A Variable Precision Fuzzy Rough Group Decision-making Model for IT Outsourcing Risk Evaluation in Nuclear Power Industry

Guodong Cong, Jinlong Zhang, and Benhai Yu

College of management, Huazhong University of Science and Technology
Luoyu road 1037, Wuhan, 430074, China
gd_cong@smail.hust.edu.cn, jlzhang@mail.hust.edu.cn,
yubhai@163.com

Abstract. Risks evaluation is critical for the success of IT outsourcing. It is especially important in nuclear industry due to high concerns about safety and service quality. This paper proposes a new integrated methodology, Variable Precision Fuzzy Rough Group Decision-making (VPFRGDM), to evaluate the risk in IT outsourcing. This method can improve fairness, flexibility and efficiency of risk evaluation, and is verified by a case in a large-scale nuclear power station.

Keywords: Risk evaluation VPFRGDM Nuclear industry.

1 Introduction

In China, nuclear industry is facing pressure of competition as the country's energy policy offers it no protection. Stations expect IT outsourcing to minimize costs and improve efficiency. However, they have experienced many failed and undesirable consequences, which are partially due to extremely high safety and service quality requirements. It is urgent for the stations to find an advanced and practical methodology to enhance competitive advantages with less cost and better IT service.

There have been many papers that have investigated IT outsourcing related risks. Validated measures of risk factors based on Transaction Cost Theory (TCT) [1], method to identify/assess risk [2]. However, papers mentioned above focus mainly on analyzing framework or prioritization of risk, yet further emphasis is needed on quantitative methodology. Additionally, the capability of handling potential error and the efficiency of the approaches need improvement.

This paper proposes a new model called Variable Precision Fuzzy Rough Group Decision-making (VPFRGDM) to evaluate IT outsourcing risk in the nuclear industry. Firstly, historical knowledge is represented in a fuzzy decision table(FDT) based on TCT; Then, based on VPFRS[3] and fuzzy TOPSIS approach[4], it evaluates the risk under a certain admissible inclusion error β and the whole error interval. The model further reduces the bias in fuzzy group decision-making (FGDM), improves the efficiency in IT outsourcing risk decision-making.

This paper is organized as follows: Section 2 describes the proposed model in detail. Section 3 provides a case of a synthetic evaluation of IT outsourcing risk. Section 4 then provides the final concluding remarks and future work required.

2 The VPFRGDM Model

Let U be a non-empty set of finite objects (the universe of discourse). Consider a fuzzy compatibility relation R , fuzzy set F and denote by X_i a compatibility class on U . With a given admissible inclusion error β , the mean rough fuzzy β -approximations $\mu_{\underline{R}\beta}^F(X_i)$ is defined in [3].

Assume that there are a total of m conditional features, denoted by $C_i (i=1, 2, \dots, m)$, one decision feature, denoted by D ; n evaluators and N possible alternatives. IT outsourcing risk evaluation will be dealt with Fuzzy TOPSIS [4]. The proposed model consists mainly of three steps:

Step 1: Calculate the weight of feature and evaluator

The weight of feature C_i will be:

$$W_{C_i}^\beta = \gamma_{C_i}^\beta(D) / \sum_i \gamma_{C_i}^\beta(D) \quad i = 1, 2, \dots, m \quad (1)$$

where $\gamma_{C_i}^\beta(D) = \sup_{X_j \in U/C_i} \sup_{F \in U/D} \{\mu_{\underline{R}\beta}^F(X_j)\}$.

Initially, each evaluator will give linguistic evaluation to each alternative and linguistic evaluation is turned into Triangular Fuzzy Number(TFN) [5]. Then the weight of each evaluator $W_{E_k}^\beta (k=1, \dots, n)$ will be calculated by mutual distance between TFN as shown in [6].

Step 2: Evaluate the risk of each alternative under a given β

Under a given β the distance of alternative i to fuzzy positive ideal solution and that to fuzzy negative ideal solution, the relative closeness to the ideal solution of alternative i , denoted by $d^\beta(\tilde{A}_i, \tilde{A}^*)$, $d^\beta(\tilde{A}_i, \tilde{A}^-)$ and RC_i^β respectively, will be attained according to [4].

