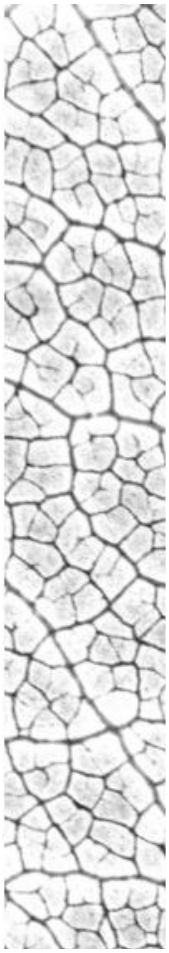

EurAsian Journal of BioSciences
Eurasia J Biosci 14, 2799-2804 (2020)

Evaluation of real estate project construction quality based on entropy - VIKOR method

Tzu-Chia Chen [1], Cheng-Jui Tseng [1*], Shu-Yan Yu [1]

[1] MBA Program, International College, Krirk University, Bangkok, THAILAND
*Corresponding author: exeterwasabi@gmail.com

Abstract
Quality evaluation of the essence of architecture is to provide the residents use facilities, living quality in human life proportion between the various elements, of the closest position, and construction engineering technology and management idea, also along with the development of human, from the safe, comfortable, beautiful, sustainable to value direction of development. In order to reflect the quality of the real estate project construction, this study constructs the evaluation index system of real estate development project is to build quality, choose a certain number of samples, using the entropy weight coefficient method to establish the weight of evaluation index system and using VIKOR method respectively to different real estate project carries on the comprehensive evaluation of the quality of option is given. Finally, this study verifies the effectiveness of the proposed method through the real estate project in Shenzhen.

Keywords: entropy - VIKOR method, real estate projects, quality evaluation

Chen T-C, Tseng C-J, Yu S-Y (2020) Evaluation of real estate project construction quality based on entropy - VIKOR method. Eurasia J Biosci 14: 2799-2804.

INTRODUCTION

Nowadays, the world has entered an era of quality management which promotes the development of national economy and global economy by quality. As construction products play an irreplaceable role as the infrastructure of national economic development, and are also related to the interests of all social strata and even everyone, their quality is particularly concerned by the government and the public. Therefore, the government requires the construction industry to be the pillar industry of the national economy and take the road of quality development. In fact, project quality is the quality of building products, which is the base point of quality management of construction enterprises and the symbol of quality of construction enterprises. Construction products are quite different from products of other industries: first, the difference of construction products is the most of all products, namely its unique singleness; Secondly, building products are fixed, that is, the fixed nature of buildings; Third, there is no industrial product comparable to the volume of building products, namely ponderality. Because of these characteristics of building products, the complexity of building construction is determined, there is no very unified model and rules to follow, its quality directly affects the service life. At the same time, as a construction engineering product engineering project, investment and consumption of labor, materials, energy are quite large, once serious quality problems occur, the loss is quite huge. Therefore, how to improve and ensure the quality of building products is bound to become a worthy of serious research.

The quality of the project directly affects the cost and schedule of the project. More importantly, once quality problems occur, they not only directly affect the economic benefits of the enterprise, but also may cause casualties, thus causing irreparable economic losses and social impact. Therefore, enterprises should always put engineering project quality management in an important position, carry out timely inspection and evaluation of engineering quality, and find quality problems as early as possible to reduce the occurrence of accidents. Based on this, this paper uses the entropy-VIKOR method to evaluate the construction quality of real estate projects, so as to reflect the actual situation of construction quality more objectively and ensure the construction quality of real estate projects.

