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Applying Kano Two-Dimensional Quality Model to Build the Performance Evaluation Indicators of Long-Life High-Quality Condominiums

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Abstract: Extending the life span of buildings and improving residential quality has been an important goal for creating residential environments with sustainable development over recent years. This study aims to establish the performance evaluation indicators of long-life high-quality condominiums in Taiwan areas. To identify the evaluation indicators, this study first identified the users' basic needs, and referred to comparative analysis of the house performance evaluation indicators in other countries. A questionnaire survey based on the Kano model was conducted to explore respondents' satisfaction with evaluation indicators. Finally, three indicators, including "equipment pipeline maintenance available on each floor", "maintenance plan", and "site transportation routes", were identified as the items of first selection priority from the indicators. Four indicators, including "exposed equipment pipeline", "site open space", "water resource recycling", and "expandability of interior space" are listed as obsolete items for the time being. The results of this study can be used as reference for the establishment of the performance evaluation indicators of long-life high-quality condominiums in Taiwan, as well as for the establishment of performance evaluation indicators for new residential buildings within the scope of the redevelopment plans of dangerous and old buildings in urban areas.

Keywords: Kano model; long-life high-quality condominiums; performance evaluation indicators

1. Introduction

According to data, the average life span of houses in the UK is approximately 140 years, approximately 103 years in the US, and approximately 80 years in Germany [1]. Chen et al. (2017) concluded that the average life span of buildings in Taiwan ranges from approximately 30 to 40 years, with reference to studies regarding the average life span of relevant buildings in Japan, which is significantly shorter than that in Western countries [2]. Considering the goal of sustainable development, providing long-life and sustainable buildings that use fewer resources and reduce CO₂ emission over the course of the building life cycle have become important building management strategies for all countries around the world.

A condominium is a type of building or complex, similar to apartments, but the building structure is divided into several units that are each separately owned, surrounded by common areas that are jointly owned. It is a common residential pattern in Asian urban areas. The residential environments of condominiums with high quality can meet the goal of sustainable development and satisfy basic living needs, thus becoming an important global development trend. The durable multi-unit housings must be constructed based on the principles of environmental protection, energy saving, and CO₂ emission reduction, in order to prolong the life span of the building [3,4]. Responding to the aforementioned trend, the Ministry of Land, Infrastructure, Transport, and Tourism in Japan released the Act on the Promotion of Popularization of Long-Life Quality Housing (for condominiums)

in 2009, and commenced to promote the indicators of long-life quality housing in the same year, which led to improvements in the efficiency and quality of condominiums [1]. To some degree, this act was an extension of the concept and experiences of open building implementation that focuses on spatial adaptability and maintainability for a long-term occupation.

Long-life high-quality housing refers to the housing is equipped with durability, adaptability, maintainability, and amenity to extend its service life for a long time. Some studies also pointed out that the factors such as physical, economic, social, technical, and functional obsolescence may affect the service life of the buildings [2,5]. In order to create a residential environment of sustainable development in long-life high-quality condominiums, identifying important evaluation indicators that can effectively measure the life span of buildings has become more foundational.

Many institutes and systems have developed relevant housing performance evaluation indicators, such as the Housing Quality Standards (HQS) in U.S federal regulations, the *Housing Quality Assurance Act* (HQAA) in Japan, the *Housing Quality Indicator* (HQI) in the United Kingdom, and *Housing-Healthy Indicators* (HHI) in the World Health Organization (WHO). Taiwan released the *Measures for the Implementation of Housing Performance Evaluation* in 2012, which stipulates evaluation indicators as the performance evaluation items for houses. However, evaluation indicators for long-life high-quality condominiums in Taiwan have not been developed at the present. For the purpose of extending the life span of buildings and improving residential quality, and hence, facilitating the creation of the residential environment of sustainable development, the establishment of such evaluation indicators has been the key to establishing a validation system.

