Selecting of the Important Warehouses Based on Vague Sets

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Abstract. Proposed a method of optimizing and sorting warehouse protection targets based on Vague sets. Analyzed the index factors that affect the selection and ranking of warehouse targets, and the fuzzy value representation of each evaluation index and the calculation method of index weight. This method can effectively avoid the subjective deviation caused by the traditional expert scoring method. Based on the method, a comprehensive evaluation model of security targets for key warehouses based on Vague sets is established, and methods for selecting and ranking security targets are given. Finally, it is verified by example analysis that the method has accurate evaluation results and has certain reference value for the scientific decision of warehouse leaders.

Keywords: Vague sets; Fuzzy value; Evaluation index; Security task.

1. Introduction

In the warehouses where store important economic value goods, the security guards have undertaken extremely heavy security tasks. Due to the limited security force, in order to use the security force reasonably and strive to obtain the best protection effect, the protection sequence of the key security targets is determined in advance, and the priority is safety an extremely important part of protection. There are not many literature about the selection and ranking of warehouse security goals. In [1], a method for determining attribute importance based on rough set attribute dependency was proposed. The insufficiency of the existing methods for establishing attribute importance of rough set theory was considered along with the direct and indirect effects of conditional attributes on decision-making. However, most of these documents used subjective scoring method when dealing with evaluation index weights. To solve this problem, this paper proposed a new method for selecting and ranking the key defense targets of air defense with the help of Vague set theory. This method obtains the evaluation index weights through quantitative calculation. Therefore, it can effectively avoid subjective deviations and better adapt to the requirements of modern defense operations on the objectivity and precision of data processing.

2. Basic Theory of Vague Sets

Gau and Buehrer proposed the Vague set theory as early as 1993[2]. Because the Vague set theory is more in line with human thinking activities. What’s more, it is widely used. Vague set theory has the following definitions:
Definition [2] Let \( X=\{x_1, x_2, x_3, \ldots, x_n\} \) be a discourse domain, and let \( X \) belong to Vague set \( A \). Then Vague set \( A \) is expressed by a positive membership function named \( t_A \) and a negative membership function named \( f_A. t_A: X\rightarrow[0,1] \ f_A: X\rightarrow[0,1], \ t_A(x_i) \leq 1-f_A(x_i) \).
The membership of any $x_i$ in $A$ can be defined by the interval value $V_A(x_i) = [t_A(x_i), 1-f_A(x_i)]$, so $V_A(x_i)$ is the Vague value of $x_i$ in $A$, which can be simply expressed as $v = [t, 1-f]$.

3. Comprehensive Evaluation Index System of Key Defense Objectives

The selection of key defense targets in the warehouse is mainly based on superior intentions, warehousing tasks undertaken, enemy destruction intentions, importance of the defense targets, characteristics of the defense targets, and our security defense capabilities. There are many factors that affect the choice of warehouse protection targets. In order to facilitate the analysis of the problem, the target value (the role of the target in the impact and the impact of the damage) is used as the basic measurement standard. Target importance, target threat degree, target vulnerability, target recovery. From this, a comprehensive evaluation index system for the key defense objectives of the warehouse can be established, as shown in Fig. 1.

![Figure 1](image)

**Figure 1.** Evaluation index system of warehouse protection targets.

4. Optimum Selection and Ranking Method Based on Vague Set

4.1. The Fuzzy Value of Evaluation Index

Assuming that there are $m$ warehouse protection targets to be evaluated, according to the system structure established above, the importance of the target, the degree of threat to the target, the vulnerability of the target, and the recoverability of the target are selected as evaluation indicators[3]. That is, there is a scheme $X = \{X_1, X_2, ..., X_m\}$, the index set $U = \{U_1, U_2, U_3, U_4\}$. Let each index weight be $w_1, w_2, w_3, w_4$ and $w_1 + w_2 + w_3 + w_4 = 1$. First adopt the following methods to normalize each index [4].