LITERATURE REVIEW

At present, the commonly used quality evaluation methods for real estate development projects are mainly divided into two types: qualitative evaluation method and quantitative evaluation method. Most of the traditional evaluation methods are based on expert scoring, voting

Received: January 2020
Accepted: April 2020
Printed: September 2020

and brainstorming. Although these methods can give good consideration to the Suggestions of experts or relevant stakeholders, the evaluation results are often easily affected by personal subjective factors, which has a certain negative impact on the actual results. With the progress of science and technology, scholars begin to adopt quantitative analysis method (Technique for Order Preference by Similarity to Ideal Solution) for analysis. This kind of method eliminates the interference of subjective factors and makes the qualitative calculation become quantitative calculation effectively. Moreover, the calculation process is relatively simple and has good applicability. TOPSIS sorts all schemes by being closest to the positive ideal solution and furthest from the negative ideal solution. However, taking the evaluation plane of the two criteria as an example, when several schemes fall on the diagonal line, the criterion sum-up method of TOPSIS method cannot actually reflect the proximity between each scheme and the ideal solution, that is, the problem of which one is better can not be effectively determined. To avoid TOPSIS's weaknesses, the VIKOR (Vlse Kriterijumska Optimizacija I Kompromisno Resenje) ranked the candidates by comparing their estimates with the approximation of the ideal solution using a maximized "Majority Rule" and a minimised "Individual Regret". VIKOR has been successfully applied in many fields such as land use planning, which significantly improves the scientific nature, accuracy and operability of multi-objective decision analysis (Tzeng and Huang, 2011). Therefore, this study adopts the entropy-VIKOR method to evaluate the building quality of real estate projects.

The literature review of four influences on building quality evaluation, including housing value, housing safety, building sustainability and environmental hazard, is as follows:

In house value research, Ridker and Henning (1967) preliminary build buy houses belong to multiple levels of goods (Multi-dimensional Commodities) concept, thought that the combination of various residential properties and residential housing option is the quality level of the important influencing factors, especially the neighborhood attributes, such as air pollution and residential internal attributes (e.g., room number), show house is made of different combinations of multiple attributes of goods. Carn, Rabianski, Racster and Sedin (1988) pointed out that a builder can obtain information about consumer tastes and preferences through specific financial, structural, base, and adjacent (location) features of a home buyer's separate construction project, and then start to build the competitive advantage of the construction project. It can be seen that the financial value, structure, site pattern and location characteristics of residential housing can affect the decision of consumers. In terms of housing safety research, Chan and Xiong (2007) believed that the factors valued by consumers to buy houses include spacious homes, sanitary environment, quality of building materials, living space and convenient transportation, which will affect housing prices and satisfaction. Bonaiuto, Fornara and Bonnes (2003) pointed out in their research that the security of the streets around the residence and the neighborhood at night, including the presence of dangerous people in the community, noise and other factors are the main factors affecting the quality of the living environment.

In terms of building sustainability, the market for high quality building design and structure is dynamic and constantly evolving. Therefore, the consideration of habitable building indicators must be combined with the assessment of environmental compatibility with the surrounding environment, whether in terms of biology, location or climate; Many scholars put forward the concept of sustainable architecture (Abdellatif and al-Shamma'a 2015, Tang 2012); Sustainable architecture design and construction will create multiple residential values of comfort, attraction and health for human life and work. Levin (1997) and Bourdeau (1999) pointed out that the sustainability of buildings is of great influence and help to environmental degradation and sustainable development. When the construction industry takes appropriate measures to correspond to the environmental performance of buildings, the overall environmental hazards can be significantly reduced. And when sustainable development is considered, potential damage to the living environment can be avoided. Grace (2005) used cost benefit analysis to construct the sustainable performance evaluation model for buildings, which is based on the environmental, social and economic aspects of sustainable development. Best and De Valence (1999) stated that building resources could be effectively utilized to meet the requirements of building housing through a cost-benefit perspective. Betty and Smith (1987) further classified the cost-effectiveness factors affecting the behavior of home purchase search into four categories, including market, product, consumer, and context. Tang (2012) also believes that future architecture must take into account the challenges and opportunities brought by technological, environmental and social changes. Intelligent buildings have the advantage of automated systems that control the environment and communicate with users. As technology, communications and the Internet of Things mature, smart buildings will become an integral part of our way of life. In terms of the environmental hazard of housing, in addition to the positive indicators, some home buyers also consider the negative indicators around the housing or the indicators that harm the living quality. Such as noise in the residential environment, air quality and noise hazards in the surrounding environment can seriously endanger the physical and mental health and living peace of residents (Bonaiuto et al. 2003).