The objective of this study is to build the performance evaluation indicators of long-life high-quality condominiums in Taiwan urban areas. First, relevant evaluation indicators are initially established by virtue of comparative analysis. Subsequently, respondents and experts in industries are invited to examine these evaluation indicators through a questionnaire survey conducted by the Kano model. Finally, evaluation indicators are screened through a quality improvement matrix and specific recommendations are provided regarding the evaluation indicators of long-life high-quality condominiums in Taiwan urban areas. The proposed evaluation indicators are expected to contribute the future design principles and urban renewal strategies for Taiwan.

2. Literature Review

2.1. Sustainable Development and Maslow's Hierarchy of Needs Theory

In 1987, the United Nations World Commission on Environment and Development released the report "Our Common Future", commonly called the Brundtland Report, which included the definitions of sustainable development [6,7]. Today, the core of mainstream sustainability thinking has become the idea of three dimensions, "environmental protection", "social sustainability", and "economic sustainability" [8]. Maslow (1943) divided human's basic needs into five hierarchies, in ascending order, physiological needs, safety needs, love and belongingness needs, esteem needs, and self-actualization needs [9]. In terms of how Maslow's theory might relate to the concept of sustainable development, the literature includes some discussion on the relationship. Parris and Kates' (2003) discussion of the requirement to satisfy basic human needs as part of a sustainability transition identifies hunger, equality, health, and education as basic needs to be satisfied, consistent with Maslow's theory [10]. Baqutayan et al. (2011) examined on how certain standards need to be encountered in housing for the societal wellbeing and then defined the need for affordable livable sustainable housing based on Maslow's theory [11]. Walsh (2010) believed that applying Maslow's theory to the examination of global sustainability has its merit [12].

2.2. Open Building Theory

The open building theory was proposed by Habraken (1961), who designed condominiums with a support system and infill system [13]. The support system refers to the structure section shared

by residents, such as columns, beams, floor-slabs, and bearing walls. The infill system refers to the detachable parts within the several units of individual residents, such as partition wall, interior decoration, furniture, equipment pipeline, etc. [13]. The infill system for housing must be adaptable to the changing lifestyles of residents, and easily fitted and removed. Minami (2016) argued that the concept of open building will play an important role in Japan's future [1]. Kim and Hwang (2017) indicated that long-life housing is a housing type in preparation for changes in residential environments in the future; long-life housing certification is evaluated in accordance with the total scores from the evaluation of each performance, as based on the durability, flexibility (the support and infill is evaluated for variability), and maintainability in Korea [14,15]. With the development of information technology and construction methods, combining open building concepts with building information modeling (BIM) techniques can be feasible to resolve the problems of sustainable renovation of old existing housing buildings [16,17].

2.3. Evaluation Categories for Activation and Reutilization of Buildings

Langston et al. (2007) implemented analysis and evaluation on the reutilization potential of existing buildings, and proposed a set of architecture, which was referred to as the adaptive reuse potential (APR) model. The model can be used to evaluate the life span of buildings through physical, economic, social, technical, functional, and legal evaluation categories [5]. Conejos et al. (2013) evaluated the potential of the activation and reutilization of existing buildings through physical, economic, social, technical, functional, legal, and political evaluation categories [18]. Chen et al. (2017) examined the life span of buildings through physical, economic, social, technical, functional, policy evaluation categories, etc. The physical evaluation category includes the maintainability of equipment pipelines, durability and seismic performance of the structure; the economic and social evaluation category includes the distance between the building and public facilities, the width of roads adjacent to the site, city landscape, and open space; the technical evaluation category includes ventilation, noise insulation, water proofing, and day-lighting; the functional evaluation category includes space variance [2].

