The prefabricated building risk decision research of DM technology on the basis of Rough Set

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Abstract. With the resources crises and more serious pollution, the green building has been strongly advocated by most countries and become a new building style in the construction field. Compared with traditional building, the prefabricated building has its own irreplaceable advantages but is influenced by many uncertainties. So far, a majority of scholars have been studying based on qualitative researches from all of the word. This paper profoundly expounds its significance about the prefabricated building. On the premise of the existing research methods, combined with rough set theory, this paper redefines the factors which affect the prefabricated building risk. Moreover, it quantifies risk factors and establish an expert knowledge base through assessing. And then reduced risk factors about the redundant attributes and attribute values, finally form the simplest decision rule. This simplest decision rule, which is based on the DM technology of rough set theory, provides prefabricated building with a controllable new decision-making method.

1. Introduction

With the resources crises and more serious pollution, the green building has been strongly advocated by most countries and become a new building style in the construction field[1]. Compared with the traditional building, the prefabricated building has its own irreplaceable advantages such as less effect to environment, fast-track construction, energy saving and environment protection, high quality, high performance, diversification and individuation etc, thus has become a hot spot in the research of construction field[2]. In the 1980s, because of the housing shortage and sharp increase in its demand at some European countries, the prefabricated building has become the main type of houses with producing and life. But China has a late start in the prefabricated building, whose development still was restricted by some major technology knots unsolved like insulation, seismic and waterproof etc[3]. Until now, with the advent of the national "new-type urbanization" policy, depending on promotion the Supply-side Structural Reform and industrial structure and developing, it is necessary to research. Due to its own advantages, the prefabricated building has a promising prospect. Domestic and foreign researchers have made a great contribution[2,3,4,5], but which are mostly in the qualitative research. However, it is still less to effectively distinguish and control the risk depending on the uncertain precondition and quantitative analysis. So it is necessary to quantitative analyze these characteristics by mathematical model. At present, there are more mature methods in the field of construction risk decision, such as Sensitivity Analysis Method, Monte Carlo method, Decision Tree, Fault Tree Analysis, Failure Mode and Effect Analysis etc[6], which still mainly depended on existed
data and decision-maker’s own experience. In the practical process, due to a shortage of knowledge and practical experience and the complexity of objective things, the reality of things was grasp completely, which can lead to serious consequences[7].

Therefore, in this paper, on the basis of predecessors’ research, combined the existing statistical data with DM Algorithm of Rough Set, we build a new system about risk decision. Firstly, define basic factor sets about the prefabricated building risk, and establish a expert knowledge base through assessing. Then reduce the redundant attributes and attribute values about risk factors by utilizing DM Algorithm of Rough Set. Finally form the simplest decision making rules, which is formed on the basis of DM technology of Rough Set theory[8]. They can lays a foundation for prefabricated building risk decision.

2. DM technology on the basis of Rough Set

2.1 Rough set theory

Rough set is an mathematical method proposed by Polish mathematician Z.Plawlak in the early 1980s, which mainly deals with uncertain, incomplete or even inconsistent data. According to rough set theory, knowledge is closely linked with the classification. The knowledge is based on the ability to classify objects. The process of classification is to classify objects with little difference into one class. Their relations are indistinguishable, and also called equivalent relations[8,9,10,11]. And in the development of rough set theory, two distinct approximation operators have been explained[12] \( [X]_R \) will stand for the equivalence class of the relation \( R \) determined by \( X \in U \). For any \( X \subseteq U \), one can characterize \( X \) by a pair of lower and upper approximations[13].

Knowledge representation system is expressed by a relational table. Decision table is a kind of special and important knowledge expression system with the conditional attributes and decision attributes. Let \( S = (U,A,V,f) \) be the knowledge representation system. \( S = (X_1,X_2,\ldots,X_n) \) is the set of finite objects. \( A = \{a_1,a_2,\ldots,a_n\} \) is the set of finite attributes, and \( V \) is the domain of the \( A \). \( f : U \times A \rightarrow V \) is an information function. Where \( A = C \cup D, C \) is the condition attribute set, \( D \) is the decision kind set.