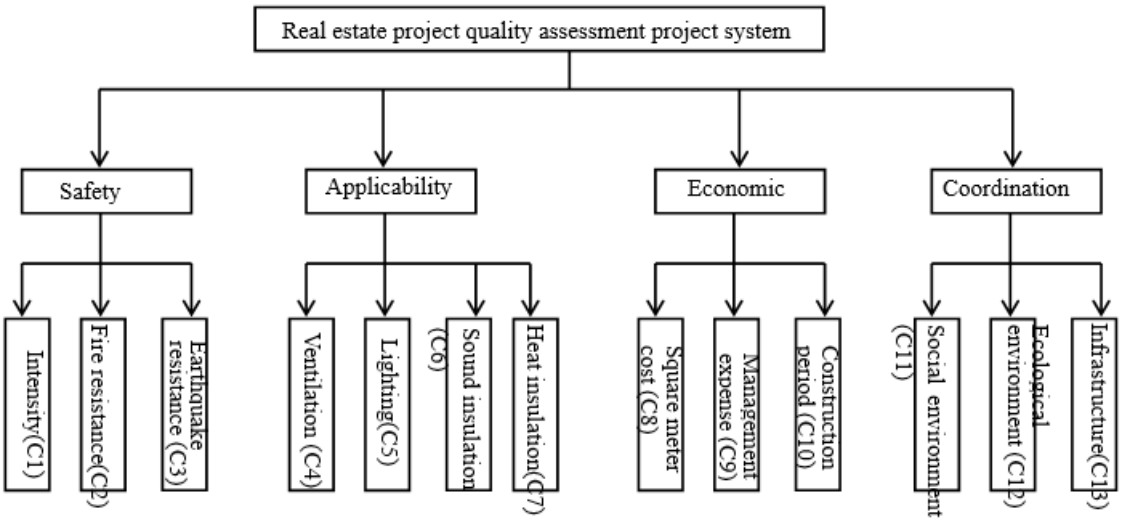

Fig. 1. Real estate project quality evaluation index system

Comprehensive existing research literature, to evaluate the quality of real estate project can know the current study presents the following characteristics: first, in the current study, research on comprehensive evaluation of quality management is more, part of the research from the Angle of research methods, evaluation is put forward, but most of these evaluation focused on qualitative evaluation, lack of quantitative evaluation, especially in the real estate development project is to combine quality evaluation to the concrete; Secondly, the existing quality evaluation methods of real estate development projects mostly determine the index weight according to subjective judgment, which seriously affects the accuracy of the index weight. Third, the current quality evaluation indicators of real estate projects generally lay stress on financial indicators and marketing indicators, and seldom involve related social benefits and environmental indicators. Therefore, in this paper, entropy-VAKOR method is adopted to carry out a comprehensive evaluation of the quality of real estate development projects. A more scientific and accurate entropy weight method is adopted to calculate the weight of each index, which can effectively reduce subjective errors. Then, the quality of different real estate projects is evaluated and ranked according to VAKOR method, and comprehensive and objective evaluation results are obtained.

PROPOSED MODEL

The Construction of the Real Estate Project Quality Evaluation Index System

As for the selection of evaluation indicators, this paper mainly based on the Quality standard system of Construction projects in China, referred to relevant literatures, and interviewed the preliminary evaluation indicators of relevant construction industry managers and scholars specializing in land and construction. It started from the four first-level indicators of safety, applicability, economy and coordination, as shown in **Fig. 1**. In the concrete evaluation with strength, fireproof, shockproof, l3 two level indexes such as concrete are designed considering the hard quality of real estate construction project requirements, and from the social environment, ecological environment, infrastructure and so on has carried on the comprehensive evaluation, to ensure the objective and effective results are obtained, to better promote the sustainable development of the real estate industry of our country.