3. Comparative Analysis of Housing Performance Evaluation Indicators

A number of studies have developed and established evaluation indicators for housing performance evaluation. For example, the housing quality standards (HQS) established by U.S federal regulations offer a guide to what is required for safe, sanitary, and affordable housing. The housing quality assurance act (HQAA), developed by the Building Center of Japan in 2000, proposes nine indicators for housing quality: Structural safety, fire safety, deterioration mitigation, maintenance management, heat environment, air environment, light environment, noise environment, and facilities for elderly people [19]. After that, The Ministry of Land, Infrastructure, Transport, and Tourism in Japan promulgated the identification criterion of long-life quality housing (for condominiums) plan in 2009, and listed nine items, including "structure-degradation countermeasures", "seismic resistance", "ease of maintenance, management, and update", "variability", "the elderly countermeasures", "energy-saving countermeasures", "residential environment", "household area", and "maintenance and preservation plan", as the evaluation indicators of long-life quality housing [1]. The housing quality indicator (HQI) system measures the quality of housing schemes funded by the Homes and Communities Agency in the United Kingdom. At present, HQI consists of 10 items, including (1) location; (2) site-visual impact, layout, and landscaping; (3) site-open space; (4) site-routes and movement; (5) unit-size; (6) unit-layout; (7) unit-noise, light, services, and adaptability; (8) unit-accessibility within the unit; (9) unit-sustainability; (10) external environment-building for life [20]. The World Health Organization (WHO) also defines three major fields for housing-healthy indicators (HHI): Economy/use, comfort, and safety indicators [21].

The competent authorities of building at the central administration in Taiwan released the "Interim Implementation Measures for Housing Performance Evaluation" in December 2012, and has established

eight items as housing performance evaluation indicators at present [22], including “structural safety”, “fire safety”, “barrier-free environment”, “air environment”, “light environment”, “sound environment”, “energy saving and water conservation”, and “housing maintenance”. However, appropriate evaluation criteria for the performance evaluation of long-life high-quality condominiums have not been established at present.

4. Research Method

4.1. Kano Two-Dimensional Quality Attributes Model

In 1979, Kano and Takahashi introduced Herzberg’s motivation-hygiene theory into quality-related fields, which furthered the relationship between the sufficient quality factors condition and user satisfaction by analogy. In 1984, Kano et al. further developed the Kano two-dimensional quality attributes model, and classified quality factors into five categories according to quality attribute, including attractive quality, one-dimensional quality, must-be quality, indifferent quality, and reverse quality attribute [23], as shown in Figure 1. The Kano model intends to analyze the internal needs of customers at the psychological level, as described below:

- Attractive quality attribute (A): Customers will be satisfied when this quality attribute is sufficient, and may also accept when this quality attribute is insufficient.
- One-dimensional quality attribute (O): Customers will be satisfied when this quality attribute is sufficient, and will be dissatisfied when this quality attribute is insufficient.
- Must-be quality attribute (M): Customers will take it for granted, but will not be satisfied when this quality attribute is sufficient; will be dissatisfied when the quality attribute is insufficient.
- Indifferent quality attribute (I): Customers will neither be satisfied nor dissatisfied when this quality attribute is sufficient or insufficient.
- Reverse quality attribute (R): Customers will be dissatisfied when this quality attribute is sufficient, and will be satisfied when this quality attribute is insufficient [24].

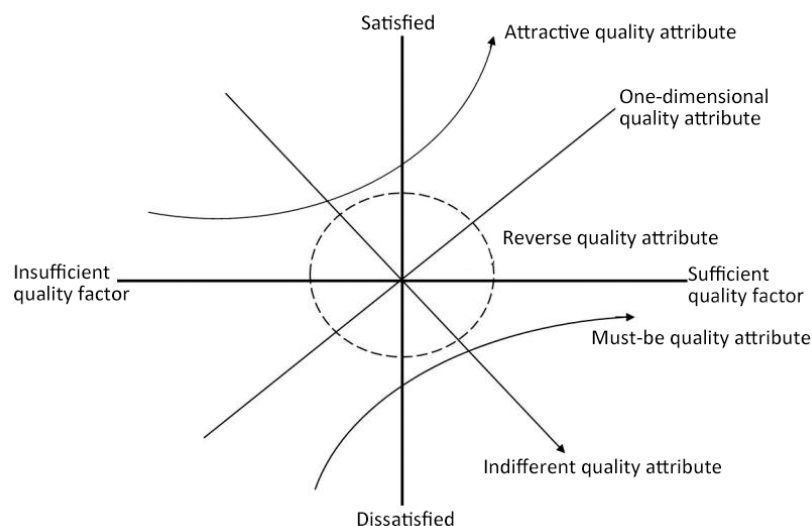


Figure 1. Kano two-dimensional quality model.