For efficiency indicators, let $t_{ij} = (x_{ij} - x_{ij}^{\min})/(x_{ij}^{\max} - x_{ij}^{\min})$ and $f_{ij} = (x_{ij}^{\max} - x_{ij})/(x_{ij}^{\max} - x_{ij}^{\min})$.

For cost indicators, let $t_{ij} = (x_{ij}^{\max} - x_{ij})/(x_{ij}^{\max} - x_{ij}^{\min})$ and $f_{ij} = (x_{ij} - x_{ij}^{\min})/(x_{ij}^{\max} - x_{ij}^{\min})$.

In the formula, $x_{ij}^{\max} = \max\{x_{ij}, x_{2j}, ..., x_{mj}\}$, $x_{ij}^{\min} = \min\{x_{ij}, x_{2j}, ..., x_{mj}\}$; $i = 1, 2, ..., m$; $j = 1, 2, 3, 4$.

The fuzzy value matrix $F = (F_{ij})_{m \times n}$ of each index can be obtained according to the following formula:

$F_{ij} = t_{ij}+(1-t_{ij}-f_{ij})(1-f_{ij})/(2(1-f_{ij}))$.

When $t_{ij} = 0$ then $F_{ij} = t_{ij} + (1-t_{ij}-f_{ij})(1-f_{ij})/2 = (1-f_{ij})/2$.

When $f_{ij} = 0$ then $F_{ij} = t_{ij} + (1-t_{ij}-f_{ij})(1+f_{ij})/2 = (1-f_{ij})/2$.

4.2. Calculation of Evaluation Index Weight

The degree of separation of scheme $x_i$ and $x^*$ is defined as:
Establish an optimization model [5]:

\[ J(x_i, x^*) = \sum_{j=1}^{5} \sqrt{f_{ij}^2 + (1-t_{ij})^2}.w_j \]

\[ \min J(w) = \sum_{i=1}^{m} \sum_{j=1}^{5} [f_{ij}^2 + (1-t_{ij})^2]w_j^2 \]

\[ s.t. w_j \geq 0, \sum_{j=1}^{5} w_j = 1 \]

Solve the weight of each index:

\[ w_j = \frac{1}{\sum_{j=1}^{5} \sum_{i=1}^{m} [f_{ij}^2 + (1-t_{ij})^2]} \sum_{i=1}^{m} [f_{ij}^2 + (1-t_{ij})^2], j = 1, 2, 3, 4 \]

For the specific solution process, please refer to [6], which will not be repeated here.

4.3. Target Optimization Method Based on Vague Set

**Step 1.** Construct a fuzzy value matrix \( F = (F_{ij})_{m \times n} \).

**Step 2.** Calculate the weight of each indicator.

**Step 3.** Determine the optimal and worst points of the solution set \( X^+, X^- \).

**Step 4.** Calculate the proximity \( E_i \) of each scheme to the best advantage \( X^+ \).

\[ d_i^+ = d(X_i, X^+) = \sum_{j=1}^{4} \sqrt{(f_{ij} - f_{ij})^2 + (t_{ij} - t_{ij})^2}.w_j, i = 1, 2, \ldots, m \]

\[ d_i^- = d(X_i, X^-) = \sum_{j=1}^{4} \sqrt{(f_{ij} - f_{ij})^2 + (t_{ij} - t_{ij})^2}.w_j, i = 1, 2, \ldots, m \]

\[ E_i = \frac{d_i^+}{(d_i^+ + d_i^-)}, i = 1, 2, \ldots, m \]

**Step 5.** Prioritize and rank the key warehouse defense targets to be evaluated by \( E_i \) value.

5. Case Analysis

Assuming that there are 4 warehouse protection targets, the defense order needs to be determined. That is, there is a plan set \( X = \{X_1, X_2, X_3, X_4\} \), index set \( U = \{U_1, U_2, U_3, U_4\} \). The index value of each scheme under each index is shown in Table 1 (the full score of each index is 10).