Entropy Weighting Method

The concept of entropy was first proposed by Shannon (1948) and introduced it into information theory to measure the average uncertainty. The index weight can be obtained effectively through the calculation of entropy value. In general, if there are *n* objects to be evaluated and *m* evaluation indexes, the specific process of calculating the index weight by entropy weight method is as follows:

1. Dimensionless treatment of evaluation index: Assume the *j* th index value of the *i* th evaluated object is $X_{ij}(i = 1, \cdots, m, j = 1, \cdots, n)$, then a matrix $A = [X_{ij}]_{mxn}$ with *m* rows and *n* columns will be formed, which is called the decision matrix here. The *i* th row value of the decision matrix is the index value vector of the *i* th evaluated object, denoted as $X_i = (X_{i1}, X_{i2}, \cdots, X_{in})$, $(i = 1, \cdots, m)$.

Here, in order to avoid the different dimensions of different indexes and the resulting inconvenience of calculation, the efficiency coefficient transformation method is adopted to transform the evaluation index value dimensionless. Calculation process is as follows:

If it is positive index (value of index is larger, the better), let

$$Y_{ij} = (1 - \alpha) + \alpha \times (X_{ij} - X_{\min(j)})/(X_{\max(j)} - X_{\min(j)}) \quad (1)$$

If it is the negative index (value of index as small as possible), let

$$Y_{ij} = (1-\alpha) + \alpha \times (X_{\max(j)} - X_{\min(j)})/(X_{ij} - X_{\min(j)}) \quad (2)$$

Where $X_{\max(j)} = \max\{X_{ij}\}$,$X_{\min(j)} = \min\{X_{ij}\}$, $0 \leq \alpha \leq 1$, generally, $\alpha = 0.9$.

After the transformation can get original data dimensionless dataY_{ij}, Y_{ij} is uniform compression in the interval $[1-\alpha, 1]$, and Y_{ij}form a normalized decision-making matrix $B = [Y_{ij}]_{m\times n}$.

2. To have the proportion of transformation calculation

$$P_{ij} = Y_{ij} / \sum_{i=1}^{m} Y_{ij} (i = 1, \cdots, m, j = 1, \cdots, n) \quad (3)$$

3. To calculate index of entropy calculation

$$e_j = -K \sum_{i=1}^{m} P_{ij} \ln P_{ij}, K = \ln m, j = 1, \cdots, n \quad (2)$$

4. To calculate index difference coefficient

$$H_j = 1 - e_j, j = 1, \cdots, n \quad (5)$$

5. Under the normalized processing, processing results are weight of each evaluation index

$$W_j = H_j / \sum_{j=1}^{n} H_j \ , j = 1, \cdots, n \quad (6)$$

VIKOR Method

VIKOR is a multi-attribute decision making method proposed by Opricovic in 1998. It is an optimal compromise solution method in multi-attribute decision making and a decision making method based on the ideal point method. VIKOR multi-criterion compromise sorting is a compromise sorting method, which can take into account the maximization of group benefits and the minimization of individual regrets against opinions, as well as the subjective preferences of decision makers. Therefore, it is more reasonable to study multi-attribute decision making problems by VIKOR method (Liou et al., 2011).

$A_i, i = 1, \cdots, m$, is set as the subject of quality evaluation of real estate development projects, and $P_k = \{P_1, \cdots, P_k\}$is set as the set composed of evaluation of relevant construction industry managers and scholars specializing in land and construction. Evaluation means that the quality management evaluation index of real estate development projects often involves a wide range of factors. In this study, the real estate project standard is $C_j, j = 1, \cdots, n$, the evaluation index set $C_j = \{C_1, \cdots, C_n\}$ is the project quality evaluation attribute value of the participant *i* to the index C_j, and ω_{ij} is the service quality evaluation index weight of the participant *i* to the index C_j. The sequence of VIKOR real estate development project quality management evaluation is as follows:

1. Determine the maximum value X_j^+(positive ideal solution) and minimum value X_j^- (negative ideal solution) of the evaluation index, that is, $X_j^+ = \max_i X_{ij}$, and $X_j^- = \min_i X_{ij}$, therefore we can get

$$r_{ij} = |X_j^+ - X_{ij}| / |X_j^+ - X_j^-| \quad (7)$$

2. Computing group utility values S_i and individual regret R_i.

If every evaluation index with the same dimension, do not need to standardize its attribute value and weight, if do not have the same dimension, each index is calculated each participation main body of real estate development project, the quality evaluation weighted evaluation matrix

$$S_i = \sum_{j=1}^{n} \omega_j \cdot r_{ij} \quad (8)$$

$$R_i = \max_j \omega_j \cdot r_{ij} \quad (9)$$

Where $\sum_{j=1}^{n} \omega_j = 1$, ω_j is the weight of the j th evaluation standard, $j = 1, \cdots, n$, can be specified directly or through other methods of empowerment.

3. Calculate the compromise value $Q_i, i = 1, \cdots, m$.

$$Q_i = \nu \frac{S_i - S^-}{S^+ - S^-} + (1-\nu) \frac{R_i - R^-}{R^+ - R^-} \quad (10)$$

where

$$S^- = \min_i S_i, S^+ = \max_i S_i, R^- = \min_i R_i, \quad R^+ = \max_i R_i \quad (11)$$

In Equation (10), ν is the decision mechanism, which is used to control whether the decision result is biased towards group utility or individual regret. The larger ν is, the more the result is biased towards group utility, and vice versa. Under the balanced decision-making mechanism of general compromise group benefit maximization and individual regret minimization, ν= 0.5.

4. According to the value of Q_i, the quality management evaluation of the real estate development project of the participating subject *i* was ranked, and Q_i was ranked from the smallest to the largest. In each sequence, the scheme ranked in the first place was higher than the evaluation in the second place.

CASE STUDY

Case Introduction

The empirical analysis this article selected the Shenzhen in 2019 four real estate development project is completed, the project 1 belong to economy is applicable the room (70% price room, 30% not limit room), because the economy is applicable the room is limited by the government and the management, overall, the project cost and product positioning are low, so low profit margins. Project 2, Project 3 and Project 4 are all located in the downtown area with higher price and profit than project 1, but they have different positioning. Project 3 has a good geographical location and the developer is a well-known brand in China. Project 2 has a large scale but a long construction cycle; Project 4 has a low price, but the comprehensive strength of the developer is general.

Table 1. Weight table of real estate project quality evaluation index elements

Project	Real estate project quality evaluation index system												
	(C1)	(C2)	(C3)	(C4)	(C5)	(C6)	(C7)	(C8)	(C9)	(C10)	(C11)	(C12)	(C13)
A_1	79	85	90	85	86	83	87	80	83	83	83	83	91
A_2	86	88	87	90	82	92	81	88	85	90	88	90	86
A_3	83	84	84	83	79	78	83	78	84	86	78	80	82
A_4	84	81	83	89	92	82	86	83	86	83	85	84	78

Table 2. Entropy and Entropy weight of real estate project quality evaluation index elements

	(C1)	(C2)	(C3)	(C4)	(C5)	(C6)	(C7)	(C8)	(C9)	(C10)	(C11)	(C12)	(C13)
Entropy	0.9997	0.9997	0.9996	0.9996	0.9988	0.9987	0.9997	0.9992	0.9999	0.9996	0.9993	0.9993	0.9988
Entropy weight	0.0430	0.0396	0.0457	0.0493	0.1484	0.1669	0.0363	0.0943	0.0079	0.0507	0.0866	0.0835	0.1477

Table 3. VIKOR evaluation values and ranking of the quality of each real estate development project

Project	A_1	rank	A_2	rank	A_3	rank	A_4	rank
S	0.5068	2	0.2295	1	0.87	4	0.5516	3
R	0.1073	1	0.1141	2	0.1669	4	0.1477	3
Q	0.2165	2	0.0575	1	1	4	0.5902	3

Proposed Model

The proposed model applies the real estate development project quality evaluation index system as shown in **Fig. 1**, and determines the factor weight through expert scoring. The specific score is based on the following criteria: very good (more than 90 points), good (80-90 points), general (70-80 points), not good (printing a 70 points). In the specific scoring, l0 industrial and academic experts in the fields of project evaluation and quality management were invited to score the buildings and real estate, and the weighted average value of each evaluation index was calculated as the final scoring result. The results were shown in **Table 1**. Then according to the entropy weight the VIKOR method for quality evaluation of four projects, the specific calculation steps are as shown in **Table 1**.