4.2. Questionnaire Survey of Quality Attributes

Respondents’ feeling to and satisfaction with the presence or absence of the quality items of products or services in the Kano questionnaire were identified as the basis for evaluating the Kano quality attributes. In terms of Kano two-dimensional quality attributes, respondents’ feelings regarding the presence (positive) and absence (negative) of such qualities are divided into “I like it that way”, “It must be that way”, “I am neutral”, “I can live with it that way”, and “I dislike it that way”, according

to the positive and negative questions in the above questionnaire, and then, quality attributes are understood through cross validation (as shown in Table 1).

Table 1. Analysis table of Kano two-dimensional quality attributes.

	Negative	Like	Must -be	Neutral	Live with	Dislike
Positive						
Like		Q	A	A	A	O
Must -be		R	I	I	I	M
Neutral		R	I	I	I	M
Live with		R	I	I	I	M
Dislike		R	R	R	R	Q

Note: Q, A, R, I, O, and M denote “Questionable”, “Attractive”, “Reverse”, “Indifferent”, “One-dimensional”, and “must-be” attributes, respectively.

4.3. Customer Satisfaction Coefficient

Berger et al. (1993) proposed the customer satisfaction coefficient to explain the relationship between “quality attribute” and “customer satisfaction” [24]. The positive ICSC ranges from 0 to 1. The closer the value is to 1, the higher the influence on customer satisfaction. On the contrary, if the negative RCSC approaches -1 , the influence on customer dissatisfaction is especially strong if the attribute of the product (or service) is not fulfilled [25].

Increasing customer satisfaction

$$\text{Coefficient (ICSC)} = (A + O)/(A + O + M + I) \quad (1)$$

Reducing customer satisfaction

$$\text{Coefficient (RCSC)} = -(O + M)/(A + O + M + I) \quad (2)$$

5. Evaluation Categories and Establishment of Evaluation Indicators

In this study, in order to establish the performance evaluation indicators of long-life high-quality condominiums that meet the goals of environmental protection, economic sustainability, and satisfying users' basic needs, evaluation categories were initially established based on the principle of sustainable development, Maslow's hierarchy of needs theory, and the open building theory (as shown in Table 2).

Second, evaluation indicators were established through comparative analysis of housing performance evaluation items in the UK and other countries (as shown in Table 2). In terms of the “physical” evaluation indicator category, (1) “exposed equipment pipeline”, “equipment pipeline maintenance available on each floor”, “maintenance plan”, and “barrier-free environment” were identified as evaluation indicators, which intend that users' physiological needs can be satisfied by enhancing building maintenance management and providing facilities for mobility-impaired persons in the context of environmental protection and economic sustainability; (2) “structural durability”, “structural safety”, and “fire safety” were identified as evaluation indicators, which intend that users' “physiological and safety” needs can be satisfied by virtue of improving the durability and safety of buildings. In terms of the “economic and social” evaluation category, “site transportation routes”, “site location”, “building for community life”, and “site open space” were identified as evaluation indicators, which intend that users' psychological needs of “love and belongingness” can be satisfied by site selection, and appropriate provision of transportation routes, community life, and open space in the context of economic and social sustainability. In terms of the “technical” evaluation category, “comfort of interior space”, “comfort of interior physical environment”, “daily energy saving”, and “water resource recycling” were identified as evaluation indicators, which intend that users' psychological needs of “esteem” can be satisfied by the high-quality interior residential environment and proper

energy saving measures in the context of environmental protection and economic sustainability. In terms of the “functional” evaluation category, “adaptability of interior space” and “expandability of interior space” were identified as evaluation indicators, which intend that interior space will enable users to develop abilities and implement flexible adjustment, and users’ psychological needs of “self-actualization” can be satisfied in the context of economic sustainability.

Table 2. Comparative analysis of evaluation indicators of long-life high-quality condominiums.

