Delphi method. Experts remain anonymous while exchanging opinions and expressing their thoughts. In contrast to the conventional Delphi method, the MDM omits the first-round open-ended questionnaire and simplifies the procedure to a literature review. Hence, researchers need not interpret the open-ended answers provided by experts and can instead focus on researching the topic of interest. This helps researchers reach a consensus among the experts to expedite subsequent operations. The AHP was employed in the second phase of this study. This method is mainly used to examine problems concerning multiple assessment criteria under uncertain or unknown situations. Such situations include application planning, sequential
decision-making, alternative plans, and performance evaluation. The AHP is prevalent in marketing, management, and various scientific fields. Figure 2 displays the research procedures of this study.

**Figure 2. Research procedures**

In the planning phase, literature was collected to determine the research direction. Literature review and expert interviews were then conducted during the execution period to compile expert opinions through the MDM. Table 1 lists the design principles and purposes of the questionnaires used in the MDM and AHP. Finally, a decision-making model for planning commercial space service design transportation architecture was created.

**Table 1. Design principles and purposes of the questionnaires.**

| Design principles | Design purpose | Recovery |
|-------------------|----------------|----------|
| **First Questionnaire** (Expert Interview and Researcher Construction) | According to the relevant highway service investment policy white paper and related commercial space design literature, form the design pointer Seek expert advice Understand the current standard of tenders and tenders in service areas and the requirements for related service proposals | Get expert selection design planning unit design pointer view | Send out 20 questionnaires, 20 points, recovery rate of 100% |
| **Second Questionnaire** | Using hierarchical analysis, a presentation of commercial space design guidelines for each service area | Get the relative weight value of each pointer | Send 30 copies, recycle 30 copies, 100% recovery rate |

**3.2. Questionnaire design**

The design principles of the questionnaires were as follows: (1) Literature related to design evaluation strategies, space-design methods, and building construction regulations was reviewed to create a preliminary list of space-design criteria. (2) Various experts were invited to select suitable criteria from
the questionnaires. These experts included representatives from interior design and construction associations, architects and technicians from architecture associations, and scholars from design departments. (3) The selected criteria were categorized to compile a list suitable for planning commercial spaces in highway rest areas. Accordingly, the formal AHP questionnaire was formulated. Based on the questionnaire responses, a weight matrix was created to perform comprehensive data analysis and propose conclusions and suggestions.

3.3. AHP

The AHP was developed in 1971 by Saaty, a scholar at the University of Pittsburgh, and is mainly used to develop decision-making evaluation criteria for multiple objectives under uncertain situations. In multiobjective decision-making, decision-makers attempt to manage a complex system that features numerous variables as well as complex and uncertain factors. The goal of the AHP is to categorize complex and unstructured problems into hierarchical levels or structures, and the opinions of experts and decision-makers are compiled to simplify the complex system. Matrices are then calculated to compare criteria in each hierarchical level, and corresponding vectors are determined to rank the criteria, which serve as references for evaluation or decision-making.

Among various systems engineering theories, the AHP is relatively useful for weight calculation. The AHP arranges various factors of a complex problem into hierarchical order and is considered a logical multiobjective, multicriterion decision-making approach that combines qualitative and quantitative analyses.

4. Case research and analysis

4.1. Design criteria formulation and selection

Based on literature related to factors affecting the planning of commercial space design [6, 7] and the opinions provided by design experts, construction project-execution units, mall managers, and tender bidders, this study compiled and analyzed relevant data to propose four major design elements and 20 design criteria (Figure 3). Subsequently, these criteria were evaluated using opinion exchange among experts.

Figure 3. AHP model for the decision-making criteria of commercial space design in transportation architecture.

4.2. Validity and reliability analysis

Table 2 lists the results of the Bartlett test of sphericity. The Kaiser–Meyer–Olkin (KMO) value was .828, which was >.8, thus indicating that the collected data were suitable for factor analysis. The chi-square
value determined using the Bartlett test of sphericity was 1154.101 and statistically significant (p = 0.000). The questionnaires used in this study were formulated by referencing relevant literature and collecting data from expert interviews; hence, their content validity required verification. Although content validity verification was relatively subjective, the pretest indicated that the questionnaire content was highly valid [8].

| Table 2. KMO & Bartlett test. |
|--------------------------------|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy | .828 |
| Bartlett's Test of Spherical Approximate Chi-Square | 1154.101 |
| df | 190 |
| Sig. | .000 |

Based on the data compiled from the literature review and interviews with experts and scholars in the first study phase, a list of evaluation criteria for planning commercial space in transportation architecture was created (table 3). These criteria were used to develop an MDM expert questionnaire, which contained structured items and involved four elements (i.e., hardware design, local characteristics, service design, and business strategy) and 20 criteria. The questionnaire was used to enable experts and scholars to reach a consensus and evaluate the adequacy of the criteria.

Babakus and Mangold [9] argued that the 5-point Likert scale can enhance the comprehensibility of questionnaire items and the quality of questionnaire responses. Therefore, this scale was employed to evaluate questionnaire items. In the first study phase, 20 questionnaires were distributed and recovered, yielding a recovery rate of 100%. The mean scores of all criteria were ≥3.5, thus indicating that all criteria were considered essential to space design. Furthermore, the standard deviation values of the mean scores were all <1, implying high consistency among experts’ opinions.