Calculation of entropy weight

1. Entropy method is used to determine the index objective weights of the index data normalizing, here we hope that all evaluation indexes is bigger, the better, so adopt positive evaluation index, and apply formula (1) to normalize the index data.
2. Calculation of entropy weight: Substitute the index data in Section 2.1 into Equation (3) to get the entropy value of each index e_j, and then substitute the entropy value e_j into equations (4) and (5) to get the entropy weight of each indexω_j. The specific calculation results are shown in **Table 2**.

Determine the project evaluation results by VIKOR method

1. Establish a normalized decision matrix according to the evaluation value and formula of indicators. According to Formula (7), the dimensionless between the indicators is eliminated, and the normalized decision matrix can be obtained as follows:

$$r_{ij} = \begin{bmatrix} 0.7900 & 0.8500 & 0.9000 & 0.8500 & 0.8600 & 0.8300 & 0.8700 & 0.8000 & 0.8300 & 0.8300 & 0.8300 & 0.8300 & 0.9100 \\ 0.8600 & 0.8800 & 0.8700 & 0.9000 & 0.8200 & 0.9200 & 0.8100 & 0.8800 & 0.8500 & 0.9000 & 0.8800 & 0.9000 & 0.8600 \\ 0.8300 & 0.8400 & 0.8400 & 0.8300 & 0.7900 & 0.7800 & 0.8300 & 0.7800 & 0.8400 & 0.8600 & 0.7800 & 0.8000 & 0.8200 \\ 0.8400 & 0.8100 & 0.8300 & 0.8900 & 0.9200 & 0.8200 & 0.8600 & 0.8300 & 0.8600 & 0.8300 & 0.8500 & 0.8400 & 0.7800 \end{bmatrix}$$

2. The positive ideal solution set X_i^+ and the negative ideal solution set X_i^- are respectively as follows:

$$X_i^+ = (0.0370,0.0349,0.0412,0.0444,0.1365,0.1535,0.0316,0.0830,0.0068,0.0457,0.0762,0.0751,0.1344)$$
$$X_i^- = (0.0339,0.0321,0.0380,0.0410,0.1172,0.1302,0.0294,0.0736,0.0066,0.0421,0.0675,0.0668,0.1152)$$

3. According to 4.2.1, the weight vector is as follows: $\omega = (0.0430,0.0396,0.0457,0.0493,0.1484,0.1669,0.0363,0.0943,0.0079,0.0507,0.0866,0.0835,0.1477)$
4. We calculate S_j, $R_j$and $Q_j$for each project (A_1, A_2, A_3 and A_4), the results were shown in **Table 3**.
5. The final ranking is also shown in **Table 3**, so the final ranking result calculated by VIKOR is $A_1 \simeq A_2 > A_4 > A_3$,, that is, the quality of the four projects is ranked in the following order: project 1≃ project 1> project 4> project 3, that is, the quality of project 3 is the optimal.

CONCLUSIONS

The quality evaluation of real estate projects is not only closely related to people's daily life, but also plays an important role in national economic and social development. Overall, in this study the VIKOR method combined with entropy weight for real estate development project quality comprehensive evaluation, the method by using entropy index weight calculation, calculation process is simple and accurate, and can effectively avoid the subjective assignment may lead to human impact on the evaluation results, real estate development project is very suitable for the quality evaluation of research. Based on the research conclusions of this study, real estate enterprises should attach importance to the quality evaluation of real estate development projects, sum up experience and lessons, follow the scientific management process, improve the quality of projects, and realize the success of project investment.