Theories	Environmental Protection, Economic Sustainability and Social Sustainability			
Human’s needs principle	Physiological needs and safety needs	Love and belongingness needs	Esteem needs	Self-actualization needs
Open Building principle	Separation of infill system from support system			Separation of infill system from support system
Establishment of evaluation categories	Physical	Economic and social	Technical	Functional
Evaluation indicators in Japan	Ease of maintenance Management and update maintenance and preservation plan Seismic resistance Structure-degradation and the elderly countermeasures	Residential environment	Household area Energy-saving countermeasures	Variability
Evaluation indicators in the UK		Location Site–visual impact, layout and landscaping Site–open space Site–routes and movement Unit–accessibility within the unit External environment–building for life	Unit- size, layout Unit- noise, light, services Unit- sustainability	Unit-adaptability
Evaluation indicators in Taiwan	Housing maintenance Structural safety Barrier-free environment fire safety		Environment- air, light and sound Energy saving and water conservation	
Establishment of evaluation indicators	Exposed equipment pipeline Equipment pipeline maintenance available on each floor Barrier-free environment Structure durability Structural safety Fire safety Maintenance plan	Site transportation routes Site location Building for community life Open space	Comfort of interior space Comfort of interior physical environment Daily energy saving Water resource recycling	Adaptability of interior space Expandability of interior space

6. Results

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn. For the purpose of screening the evaluation indicators, in this study, a questionnaire survey of Kano two-dimensional quality attributes was conducted on 105 subjects. They have background in building-related industries, and interact with building users in Taipei City. Among the respondents, 42 persons are in real estate, 21 in architectural engineering, 18 in civil engineering, 6 in public administration, 5 in land development, 5 in electrical engineering, and 8 in other industries. The results of the questionnaire survey concerning the two-dimensional quality attributes of 17 evaluation indicators in this study were established and are described below.

6.1. Physical Evaluation Category

- Exposed equipment pipeline (No.1) evaluation indicator: This refers to the evaluation method regarding whether the equipment pipeline within a building is designed in the form of an “exposed pipeline”, meaning that it is separated from the structure (as shown in Figure 2). This indicator was identified as a must-be quality attribute (as shown in Table 3) through statistics and analysis, indicating that customers will take it for granted, but will not be satisfied when the quality is sufficient, and will be dissatisfied when the quality is insufficient.
- Equipment pipeline maintenance available on each floor (No.2) evaluation indicator: This refers to the evaluation method regarding whether appropriate manholes are provided at each floor within a building, in order to facilitate equipment pipeline (e.g., water and electricity pipelines) repair (as shown in Figure 2). The indicator was identified as a must-be quality attribute through statistics and analysis.



Figure 2. (a) Exposed equipment pipeline; (b) equipment pipeline maintenance available on each floor.

- Barrier-free environment (No.3) evaluation indicator: This refers to the evaluation method regarding whether the common parts and special parts within a building meet the provisions of a barrier-free environment design. The indicator was identified as a must-be quality attribute through statistics and analysis.
- Structural durability (No.4) evaluation indicator: This refers to the evaluation method regarding whether the main structure of a building can be used continuously under general maintenance and management conditions within a specific time. The indicator was identified as a must-be quality attribute through statistics and analysis.
- Structural safety (No.5) evaluation indicator: This refers to the evaluation method regarding whether the building structure can withstand specific seismic force and will not collapse, and whether the angle of displacement between floors above ground meets relevant requirements. The indicator was identified as a must-be quality attribute through statistics and analysis.
- Fire safety (No.6) evaluation indicator: This refers to the evaluation method regarding whether the fire alarm, fire-fighting, evacuation, and fire spread prevention in a building meet relevant requirements. The indicator was identified as a must-be quality attribute through statistics and analysis.
- Maintenance plan (No.7) evaluation indicator: This refers to the evaluation method regarding whether futurity is considered from the planning and design phase of a building, and a plan has been developed for inspection and repair. The indicator was identified as a one-dimensional quality attribute through statistics and analysis, indicating that customers will be satisfied when the quality is sufficient and dissatisfied when the quality is insufficient.