2.2. DM process

The data mining(DM) process is to simplify the decision table. The process is to reduce the condition attributes. The decision table has the same function as before but fewer condition attributes. Therefore, the process is very important in the practical application, so that the same decision result can be based on a smaller number of conditions, which can be obtained using some simple means. The simplified steps are as follows:

(1) Attributes reduction. For knowledge representation systems \( S = (U,A,V,f) \), \( A = C \cup D \), \( B \subseteq C \), if \( \gamma_c(D) = \gamma_b(D) \) and \( B \) is independent on \( D \), then \( B \) is the \( D \) reduction of \( C \), recorded as \( \text{RED}_D(C) \).

(2) Value reduction. For knowledge representation systems \( S = (U, \text{RED}_D(C) \cup D,V,f) \), calculate all core data.

3. Empirical analysis

3.1 Define attribute sets

Compared with the ordinary architecture, the prefabricated building has the different risk characteristics. On the basis of existing qualitative analysis, we construct new internal and external factors in the risk decision-making. In this paper, we select several sets of factors that can mostly reflect the risk of that is, the conditional attribute set includes four risk factors: technical level (a), investment scale (b), market environment (c) and management level (d). The decision kind set includes enterprise scale (e), risk response measures (f). This paper selects 13 engineering projects to carry on the
investigation. In the decision support system, by the conditional - decision table, finally the risk decision table based on rough set theory is constructed. It is shown in Table 1.

3.2 Building knowledge base
The conditional attributes and decision attributes are discretized to establish an expert knowledge base. The steps are as follows: Firstly, according to the survey results above the condition attribute sets, we discretize the conditional attributes. The technical level is divided into 3 levels, recorded as \{1,2,3\}, representing \{low, medium, high\}. The investment scale is divided into 4 levels, recorded as \{1,2,3,4\}, representing \{small, general, big, very big\}. The market environment is divided into 4 levels, recorded as \{1,2\}, representing \{unstable, good\}. The management level is divided into 3 levels, recorded as \{1,2,3\}, representing \{low, medium, high\}. Secondly, discrete the decision attributes according to the survey results. The enterprise scale is divided into 2 levels, recorded as \{1,2\}, representing \{small, big\}. The risk response measures are divided into 3 levels, recorded as \{1,2,3\}, representing \{risk retention, sharing, avoidance\}. That is shown in Table 1.

| A | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 1 | 2 | 2 | 3 | 3 | 2 | 1 | 3 | 3 | 2 | 1 |
| 2 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 2 | 1 | 3 | 3 | 2 | 1 |
| 3 | 2 | 2 | 1 | 1 | 2 | 3 | 3 | 2 | 1 | 3 | 3 | 2 | 1 |
| 4 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 2 | 1 | 3 | 3 | 2 | 1 |
| 5 | 1 | 2 | 1 | 2 | 1 | 3 | 3 | 2 | 1 | 3 | 3 | 2 | 1 |
| 6 | 2 | 2 | 1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 7 | 2 | 3 | 1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 8 | 3 | 3 | 1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 9 | 3 | 3 | 2 | 3 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 10 | 3 | 4 | 2 | 3 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 11 | 3 | 4 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 12 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 13 | 3 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

Table 1. Projects risk decision original table

3.3 Attributes reduction
Attributes reduction is done on decision table. From the data in Table 1, it can be found that which are redundant attributes and which are core attributes. The results are shown in Table 2.

| A | 1,2 | 3 | 4 | 5 | 6,7 | 8 | 9,10 | 11,12,13 |
|---|-----|---|---|---|------|---|-------|---------|
| 1  | 2  | 1 | 2 | 2 | 3    | 3 | 2     | 3       |
| 3  | 2  | 1 | 1 | 2 | 3    | 3 | 2     | 3       |
| 4  | 1  | 1 | 1 | 1 | 3    | 3 | 2     | 3       |
| 5  | 1  | 1 | 2 | 1 | 3    | 3 | 2     | 3       |
| 6  | 2  | 1 | 3 | 2 | 2    | 2 | 2     | 2       |
| 7  | 2  | 3 | 1 | 3 | 2    | 2 | 2     | 2       |
| 8  | 3  | 1 | 3 | 2 | 2    | 2 | 2     | 2       |
| 9  | 3  | 3 | 2 | 3 | 2    | 2 | 2     | 2       |
| 10 | 3  | 3 | 3 | 2 | 1    | 2 | 2     | 2       |

