

Article

Prioritization of Factors Affecting Sustainability Property Improvement by Using Analytical Hierarchy Process and Important-Satisfaction Model: The Case of TAIPEI 101 Tower

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Abstract: In order to maintain the best conditions of the building from the first day of opening, explorations of office buildings in the world investigated the approaches of optimizing the building operation and property facilities, whereas building managers often have trouble prioritizing improvements toward their sustainable objectives. The challenge is due to numerous equipment types in the building, which has various durability in years and represents users' different feelings of importance and satisfaction. When faced with multiple improvement projects, building managers are often unable to determine the order of implementation.

Hence, this research applies the Analytic Hierarchy Process (AHP) using TAIPEI 101 Tower as a case study to explore the key factors affecting tenants' willingness to lease office buildings by distributing questionnaires to real estate experts. By filtering out key indicators related to property facilities that users care about, this study used Importance and Satisfaction Analysis (IS Analysis) to identify items that need urgent improvement.

The research revealed that air conditioning is the top priority for improvement through empirical evaluation and weight ranking. This study hopes to establish an evaluation model for facility improvements to help clarify the prioritization and defeat limited resources to projects effectively, which is helpful for sustainable property management.

Keywords: Analytic Hierarchy Process, Important-Satisfaction Model, TAIPEI 101, Sustainability

1. Introduction

After cities achieve notable economic goals, they are eager to show unique masterpieces in architecture. Therefore, property such as a skyscraper is turned into a symbol of economic development, and it is also representing substantial wealth and prosperity. The accumulation of years, technology innovation and economic fluctuations exert a direct effect on the operation of property. In order to remain highly profitable in operations, the maintenance of property facilities has become an issue that owners cannot ignore. Berardi (2012) pointed out that the sustainability of buildings should include considering sustainable development in three primary aspects: economic, environmental and social [1].

For property managers, the limited resources need to be invested in projects in need of urgent improvement. However, because there is no absolute rule to follow in the selection decision, it often causes difficulties while determining the improvement projects. In contrast to ordinary buildings, an office building can be viewed as a vertical city that contains various problems concerning safety, transportation, cleaning, and energy consumption that are difficult to resolve. Office buildings with a higher number of floors tend to exhibit more issues related to safety, durability, comfort, and

relatively high requirements for professional property management. Such buildings are also extensive in building structure, electrical and mechanical systems, air conditioning, and elevators. This study hopes to use the importance-satisfaction model to analyze the tenants' real perception and improve the prioritization of projects in property management. The owners can use this tool to focus precious resources on priority improvement projects.

2. Materials and Methods

This study uses the Taipei 101 tower as a case study. First, in-depth interviews are conducted with experts who have executed real estate projects. After collecting these experts' opinions, this research reviewed the actual cases of office leasing in Taipei 101 tower to establish indicators that affect the willingness to lease office buildings. After anonymous questionnaire survey was conducted, Delphic hierarchy process along with Analytical Hierarchy Process (Satty,1980) was employed, constructing a framework and rankings of key factors affecting the tenant's willingness to lease.

From the above indicators, this study screened out the relevant indicators for property and facility improvements, and carried out the importance and satisfaction analysis by the interviewees based on their actual perceptions.

2.1 Expert interviews

Bainbridge pointed out that even if there are not many interviewees in the interviews while using the method of In-Depth Interview, since the breadth and depth of the interviews are sufficient to provide a variety of possible answers, researchers can better grasp the respondent's complex reactions to this issue. The advantage of In-Depth Interview Method is to collect all possible responses and develop integrated hypotheses from them, which will serve as the basis for future research (Bainbridge, 1989) [2]. The experts consist of representatives of management group in domestic and international enterprises. Professional consultants who have deep understanding in real estate market are also invited to participate in questionnaire surveys and interviews. Based on their professional backgrounds, two different groups are created: management group and consultant group, totaling 30 experts. Among them are 7 property management consultants, 2 senior managers of international enterprises, 8 equipment maintenance personnel. Table 1 lists the groups of experts. Hartman proposed that through anonymous written discussions, experts can be guided to reach consensus based on their professional knowledge, practical work experience, and opinions, which helps solve complex issues (Hartman, 1981) [3]. By conducting in-depth interviews with experts, we can obtain new core values that are different from conventional property facility improvement.