6.2. Economic and Social Evaluation Category

- Site transportation routes (No.8) evaluation indicator: This refers to the evaluation method regarding whether the economical efficiency and convenience of the transportation routes for pedestrians and vehicles on the building site meet relevant requirements. The indicator was identified as a one-dimensional quality attribute through statistics and analysis.
- Site location (No.9) evaluation indicator: This refers to the evaluation method regarding whether the distance between the site location and public facilities, adjacent facilities, and noise source is appropriate. The indicator was identified as a one-dimensional quality attribute through statistics and analysis.
- Building for community life (No.10) evaluation indicator: This refers to the evaluation method regarding whether the quality and quantity of the building for community life of the building meet relevant requirements. The indicator was identified as a one-dimensional quality attribute through statistics and analysis.
- Site open space (No.11) evaluation indicator: This refers to the evaluation method regarding whether appropriate open space is provided on site. The indicator was identified as an indifferent quality attribute through statistics and analysis, indicating that customers will neither be satisfied nor dissatisfied when the quality is sufficient or insufficient.

6.3. Technical Evaluation Category

- Comfort of interior space (No.12) evaluation indicator: This refers to the evaluation method regarding whether the size of interior space meets relevant requirements. The indicator was identified as a one-dimensional quality attribute through statistics and analysis.
- Comfort of interior physical environment (No.13) evaluation indicator: This refers to the evaluation method regarding whether sound insulation, sunshine exposure, ventilation, and day-lighting of the interior space of the housing meet relevant requirements. The indicator was identified as a one-dimensional quality attribute through statistics and analysis.
- Daily energy saving (No.14) evaluation indicator: This refers to the evaluation method regarding whether sunshade, thermal insulation, and lighting system of the building meet relevant requirements. The indicator was identified as a one-dimensional quality attribute through statistics and analysis.
- Water resource recycling (No.15) evaluation indicator: This refers to the evaluation method regarding whether the recycling of rainwater and domestic sewage meets relevant requirements. The indicator was identified as an indifferent quality attribute through statistics and analysis.

6.4. Functional Evaluation Category

- Adaptability of interior space (No.16) evaluation indicator: This refers to the evaluation method regarding whether interior sound insulation of the building can be adjusted appropriately according to the users' life style. The indicator was identified as an attractive quality attribute through statistics and analysis. It is a quality attribute that customers will be satisfied when the quality is sufficient, but may also accept when the quality is insufficient.
- Expandability of interior space (No.17) evaluation indicator: This refers to the evaluation method regarding whether the exterior wall of the building can be adjusted appropriately according to the users' life style. The indicator was identified as an indifferent quality attribute through statistics and analysis.

6.5. Questionnaire Survey of Evaluation Indicators

The results of questionnaire survey concerning the two-dimensional quality attributes of 17 evaluation indicators in this study were calculated according to equations for "increasing customer

satisfaction coefficient” and “reducing customer dissatisfaction coefficient”. The statistical results are shown in Table 3.

Table 3. Statistic and analysis of questionnaire survey results of evaluation indicators.

Evaluation Category	No	Evaluation Indicator Item	A	O	M	I	R	Quality Attribute	Increasing Customer Satisfaction Coefficient	Reducing Customer Dissatisfaction Coefficient
Physical	1	Exposed equipment pipeline	0.21	0.23	0.30	0.24	0.02	M	0.44	−0.53
	2	Equipment pipeline maintenance available on each floor	0.22	0.28	0.31	0.19		M	0.50	−0.59
	3	Barrier-free environment	0.16	0.27	0.46	0.11		M	0.43	−0.73
	4	Structural durability	0.10	0.35	0.48	0.08	—	M	0.45	−0.83
	5	Structural safety	0.06	0.41	0.50	0.04	—	M	0.47	−0.91
	6	Fire safety	0.04	0.39	0.53	0.04	—	M	0.43	−0.92
	7	Maintenance plan	0.20	0.31	0.30	0.19		O	0.51	−0.61
Economic and social	8	Site transportation routes	0.18	0.37	0.24	0.21	—	O	0.55	−0.61
	9	Site location	0.21	0.33	0.19	0.27	—	O	0.54	−0.52
	10	Building for community life	0.26	0.33	0.13	0.28	—	O	0.59	−0.46
	11	Site open space	0.24	0.25	0.18	0.33		I	0.49	−0.43
Technical	12	Comfort of interior space	0.24	0.27	0.24	0.25		O	0.51	−0.51
	13	Comfort of interior Physical Environment	0.23	0.30	0.24	0.23		O	0.53	−0.54
	14	Daily energy saving	0.24	0.28	0.27	0.21		O	0.52	−0.55
	15	Water resource recycling	0.23	0.26	0.24	0.27		I	0.49	−0.50
Functional	16	Adaptability of interior space	0.35	0.21	0.13	0.31	—	A	0.56	−0.34
	17	Expandability of interior space	0.30	0.18	0.13	0.39		I	0.48	−0.31
Average value									0.50	−0.58