Step 3: Evaluate the risk on the whole admissible inclusion error interval $[0, \alpha]$

From the process, it is easy to know that $W_{C_i}^\beta$ and $W_{E_k}^\beta$ are linear functions of β ($\forall i \in [1, m], k \in [1, n]$). Consequently, function $d^\beta(\tilde{A}_i, \tilde{A}^*)$ and $d^\beta(\tilde{A}_i, \tilde{A}^-)$ are Riemann integral. Then the mean positive distance will

$$\text{be } \overline{d(\tilde{A}_i, \tilde{A}^*)} = \frac{1}{\alpha} \int_0^\alpha d^\beta(\tilde{A}_i, \tilde{A}^*) d\beta$$

and similarly will be the mean negative distance $\overline{d(\tilde{A}_i, \tilde{A}^-)}$.

Thus, the mean risk of alternative i will be

$$RC_i = \overline{d(\tilde{A}_i, \tilde{A}^-)} / \left[\overline{d(\tilde{A}_i, \tilde{A}^-)} + \overline{d(\tilde{A}_i, \tilde{A}^*)} \right], \quad i = 1, 2, \dots, N \tag{3}$$

3 A Numerical Case

The numerical case is from a famous nuclear power station in China, Nuclear Power Company (NPC). The IT staff established the index system and generated FDT, as shown in Table 1. In Table 1, ‘L’, ‘M’ and ‘H’ represents ‘low’, ‘medium’ and ‘high’ respectively. Data is the membership of an object belongs to the class.

Table 1. Fuzzy Decision Table of Risks in outsourcing IT operations

U	Transaction			Client			Supplier			Risk of decision		
	L	M	H	L	M	H	L	M	H	L	M	H
1	0.8	0.2	0	0	0.3	0.7	0.7	0.3	0	0.8	0.2	0
2	0.7	0.3	0	0.2	0.8	0	0.7	0.3	0	0.5	0.5	0
3	0.5	0.5	0	0.2	0.7	0.1	0.6	0.3	0.1	0.3	0.7	0
4	0.2	0.7	0.1	0.1	0.7	0.2	0.9	0.1	0	0.7	0.3	0
5	0.2	0.8	0	1	0	0	0.6	0.4	0	0.7	0.3	0
6	0	0.8	0.2	0	0.1	0.9	1	0	0	0.3	0.7	0
7	0.2	0.8	0	0.7	0.3	0	0.1	0.6	0.3	0.1	0.8	0.1
8	0	0.4	0.6	0.9	0.1	0	0.8	0.2	0	0.5	0.5	0

This time, NPC is about to choose the IT outsourcing service providers from four alternatives. Herein the threshold of inclusion error is $\alpha = 0.3$.

The evaluation results, under various β and the mean method^c are shown in Table 2. According to Table 2, the final decision-making is to choose alternative 3

Table 2. The rating and ranking results

Alternative	$\beta \in [0, 0.2)$		$\beta \in [0.2, 0.25)$		$\beta \in [0.25, 0.3]$		Mean	
	RC_i	Rank	RC_i	Rank	RC_i	Rank	RC_i	Rank
1	0.699	3	0.582	3	0.643	2	0.674	3
2	0.116	4	0.193	4	0.212	4	0.139	4
3	0.742	2	0.749	1	0.821	1	0.754	1
4	0.759	1	0.716	2	0.583	3	0.729	2

With the results in Table 2 compared, it is easy to see that the ranks of 1, 3, and 4 are varying. The reason of these variations is violent fluctuations in weights of features when β is small. When $\beta > 0.2$, the evaluation turns to be stable and more reasonable. It is evidence that the classification error and its associated negative influence are under better control. The final result is clear and convincing, which demonstrates the effectiveness of the mean method to eliminate bias.

4 Conclusion

This paper aims at facilitating evaluation of IT outsourcing risk in the nuclear industry, proposes a model to evaluate IT outsourcing risk. The model retains the advantages of FGDM and improves fairness, flexibility, versatility and efficiency in IT outsourcing risk measurement and decision-making, which is verified by the case of the company NPC.

The model could also be generalized to other risk domains and GDM methodology. Further research may be conducted in searching for fuzzy rules and fuzzy reasoning in risk knowledge discovery in order to optimize the risk decision-making.

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