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Housing refurbishment contractors selection based on a hybrid fuzzy-QFD approach

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ABSTRACT

With low demand for new construction, limited land usage, and being aware of sustainability, the refurbishment market has grown greatly and has become more in demand in the construction industry. Most refurbishment work, however, involves a high level of risk, uncertainty, and coordination, which are likely to cause asymmetric information between contractors and residents in a refurbishment process. Most private refurbishment contractor selections are usually based on word-of-mouth referrals that lack a systematic and objective assessment method. This study proposes a hybrid approach combining fuzzy set theory and quality function deployment (QFD) to establish a housing refurbishment contractor selection model. With this model, residents can select an optimal refurbishment contractor according to requirements. To test the effectiveness of the proposed model, a known multiple criteria decision-making method, PROMETHEE, is applied to compare the results of contractor selections. The result reveals that the proposed hybrid fuzzy-QFD approach can be expected to be successful and has potential for handling multiple criteria decision-making problems.

1. Introduction

The refurbishment industry has received increasing attention and grown hugely in the last decade, because of the change in economic conditions and the emphasis on sustainable development [1]. Global organizations have invested plentiful resources in creating sustainable refurbishment environments [2,3]. Although a refurbishment project is relatively small, in some developed countries, the total turnover of the refurbishment market reaches almost a half of the total construction output [4].

Refurbishment has a heterogeneous nature that requires different specialties to perform well in highly variable conditions and requires knowledge and technique to do well [5]. These kinds of projects are usually characterized by complex, small-scale and highly labor-intensive renovation tasks that are full of risk and uncertainty [6,7]. Some research reveals that one of the severest challenges of refurbishment projects is asymmetric information between contractors and residents in a refurbishment process [8]. Residents with inadequate refurbishment knowledge usually lack the judgment ability on cost, quality and service provided by contractors. Disreputable contractors who propose deceitful cost estimation, unpredicted quality, and unstable service usually affects customers' satisfaction and project performance. Asymmetric information results in the gap between expectation and perception, and it may lead residents to be in vulnerable conditions [9].

A great number of studies have explored how to evaluate construction bidding contractors for new construction projects [10,11]. Only a few efforts, however, have been focused on establishing a contractor selection model in refurbishment projects [12], because most housing refurbishment business comes from word-of-mouth referrals [8]. Some refurbishment jobs are even conducted by unskilled "cow boy" operators, which has multiplied management difficulties [13]. The nature of refurbishment makes it difficult to select an optimal refurbishment contractor. Therefore, an effective and structured contractor selection process for residents needs to be developed.

Quality function deployment (QFD) is a quality management method for converting the customer's needs into design specifications [14]. It brings an opportunity to solve asymmetric information problems between resident's implicit needs (What) and contractor's explicit services (How). To help residents express their preference needs precisely, fuzzy set theory is introduced to combine the QFD, a hybrid fuzzy-QFD approach, to explore the asymmetric refurbishment condition between residents and contractors. By means of a refurbishment contractor selection example, the multiple criteria PROMETHEE methodology is adopted to compare results from the proposed approach to test the effectiveness. It is expected that this innovative approach can make a contractor selection process much

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more useful and the conventional multi-criteria decision-making problems more convincing.

2. Characteristics of the refurbishment industry

Refurbishment projects are usually characterized by complex, small-scale and highly labor-intensive renovation tasks [12]. Special characteristics of housing refurbishment include site-driven works undertaken in an existing building [6], intensified uncertainty [15], long turn-round time [16], and many simultaneously operating workers in a restricted space [17]. These unique characteristics render it more difficult to standardize the delivered service, compared to new construction, and the outcome of the refurbishment performance will be highly dependent on a contractor's capability and experience.

Refurbishment can be categorized as a service industry [8]. Providing what customers expect, such as customized products or services, is a key to reach customer satisfaction in service management. The service quality model has indicated the gap between customers' quality perceptions and suppliers' service delivery [9]. Asymmetric information problems between contractors and residents in a refurbishment process will cause an increase in the service quality gap. To improve customer's satisfaction and contractor's competitiveness, a method for decreasing the gap is crucial for refurbishment projects.

3. Contractor selection

Construction contractor selection and evaluation is always one of the most important critical activities of construction procurement. Various studies have focused on the establishment of selection criteria and the development of selection methods. Contractor selection decisions are complicated by the fact that various criteria have to be considered in the decision-making process [18]. These criteria may have quantitative and qualitative dimensions. Preference for a given contractor is generally assumed to depend on an assessment of the quality, price, capability, and performance that the contractor can provide [19,20]. On the other hand, a vast number of methods have been suggested for supporting contractor selection decisions in construction projects [21]. These studies include the application of artificial intelligence (AI) techniques [22], mathematical programming models [23], and multi-criteria decision-making methods [24]. Some research also proposes the applications of outranking methods, such as ELECTRE and PROMETHEE [25], to explore contractor selection problems. Unlike plentiful studies that have explored contractor selection problems in construction projects, there have been relatively few studies on refurbishment projects. The above-mentioned studies, regarding criteria and methods, may provide insights for establishing a refurbishment contractor selection model.