Berger et al. (1993) established the quality improvement matrix according to the average value of “increasing customer satisfaction coefficient” and “reducing customer dissatisfaction coefficient”; customer satisfaction with products or services can be improved and customer dissatisfaction can be reduced through screening of the evaluation indicators. In order to screen the performance evaluation indicators of long-life high-quality condominiums, in this study, a quality improvement matrix was established, as based on the average value of increasing customer satisfaction coefficient and reducing customer dissatisfaction coefficient, as shown in Figure 3.

Increasing customer satisfaction coefficient and reducing customer dissatisfaction coefficient of equipment pipeline maintenance available on each floor (No.2), maintenance plan (No.7), site transportation routes (No.8), and other evaluation indicators are above the average value, and all such indicators are within the first quadrant of the quality improvement matrix, as shown in Figure 3. It is shown that among all evaluation indicators, the above-listed three indicators can make above-average-level contributions to increasing customer satisfaction and reducing customer dissatisfaction; therefore, they are items of first priority in selection. Reducing customer dissatisfaction coefficient of barrier-free environment (No.3), structural durability (No.4), structural safety (No.5), fire safety (No.6), and other indicators is above the

average value (−0.58), and all such indicators are within the second quadrant of the quality improvement matrix, as shown in Figure 3.

Increasing customer satisfaction coefficient” of site location (No.9), building for community life (No.10), comfort of interior space (No.12), comfort of interior physical environment (No. 13), daily energy saving (No.14), adaptability of interior space (No. 16), and other indicators are above the average value (0.50), and all such indicators are within the fourth quadrant of the quality improvement matrix. Increasing customer satisfaction coefficient and reducing customer dissatisfaction coefficient of exposed equipment pipeline (No.1), site open space (No.11), water resource recycling (N.15), expandability of interior space (No.17), and other indicators are below the average value, and all such indicators are within the third quadrant of the quality attribute matrix. In the questionnaire survey, some respondents thought that No.1, the design of exposed equipment pipeline, will lead to a decrease in the interior usable area in accordance with current acts and regulations in Taiwan; No.11 will cause a problem in residential space management, because open space on site must be available for the general public, in accordance with current acts and regulations in Taiwan; in terms of No.15, it will lead to poor cost effectiveness in water resource recycling due to the relatively low water price in Taiwan at present; in terms of No.17, change to the exterior wall of apartments must be approved at the meeting of the unit owners in accordance with current acts and regulations in Taiwan; hence, it is difficult to make changes.

In view of the above, at the present stage, the relevant acts and systems in Taiwan must be improved and the concept of sustainable development for the public must be reinforced if recognition is to be obtained. As a result, the four evaluation indicators above can be listed as obsolete items for the time being.