Table 1. Backgrounds of expert groups

Group	Background	No. of experts	Percentage	Total
Management Experts	Taipei 101 Tower	4	13.33%	23.33%
	Domestic Enterprise	1	3.33%	
	International Enterprise	2	6.67%	
Consultant Experts	Leasing Agent	12	40.00%	76.67%
	Appraiser	4	13.33%	
	PM Consultant	7	23.34%	
Total		30	100%	100%

2.2 Literature review

2.2.1 Bid rent function theory

Alonso's (1960) bid rent function theory [4], concurs with Huang and Chang(2005)'s research on office relocation of enterprises shifting in the Taipei metropolitan area [5], found that the conditions of property facilities will affect willingness to rent. Holloway and Wheeler [6] analyzed the data of top 500 enterprises from Fortune magazine to investigate the shifts of office locations in the duration from 1980 to 1987, and found that the quality of property facilities is one of the key factors. Lin (2006) [7] pointed out that physical factors such as the quality of design, building materials, facility management of the office building would affect the willingness of enterprises to rent. Based on the above works, the maintenance of property facilities is crucial for tenant satisfaction and a key factor for the success or failure of real estate operations.

2.2.2 Delphi Method

Delphi Method, also known as Expert Judgment Method, is one of group decision-making approaches, used in qualitative research. These experts' experience are adopted in this method to solve a specific topic through multiple rounds of feedback, thereby minimizing the difference between the experts' opinions. Above mentioned AHP is mainly employed in decision-making problems that involve uncertain situations with lots of criteria. It is used in behavioral analyst, marketing strategies plan and investment portfolios.

In 1988, Khorramshahgol and Moustakis proposed Delphi Hierarchical Procedure (DHP) [8]. This method is used to establish the hierarchy and pairwise comparison matrix, and the rest of the process is the same as Analytical Hierarchy Process (AHP). This multi-criteria decision theory was developed by Thomas L., Saaty (1990) [9]. The purpose is to select the correct option for the systemize complex problems.

When there is not only one evaluation factor, multi-criteria decision-making method can simplify the complex problems. The hierarchical analysis method can not only help experts to reach a consensus, also use standardized criteria to strengthen the credibility of the result and credibility. Not only has the advantages of the AHP, but also utilizes group decision-making model of the DHP method can reduce the difference between subjective cognitions in the construction and analysis of hierarchy and performing pairwise comparison of individuals or groups by using AHP. (Yang et al., 2005) [10].

2.2.3 Important-Satisfaction Analysis

Parasuraman, Zeithaml and Berry, proposed P.Z.B service quality model, and it is customer that determines the service quality. The difference between customer's expectations and actual cognition determines the standard of service quality [11]. The conceptual framework of "Importance and Satisfaction Analysis" (IS Analysis) is a questionnaire analysis method of "Importance-Performance Analysis" (IPA) [12] put forward by Martilla and James (1977). This analysis method finds out the relevant indicators such as products, consumption goals or business models that affect the company's operations, and a two-dimensional graph can be drawn with vertical and horizontal axel that respectively represent the importance index and performance index of each indicator to the company. Centered at the median of importance and performance, the two-dimensional graph is divided into four quadrants. In 1992, Graf, Hemmasi, and Nielsen (1992) [13] reconceptualized the importance-performance analysis of IPA into Importance-Satisfaction Analysis (IS Analysis), which was different from the original IPA in that the original external strategy concept (consumers and products) is extended to internal operations. This model used in resource management application is to evaluate the importance of key indicators and cognitive satisfaction by organization members, thus it is called "Importance-Satisfaction Analysis (I-S Analysis)", as shown in Figure 1.