Through empirical analysis, this study summarizes the following research conclusions. First, experts believe that the economic value of building sustainability (construction cycle and ecological environment) is not a key indicator of the quality of real estate projects. The reason for the estimation may be that experts believe that the current construction site and space technology have sufficient basic level, the builders can fully

maximize the use of building resources, in order to meet the requirements of building living, the quality of the real estate project is relatively unaffected by the age of the housing. Therefore, this point is not favored by experts as one of the key indicators of real estate project quality. Second, experts believe that the living environment (lighting, sound insulation and social environment) inside and outside the basic city is the most critical evaluation index for the quality of real estate projects. The analysis and estimation of this study is that the experts focus on the comfort of residents, and they believe that the construction cost will be reflected in the real estate price. And experts pay less attention to building sustainability. Third, the study finds that the housing safety (fire prevention, earthquake resistance and strength) is not the key index that experts attach the most importance to compared with other projects. This may be because the housing safety of domestic real estate projects has a certain level due to the national standards. Therefore, experts pay more attention to the comfort of living. Finally, the management cost is not paid attention by experts, which indicates that experts pay less attention to property management and more attention to the comfort of living.

In this study to explore the development of real estate project evaluation indicators, by way of literature induction, for indicators of gathering, may cause index considering not perfect, the Suggestions for future research can be included in the relevant important selection evaluation index of real estate development project, such as: site selection, building shape, development plan and development construction to the environment load and other factors, to arrange housing the selection of indicators to consider more complete. In addition, in terms of research methods, only academic literature is used to collect evaluation indicators of real estate development projects. It is suggested that qualitative research methods (e.g., case interviews) and practical experts should be employed in subsequent studies to collect more in-depth and complete evaluation indicators. Structural Equation Modeling (SEM) or Fuzzy Analytic Hierarchy Process; (FAHP) can also be used to explore research issues, policy weights and corresponding results from different perspectives. in this study.

REFERENCES

Abdellatif M, Al-Shamma'a A (2015) Review of sustainability in buildings. Sustainable Cities and Society, 14: 171-177.

Beatty SE, Smith SM (1987) External search effort: An investigation across several product categories. Journal of consumer research, 14(1): 83-95.

Best R, De Valence G (Eds.) (1999) Building in value: pre-design issues. Routledge.

Bonaiuto M, Fornara F, Bonnes M (2003) Indexes of perceived residential environment quality and neighbourhood attachment in urban environments: a confirmation study on the city of Rome. Landscape and urban planning, 65(1-2): 41-52.

Bourdeau L (1999) Sustainable development and the future of construction: a comparison of visions from various countries. Building Research & Information, 27(6): 354-366.

Carn NG (1988) Real estate market analysis: techniques and applications. Prentice Hall.

Chan CS, Xiong Y (2007) The features and forces that define, maintain, and endanger Beijing courtyard housing. Journal of Architectural and Planning Research: 42-64.

Ding GK (2005) Developing a multicriteria approach for the measurement of sustainable performance. Building Research & Information, 33(1): 3-16.

Levin H (1997, June) Systematic evaluation and assessment of building environmental performance (SEABEP). In Proc. Second International Conference on Buildings and the Environment, CSTB and CIB (Vol. 2, pp. 3-10).

Liou JJ, Tsai CY, Lin RH, Tzeng GH (2011) A modified VIKOR multiple-criteria decision method for improving domestic airlines service quality. Journal of Air Transport Management, 17(2): 57-61.

Opricovic S, Tzeng GH (2004) Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS. European journal of operational research, 156(2): 445-455.

Ridker RG, Henning JA (1967) The determinants of residential property values with special reference to air pollution. The review of Economics and Statistics: 246-257.

Shannon CE (1948) A mathematical theory of communication. The Bell system technical journal, 27(3): 379-423.

Tang T (2012) Sustainable Buildings: Smart, Green and People-Friendly. CEM Occasional Paper Series.

Tzeng GH, Huang JJ (2011) Multiple attribute decision making: methods and applications. CRC press.