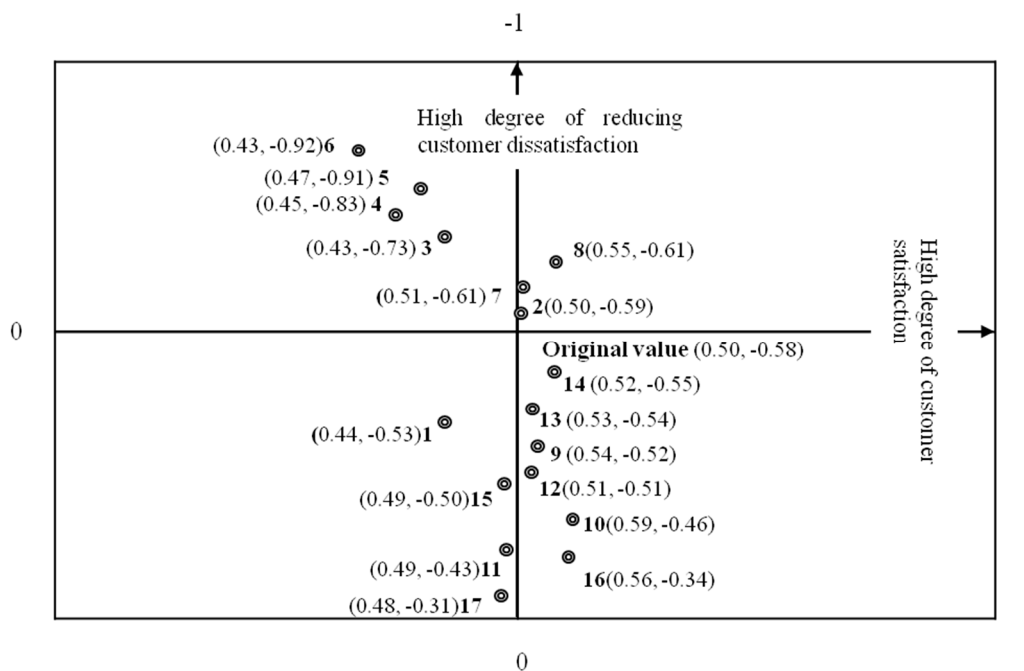


Figure 3. Quality improvement matrix.

7. Conclusions

Condominiums are a common residential pattern in Asian urban areas. This study identified the performance evaluation indicators of long-life high-quality condominiums that satisfy the goal of sustainable development and meet the basic needs of users in terms of physical, economic, social, technical, and functional evaluation categories. A questionnaire survey was conducted to understand the respondents’ satisfaction with evaluation indicators using the Kano two-dimensional quality

model. Thirteen evaluation indicators from 17 items were identified based on quality improvement matrix analysis.

In terms of the “physical” category, six indicators, excluding the “maintenance plan”, were recognized as must-be quality attributes; in terms of the “economic and social” category, all three indicators were recognized as one-dimensional quality attributes; in terms of the “technical” category, all three indicators were recognized as one-dimensional quality attributes; in terms of the “functional” category, one indicator was identified as an attractive quality attributes. The above survey results show that users’ physiological, safety, and social needs (including love and belongingness, esteem, and self-actualization needs, etc.) at the higher hierarchy will be generated upon the satisfaction of users’ physiological and safety needs. The quality attributes of evaluation indicators also gradually transformed from must-be quality to one-dimensional and attractive quality attributes. In order to satisfy users’ basic needs, among the above evaluation indicators, but excluding “equipment pipeline maintenance available on each floor”, “maintenance plan”, and “site transportation routes”, which were the three items of the first priority in selection, the other 10 indicators should be included in items of priority in selection. In terms of “exposed equipment pipeline”, “site open space”, “water resource recycling”, and “expandability of interior space”, both “increasing customer satisfaction coefficient” and “reducing customer dissatisfaction coefficient” are below the average value.

Taiwan’s government is positively promoting the massive construction of public and social housing, as well as enacting the regulations on accelerating the redevelopment of urban dangerous and old buildings. The concepts of these thirteen indicators in this study have been incorporated into the current building codes in Taiwan as the major design principles for future public housing and urban renewal projects. For example, equipment pipeline maintenance available on each floor and the emphasis on structural durability will become the mainstream for the future building design (currently more than 65% of buildings’ pipelines such as drainage are embedded in the concrete in Taiwan, which may cause structural damage while renovation and also reduce structural strength). In other words, the effect of long-life high-quality condominiums has been functioned and its influence on the industrial change is expected. However, due to time constraints, it is recommended to implement continuous studies on the evaluation framework, evaluation standards, evaluation organization, and incentives, in order that the performance evaluation indicators of long-life high-quality condominiums in Taiwan will be further improved.

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