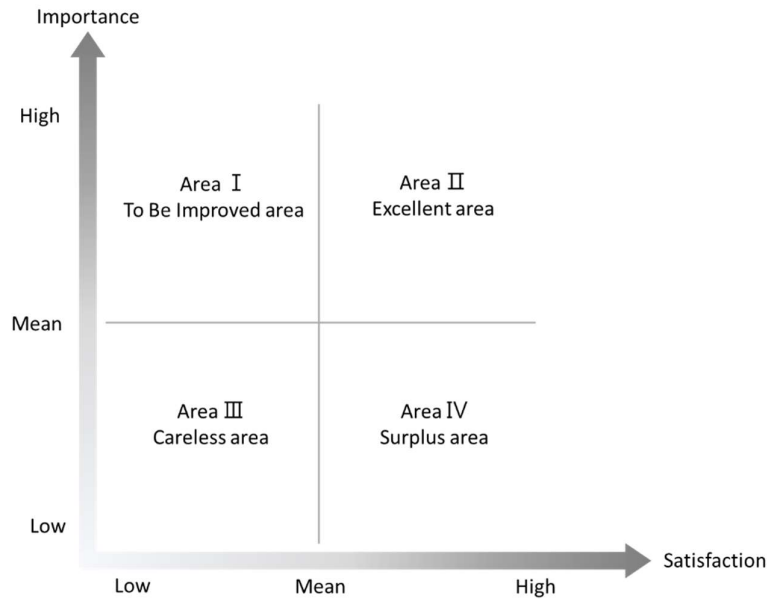


Figure 1. Importance-Performance Analysis

The first step of I-S Analysis is to complete a comprehensive list of key indicators, and through literature review and in-depth interview with experts to understand subjective experiences from these interviewees, guiding them to provide some information or express their opinions and thoughts (Henderson, 1991) [14]. Indicators can be collected by either Interviewees talk over the questions raised by the interviewers or group interviews are conducted. I-S Rating is made based on the list of the collected indicators. Interviewee would be asked to score for satisfaction rating for the key indicators on the rating scale (such as a 5-scale score, 1 = very dissatisfied, 5 = very satisfied), and the importance rating is also given to each key indicator. Similar to the satisfaction rating, it is rated on the scale from the "very unimportant" to the "very important". Importance and Satisfaction have different meanings. Importance refers to the importance of employees' awareness of the organization's various environmental measures, services or management factors, while satisfaction means the degree of satisfaction that employee's sense about each factor. Like IPA analysis, the average scores of importance and satisfaction are drawn into a two-dimensional matrix, and then the subsequent decision-making analysis is carried out according to the quadrant position of each attribute. Importance analysis can help organizations prioritize the allocation of various resources or decision-making, and satisfaction analysis can find out how satisfied respondents are with environmental facilities, services, or management. The development strategy of the indicator then can be analyzed through the quadrant of each indicator located. These high importance-high satisfaction indicators must be maintained, and these high importance-low satisfaction indicators will be focused on improvement, the low importance-low satisfaction indicators can be ignored, and the resources invested on the low importance-high satisfaction indicators can be reduced. The use of I-S Analysis quadrant graph can not only rank the improvement priority, but also provide reference for making strategy. (Sampson & Showalter, 1999; Slack, 1994) [15]

3. Results

3.1 AHP & DHP weighting and ranking

The comprehensive evaluation method and system of sustainable buildings can be applied to the considerations of pre-design, building construction, management operation, facility maintenance of sustainable buildings to the end of life of main building (Vierra, 2015) [16]. This study takes Taipei

101 Tower, once the tallest building in the world, as a research case. Through in-depth interviews, based on years of work experience and insights in the professional field, experts put forward their own opinions. After sorting out the factors that affect the willingness to rent, there are a total of 5 aspects and 25 key factors, as shown in Table 2.