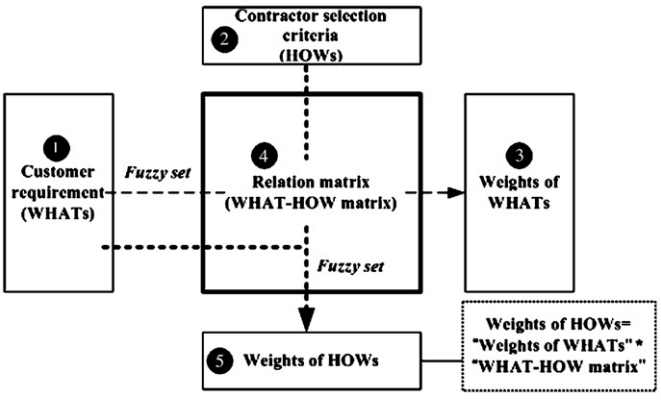

Fig. 1. WHAT–HOW matrix.

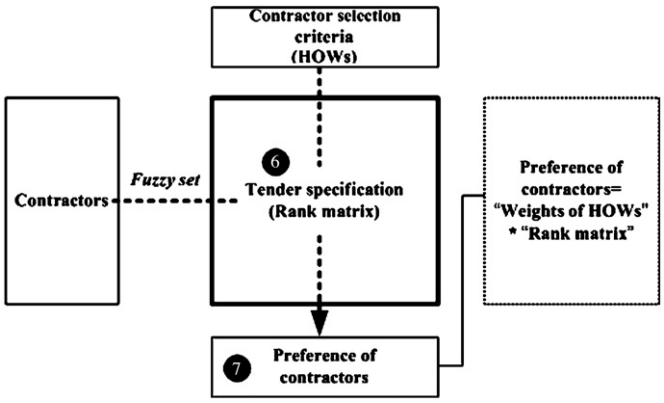

Fig. 2. Rank matrix assessment for rating preference of contractors.

4. Fuzzy-QFD approach for refurbishment contractor selection

4.1. Quality function deployment (QFD)

QFD has been defined as a method for developing a design aimed at satisfying the customer and then translating the customer's demands into design targets and major quality assurance points to be used throughout the production phase [26]. It is a highly effective and structured planning tool to deal with customer demands more systematically. In a refurbishment project, contractors' services may not always satisfy the residents' needs, expectations and quality standards, because refurbishment involves complicated and intensive work that is difficult to integrate. Problems in terms of refurbishment styles, delays due to incomplete designs, misunderstanding of client expectations, rework, etc. are often observed [27]. Some research has demonstrated the benefits of QFD in reducing quality related problems [28]. Therefore, QFD is used in this study for assessing the quality of contractors' services on the basis of the residents' needs.

4.2. An innovative approach: fuzzy set theory based on QFD

Refurbishment usually requires intensive communication between residents and contractors, as well as a complicated process in the design and construction phases. Non-professional residents' inability to analyze the cost and quality of refurbishment may produce difficulty in decision-making and discrepancies between expectations and results [29]. How to effectively extract resident's needs and judge contractors' services is crucial for the success of a refurbishment project.

The fuzzy set theory is widely applied to solve real-life problems that are subjective, vague, and imprecise in nature [30]. To reflect a resident's specific needs in a refurbishment contractor selection, fuzzy set theory is combined with QFD in this study. The linguistic variables are determined and then translated into fuzzy numbers by defining appropriate membership functions. In this study, for example, let F={VL, L, M, H,

Table 1
Resident's requirements and their weights of WHATs

WHATs	DM 1	DM 2	DM 3	Average fuzzy number (LE, ME, UE)	Weight of WHATs (W_{Wi})
Refurbishment quality	VH	VH	M	(6.67, 7.67, 8.67)	0.169
Refurbishment cost	VH	H	VH	(7.33, 8.33, 9.33)	0.184
Transparent information	VH	H	VH	(7.33, 8.33, 9.33)	0.184
Work schedule	VH	VH	H	(7.33, 8.33, 9.33)	0.184
Work integration	H	M	M	(4.67, 5.67, 6.67)	0.125
Service satisfaction	VH	H	M	(6.00, 7.00, 8.00)	0.154