**Table 1.** Evaluation indexes of warehouse protection targets.

|        | \( U_1 \) | \( U_2 \) | \( U_3 \) | \( U_4 \) |
|--------|----------|----------|----------|----------|
| \( X_1 \) | 8.25     | 7.84     | 5.45     | 4.61     |
| \( X_2 \) | 9.31     | 5.05     | 8.26     | 7.11     |
| \( X_3 \) | 9.12     | 4.41     | 6.51     | 6.64     |
| \( X_4 \) | 9.08     | 5.61     | 5.01     | 7.06     |

5.1. The Fuzzy Value of Evaluation Index

Normalize it according to formulas (1) ~ (4), so that the Vague set representation of each index can be obtained.
\[ X_1=\{(U_1,[0.00, 0.00]), (U_2,[1.00, 1.00]), (U_3,[0.14, 0.14]), (U_4,[1.00, 1.00])\}. \]

\[ X_2=\{(U_1,[1.00, 1.00]), (U_2,[0.19, 0.19]), (U_3,[1.00, 1.00]), (U_4,[0.00, 0.00])\}. \]

\[ X_3=\{(U_1,[0.83, 0.83]), (U_2,[0.00, 0.00]), (U_3,[0.46, 0.46]), (U_4,[0.18, 0.18])\}. \]

\[ X_4=\{(U_1,[0.79, 0.79]), (U_2,[0.35, 0.35]), (U_3,[0.00, 0.00]), (U_4,[0.02, 0.02])\}. \]

Thus, the fuzzy value matrix can be obtained as following.

\[
\begin{bmatrix}
0.00 & 1.50 & 0.14 & 1.50 \\
1.50 & 0.19 & 1.50 & 0.00 \\
0.83 & 0.00 & 0.46 & 0.18 \\
0.79 & 0.35 & 0.00 & 0.02
\end{bmatrix}
\]

To calculate the weight of each index as follows: \(w_1=0.408\), \(w_2=0.211\), \(w_3=0.215\), \(w_4=0.166\).

5.2. Determine the Optimal and Worst Point of the Solution set \(X^+, X^-\).

\[ X^+=\{(U_1,[1.00,1.00]), (U_2,[1.00,1.00]), (U_3,[1.00,1.00]), (U_4,[1.00,1.00])\}. \]

\[ X^-=\{(U_1,[0.00,0.00]), (U_2,[0.00,0.00]), (U_3,[0.00,0.00]), (U_4,[0.00,0.00])\}. \]

5.3. Determine the Distance from Each Plan \(X_i\) to the Best and Worst Point \(d_i^+, d_i^-\).

\[ d_1^+=0.795, d_2^+=0.481, d_3^+=0.761, d_4^+=0.850. \]

\[ d_1^-=0.576, d_2^-=0.938, d_3^-=0.661, d_4^-=0.565. \]

5.4. Determine the Proximity \(E_i\) of Each Scheme \(X_i\) to the Most Superior \(X^+\).

\[ E_1=0.420, E_2=0.661, E_3=0.465, E_4=0.399. \]

According to the size of \(E_i\), the priority cover order of each defense target is get as follows: \(X_1> X_2> X_3> X_4\).

The example proves that the priority protection sequence of this defense goal is in line with the actual situation and is consistent with expert judgment. Therefore, this method obtains a high reliability.

6. Conclusion

This paper proposed a method for selecting and prioritizing key warehouse defense targets based on Vague sets. This method took full account of the randomness and uncertainty of defense information with the help of fuzzy theory, and solved the warehouse security targets in a quantitative way. The problem of optimization and ranking can effectively avoid the shortcomings of traditional fuzzy decision-making methods, has strong practicability and robustness, and can provide more reliable auxiliary decision-making for warehouse leaders. The example proves that this method is simple and effective, and it has a wider application prospect in the optimization of security defense forces.

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