Table 2. Indicators affecting the leasing willingness

GOAL	LEVEL 1	LEVEL 2
Indicators affecting the leasing willingness	Building facilities	1. Height of ceiling
		2. Defense of earthquake
		3. High-Level materials
		4. Independent A/C
		5. Backup power
	Geographical location	6. Central Business district
		7. Shopping area
		8. Dining selections
		9. Zoning
		10. Recreational area
	Nearby facilities	11. Common Facilities
		12. Service amenities
		13. Dual power
		14. Healthcare support
		15. Hotel selections
	Transportation convenience	16. Metro stations
		17. Highway interchanges
		18. Car Parking
		19. Public transit
		20. Road networks
	Image	21. Landmark building
		22. Green and smart building
		23. Tenant portfolio
		24. Image of Owner
		25. Property management

We used both of AHP and Delphi methods for questionnaire verification, and then calculated the weights of core indicators. Total of 40 expert questionnaires were sent, 36 questionnaires responded, finally there are 26 were effective (see Table 3).

Table 3. Background of Experts

Group	Type	Distributed copies	Returned copies	Valid copies
Management group	Finance	5	4	4
	Engineering	5	5	1
	Building Management	5	5	2
Consultant group	Leasing agency	10	10	12
	Appraiser	5	5	4
	PM consultant	10	7	3
Total		40	36	26

The return rate of questionnaire was 90%, with the effective questionnaire data consistency ratio ($CR \leq 0.1$), and all data are included in the statistics. On the first level, sort order by weight are " Geographical location 29.99%", "Transportation convenience 24.25%", "Image 20.41%", "Building Facilities 15.06%" and " Nearby facilities 10.29%". The overall weights and ranking of indicators are listed in Table 4.

Table 4. AHP ranking of the weighted indicators

LEVEL 1	LEVEL 2	Cumulative weight	Rank
Building Facilities 15.06%	1. Height of ceiling	1.17%	25
	2. Defense of earthquake	3.22%	10
	3. High-Level building materials	1.30%	14
	4. Independent A/C	2.37%	20
	5. Backup power	2.69%	16
Geographical location 29.99%	6. Central Business district	11.57%	1
	7. Shopping area	3.12%	11
	8. Dining selections	7.46%	4
	9. Zoning	3.54%	9
	10. Recreational area	2.67%	17
Nearby facilities 10.29%	11. Common Facilities	2.84%	14
	12. Service amenities	2.83%	15
	13. Dual power	2.48%	18
	14. Healthcare support	1.49%	23
	15. Hotel selections	1.78%	22
Transportation convenience 24.25%	16. Metro stations	9.97%	2
	17. Highway interchanges	2.26%	21
	18. Car Parking	4.03%	8
	19. Transportation	6.29%	5
	20. Road networks	3.12%	12
Image 20.21%	21. Landmark building	7.65%	3
	22. Green and smart building	2.92%	13
	23. Tenant portfolio	4.98%	7
	24. Image of Owner	2.38%	19
	25. Property management	5.88%	6
100%		100%	

3.2 External and internal key indicators

Through AHP and DHP analysis, the sort order of 25 key indicators affecting leasing willingness is derived. Key indicators can be divided into external and internal indicators as shown in Table 5. Among them, the external indicators belong to the projects that cannot be improved by property management unit alone. The improvement of internal indicators will help increase the willingness to rent, thus the operation of sustainable buildings will be more stable due to the increase in user satisfaction.