| Table 3. First questionnaire results. |
|--------------------------------------|
| Evaluation criteria | M | SD | MO | MO-M |
| 1 Hardware design element | Understanding of relevant regulations | 4.90 | 0.305 | 5 | 0.100 |
| 2 | Line planning | 4.97 | 0.183 | 5 | 0.033 |
| 3 | Universal design | 4.87 | 0.346 | 5 | 0.133 |
| 4 | Sustainable design | 4.83 | 0.379 | 5 | 0.167 |
| 5 | Green energy and household items | 4.80 | 0.407 | 5 | 0.200 |
| 6 Local characteristics element | Innovative design | 4.73 | 0.45 | 5 | 0.267 |
| 7 | Regional revitalization | 4.77 | 0.43 | 5 | 0.233 |
| 8 | Theme display | 4.77 | 0.43 | 5 | 0.233 |
| 9 | Local culture import | 4.67 | 0.479 | 5 | 0.333 |
| 10 | Public art display | 4.53 | 0.629 | 5 | 0.467 |
| 11 Service design element | Information media display | 4.80 | 0.407 | 5 | 0.200 |
| 12 | Sign system identification | 4.93 | 0.254 | 5 | 0.067 |
| 13 | Interactive design | 4.57 | 0.504 | 5 | 0.433 |
| 14 | User Demand Services | 4.77 | 0.43 | 5 | 0.233 |
4.3. AHP questionnaire survey and analysis
In the second study phase, survey respondents were mostly experts in design-related fields (including architects, interior designers, landscape designers, engineering technicians, brand managers, and academics). A total of 30 questionnaires were distributed and recovered. The questionnaires were primarily distributed through the Internet. Questionnaire responses were subject to AHP analysis to determine the relative weight of each criterion.

Table 4. Analytical hierarchy process results.

| Level 1                          | Statistic weight | Level 2 Design index factor | Intra-group weights | Relative weight | Sorting weights |
|---------------------------------|------------------|----------------------------|---------------------|----------------|-----------------|
| Hardware design element         | 0.2588           | Understanding of relevant regulations | 0.0533             | 0.2057         | 7               |
|                                 |                  | Line planning              | 0.0927             | 0.3580         | 1               |
|                                 |                  | Sustainable design         | 0.0427             | 0.1650         | 14              |
|                                 |                  | Sustainable design         | 0.0399             | 0.1543         | 17              |
|                                 |                  | green energy and household items | 0.0303             | 0.1170         | 20              |
|                                 |                  | Innovative design          | 0.0726             | 0.2703         | 3               |
|                                 |                  | regional revitalization    | 0.054              | 0.2010         | 10              |
|                                 |                  | Theme display              | 0.0552             | 0.2056         | 8               |
|                                 |                  | Local culture import       | 0.0538             | 0.2004         | 11              |
|                                 |                  | Public art display         | 0.033              | 0.1227         | 19              |
| Local characteristics element   | 0.2687           | Information media display | 0.0416             | 0.1593         | 16              |
|                                 |                  | display sign system        | 0.071              | 0.2719         | 2               |
|                                 |                  | identification interactive design | 0.0441             | 0.1691         | 12              |
|                                 |                  | User Demand Services       | 0.0651             | 0.2492         | 4               |
|                                 |                  | Diversified Catering Brands | 0.0393             | 0.1504         | 18              |
| Service design element          | 0.2611           | horizontal alliances       | 0.0351             | 0.1660         | 13              |
|                                 |                  | feedback loop              | 0.0347             | 0.1642         | 15              |
| Business strategy element       | 0.2114           | Phase maintenance plan     | 0.0379             | 0.167          | 10              |
The weights of hardware design, local characteristics, service design, and business strategy elements were 0.2588, 0.2687, 0.2611, and 0.2114, respectively. This indicates that when designing commercial spaces of transportation architecture, the local characteristics element is the most essential, followed by service design, hardware design, and business strategy. Within the hardware design element, understanding of relevant regulations and line planning yielded a weight of >0.05. Within the local characteristics element, experts emphasized innovative design, regional revitalization, theme display, and local culture import. Within the service design element, sign system identification and user demand services were considered the most crucial criteria. In the business strategy element, no criteria were considered essential.

Of all the criteria, the top five were line planning, sign system identification, innovative design, user demand services, and executive budget control (Figure 4). Of all the elements, criteria with weights of >0.05 were understanding of relevant regulations, line planning, innovative design, regional revitalization, theme display, local culture import, sign system identification, and user demand services. The experts regarded these criteria as essential (Figure 4).

**Figure 4.** Results of group decision-making (weights) by experts.

5. Conclusions and limitations
Decision-making problems are frequently encountered in real-world situations. However, using quantitative methods to describe related factors in this type of problem is often difficult. The AHP is effective for solving such problems. This process organizes a complex decision-making system into hierarchical levels. Related factors in each level are then compared in terms of their importance to
provide a quantitative reference for making decisions. The space design industry in Taiwan has become increasingly diverse. In response to consumers’ increasing standards for design quality and the perpetually competitive market, designers must have professional abilities across different fields to satisfy consumer needs. These abilities include understanding related regulations, material selection, and cultural innovation. This study compiled a list of criteria for designing commercial spaces in transportation architecture and ranked the criteria by their weights. The study results can serve as a reference for future designers to make adequate decisions in designing commercial spaces in highway rest areas, thereby helping them acquire tenders for related projects.

The research limitations of this study were as follows:

(1) The questionnaires used in this study were based on the MDM. Future researchers should use scales based on service design and innovation theories to acquire more objective data and create innovation-design models.

(2) The questionnaires used in this study were designed on the basis of the space-design experience of experts and related literature and theories. To ensure the integrity of questionnaire items and respondents’ willingness to complete the questionnaires, the wording used in the items must be clear, and the number of items must be reasonable. Consequently, items related to some topics were omitted from the questionnaires.

(3) This study mainly focused on commercial space in transportation architecture. Future scholars may extend the results of this study by targeting commercial spaces in other types of transportation architecture, such as airports or railway stations.

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