Table 2. Attributes reduction result table

3.4 Value reduction
The results of the reduction are shown in Table 3.
Table 3. Attribute value reduction result table

|   |   | a | c | d | e | f |
|---|---|---|---|---|---|---|
| 1 | 2 | 2 | 2 | 2 | 3 |
| 3 | 2 | - | 1 | 2 | 3 |
| 4 | 1 | - | - | 1 | 3 |
| 5 | 1 | - | - | 1 | 3 |
| 6 | 7 | - | 3 | 2 | 2 |
| 8 | - | 1 | - | 2 | 2 |
| 9 | 10| - | 2 | - | 2 | 1 |
| 11,12,13 | - | - | - | 2 | 1 |

3.5 Result analysis

The following decision results can be obtained from table 3:

\[ a_2 d_2 \rightarrow (2,3) \text{ or } a_2 d_1 \rightarrow (2,3), a_1 \rightarrow (1,3), d_3 \rightarrow (2,2) \text{ or } c_1 \rightarrow (2,2), c_2 \rightarrow (2,1). \]

To sum up:

\[ a_2 d_2 \lor a_2 d_1 \rightarrow (2,3), a_1 \rightarrow (1,3), d_3 \lor c_1 \rightarrow (2,2), c_2 \rightarrow (2,1). \]

The results are made from the above four composite decision rules. Interpretations are as follows:

(1) When the technical level is medium and the management level is medium or low, the larger company's strategy is to avoid the risk. The prefabricated building construction should be changed into traditional construction method, or abandon the project.

(2) When the management level is high or the market environment is unstable, the larger company's strategy is to share the risk. The prefabricated buildings can be chosen.

(3) When the market environment is good, the larger company's strategy is to bear the risk. The prefabricated buildings using its advantages can bring more profits for the enterprise. It also has less impact on the environment, should be vigorously promoted.

4. Conclusion

In this paper, based on the existed qualitative research, and combined with the former statistics and the rough set reduction algorithm, and using the DM technology to find the underlying regularity from a large number of data, the mass data is modeled and a risk decision system is build. And factor sets that affect the risk of the prefabricated buildings are identified. The four condition attributes includes the technical level, investment scale, market environment, management level, combined with the two decision attributes including the company scale, risk response measures. Then through quantify risk factors and reduce the redundant attributes and attribute values in the condition factors, the simplest decision rules are formed. The results are shown the accuracy and explanation ability of the algorithm, which can be improved through DM classified rules, so can application value. The data mining technology based on rough set theory lays the practical foundation for the quantitative research of the prefabricated buildings risk decision.

References

[1] Che Hui and Wan Wan. A survey of the risk of green building. Modern City. 3(2015):p35-7.
[2] Yang Cun and Liu Xiang. Analysis of existing problems and countermeasures on prefabricated housing. Architecture Technology 47.4(2016):p301-4.
[3] Jiang Qinjian. Summary on development of prefabricated concrete building both home and abroad. Architecture Technology 41.12(2010):p1074-7.
[4] Wan Xin, Qin Xuan and Li Qiming. Risk impact analysis of green building projects in china. Construction Technology 42.3(2013):p4-10.
[5] Yin Sui. Preliminary analysis report of the prefabricated building using in the guangdong
region. Guangdong Architecture civil engineering. 12(2011): p29-32.
[6] Ahmed, Ammar, B. Kayis, and S. Amornsawadwatana. A review of techniques for risk management in projects. Benchmarking 14.1(2007): p22-36.
[7] Zeng Xueqin, Chen Jianguo and Lv Feng. Risk assessment of construction project based on fuzzy number and rough set. Statistics & Decision. 1(2015): p80-3.
[8] Z. Pawlak. 1994 Rough sets-theoretical aspects of reasoning about data. (New York: Klystron Academic Publisher).
[9] Wu Bing, Li Weixiang and Zhao Lindu. Least decision-making model based on rough set theory. Information Technology. 4(2002): p 4-5.
[10] MLAMarsala, Christophe and B. Bouchon-Meunier. Fuzzy data mining and management of interpretable and subjective information. Fuzzy Sets and Systems 281.C(2015): p252–9.
[11] Guan Yaxiong and Chen Weidong. Sales promotion decision support system based on data mining. Journal of Zhejiang University of Technology 34.2(2006): p174-8.
[12] Yao, Y. Y. Relational interpretations of neighborhood operators and rough set approximation operators. Information Sciences. 111(1-4)(1998): p239-59.
[13] Dai, Jianhua, et al. Catoptrical rough set model on two universes using granule-based definition and its variable precision extensions. Information Sciences (2016).