Table 5. External and internal key indicators

Type	Key indicators	Description
External	1. Central business district	Located in the main business district of Taipei City
	2. Recreational space	Close to recreational space such as Xinyi Sports Center
	3. Common facilities	Nearby area provides a full range of necessary public facilities
	4. Healthcare support	Close to medical resources such as hospital in case of emergency
	5. Hotel selections	Adjacent to star-rated hotels providing Accommodation options for foreign visitors
	6. Metro stations	The building is connected to the exit of the MRT station
	7. Highway interchanges	Connectivity to the highway interchange.
	8. Transportation	Public transit is convenient around the building
	9. Road networks	Connectivity to complete road networks
Internal	1. Height of ceiling	Indoor ceiling height exceeds 2.8 meters
	2. Defense of earthquake	Various seismic equipment including wind dampers
	3. High-Level building material	high quality building materials used in building
	4. Independent A/C	Independent air conditioning equipment provided by the owner
	5. Backup power	Backup power supply in case of emergency
	6. Shopping area	Adjacent to shopping district
	7. Dining selections	Numerous dining options nearby
	8. Zoning	Land use zoning is legal for company establishment and registration
	9. Service amenities	Provides complete business supporting amenities such as convenience store, express and dry cleaning
10. Dual power	The building has the power supply from Taipower's dual power substation	
11. Car parking	The building provides sufficient parking spaces for tenants and visitors	
12. Landmark Building	The building itself is an internationally renowned landmark building	
13. Green and smart building	The building is designed or operated as green buildings and smart buildings	
14. Tenant portfolio	High quality tenant mix	
15. Image of Owner	The building has a good social image	
16. Property management	Owners provide high quality property management	

The importance and satisfaction of property facilities were analyzed based on 16 internal indicators. 25 respondents rated 16 key indicators following Likert Scale [17]. Importance and satisfaction scores of each indicator are shown in Table 6.

Table 6. Importance and satisfaction scores of internal key indicators

Key indicators	Importance	Satisfaction
1. Height of ceiling	4.3667	3.6000
2. Defense of earthquake	4.3667	4.6333
3. High-Level building materials	3.8667	3.6667
4. Independent A/C	4.3667	3.0000
5. Backup power	4.6333	3.8333
6. Shopping area	3.8333	4.3333
7. Dining selections	4.3000	4.0000
8. Zoning	4.1667	3.9000
9. Service amenities	4.4333	4.4333
10. Dual power	4.4333	3.8000
11. Car parking	4.7000	3.9667
12. Landmark Building	4.4000	4.3000
13. Green and smart building	3.9667	3.8000
14. Tenant portfolio	4.5667	3.8000
15. Image of Owner	3.8000	3.9000
16. Property management	4.6667	4.3667

The distribution of internal indicators based on the scores of importance and satisfaction is illustrated in figure 2.

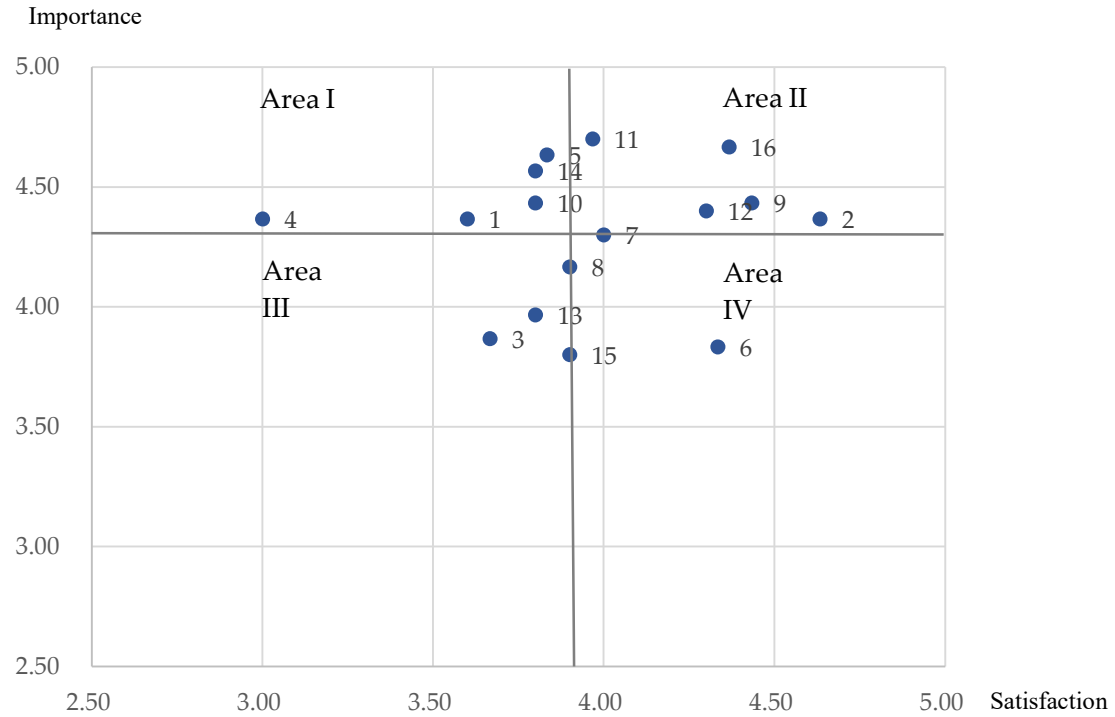


Figure 2 Importance-Performance Distribute Analysis

4. Discussion

Uher & Lawson (1998) pointed out that specific environmental problems need to rely on the performance standards and indicators of sustainable building to evaluate the performance of buildings or facilities [18]. Sustainable building is the creation and the practice of reconstruction, operation, maintenance, and demolition of architecture models using healthier and more resource-efficient construction methods (Roy, 2008) [19]. In this case study, based on the analysis of I-S Model, there are 5 items fell in Area I (To be Improved Area); 6 items fell in Area II (Excellent Area); 4 items fell in Area III (Careless Area) ; 1 items in Area IV (Surplus Area). Key indicators are listed in table 7.

Table 7. I-S Model Interanal key indicators distributed area

Area I	Area II
Height of ceiling	Dining selections
Independent A/C	Car parking
Backup power	Defense of earthquake
Dual power	Service amenities
Tenant portfolio	Landmark building
	Property management
Area III	Area IV
High-Level building materials	Shopping area
Green and smart building	
Zoning	
Image of owner	

In Area I (To be Improved Area), there are 5 items that need to be improved first in this study. Among them, the most urgent item of property facilities to be improved is air-conditioning facilities.

The importance is high but the satisfaction is low. After in-depth investigation, it is found that regarding the interviewees are mainly dissatisfied with the air-conditioning facilities, suggested solutions for the improvement order can refer to Yang's proposal (2003), between importance and satisfaction using improvement coefficient method [20] to calculate the difference ratio. The greater the negative value, the higher the priority to improve.

The formula is as follows:

$$\text{Improvement coefficient} = \frac{(\text{customer satisfaction} - \text{customer importance})}{\text{customer importance}} \quad (1)$$

5. Conclusions

The value of the building starts from the day of completion, and the life span of the building will depend on the maintenance and management of the property facilities. Berardi (2012) has pointed out that building's sustainability should consider sustainable development in three primary aspects: economic, environmental and social, while also meeting functional performance requirements [21]. Achieving sustainable architecture is one of the main objectives for humans to create a better life and an ultimate model for professional activities. Hence, moving forward to a greener architecture is one of the primary goals for modern architecture in our time (Mahdavinejad, Arash, Airya, Setareh & Narjes, 2014) [22].

Enterprises usually operate with limited resources, the same situation as the sustainable operation and management of buildings. When faced with increasingly sophisticated construction methods and continuous advancement of equipment for property and facility management, there is no particular rule to follow in the past. In the face of inadequate resources, the order of improvement projects often depends on the project budget required. Such an arrangement may not meet users' expectations, and huge costs are invested in ineffective property and facility improvements; however, the user's satisfaction cannot be improved afterward, ultimately leading to poor operations. This study provided the basis for the advancement of property facilities through the selection process of key indicators and the analysis method of the user's importance and satisfaction, and a practical framework for the decision making of property managers and owners.

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