Research on the Evaluation of Vehicle Equipment Maintenance Support Capability

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Abstract: The maintenance support capability of vehicle equipment is directly related to the overall combat capability and the probability of successful completion of combat tasks. In this paper, an evaluation model of vehicle equipment maintenance support capability based on game theory cloud matter element is proposed, and the model is verified by an example. The results show that the model is objective, effective, scientific and reasonable, and has certain application value.

Keywords: vehicle equipment; maintenance support capability; game theory; cloud matter element

1. Introduction

Practice shows that equipment maintenance support has become an important factor that restricts and affects the overall combat capability of the army. Vehicle equipment, as one of the land-based mobile platforms in modern high-tech war, has become a weapon bearing platform. Its maintenance support capability directly affects the combat effectiveness of the army in the complex and changeable battlefield environment, and whether the army can successfully complete the combat tasks on time. The scientific and reasonable evaluation of vehicle equipment maintenance support capability can find out the deficiencies of vehicle equipment maintenance support system in time, so as to give targeted opinions and suggestions to effectively improve the maintenance support ability, and provide decision-making basis for reasonable allocation of maintenance support resources and ensuring the successful completion of maintenance support tasks.

In the aspect of equipment maintenance support capability evaluation, on the basis of determining the evaluation index system, reference [1] establishes the evaluation model of aviation equipment maintenance support capability by using analytic hierarchy process, Delphi method and multi-level fuzzy comprehensive evaluation method; reference [2] uses matter-element extension method to evaluate the maintenance support capability of helicopter; reference [3] analyzes the maintenance support capability of aviation equipment On this basis, the grey clustering model of aviation equipment maintenance support capability evaluation is established. Although scholars have carried out more in-depth research on the evaluation of equipment maintenance support capability, these research results have the following shortcomings: first, there are few research results related to equipment maintenance support capability evaluation; second, most of the evaluation index weights are determined by the subjective weighting method, which mainly depends on the knowledge and experience of experts, and has great randomness; third, it is specially aimed at the evaluation of equipment maintenance support capability. The research on vehicle equipment is less, and these research results are difficult to be directly applied to the evaluation of vehicle equipment maintenance support capability.

In view of this, on the basis of establishing the evaluation index system of vehicle equipment maintenance support capability, this paper puts forward an evaluation model of vehicle equipment maintenance support capability based on game theory cloud matter-element theory, based on game theory and cloud matter-element theory, in order to provide method support for vehicle equipment maintenance support ability evaluation and further enrich equipment maintenance support ability evaluation theory.

2. Determination of Matter Element and Index Correlation Degree of Standard Cloud

This paper combines game theory and cloud matter-element to establish the evaluation model of vehicle equipment maintenance support capability. It is mainly based on the following two considerations:

One is that the index weight represents the status and role of the evaluation index in the whole evaluation index system, and whether the determination is reasonable or not is directly related to and affects the accuracy and rationality of the evaluation results. At present, the methods of determining the weight of evaluation index mainly include subjective weighting method and objective weighting method. The objective weighting method can make good use of the original data of the evaluation indicators, but sometimes the results obtained are inconsistent with the actual situation, and the interpretation is poor. Therefore, this paper combines the subjective and objective weighting methods and integrates the weighting with game theory, so that the knowledge and experience of experts and the original data of evaluation indicators can be fully utilized at the same time, giving full play to the subjective and objective endowments The advantages of weight method ensure that the weight of evaluation index is more scientific and reasonable.

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Second, the quantitative value of qualitative evaluation index in the evaluation index system of vehicle equipment maintenance support ability is difficult to be directly given, which has strong uncertainty. Cloud matter-element model combines cloud model and matter-element analysis method, reconstructs matter-element in matter-element analysis method, and evaluates things by improving the shortcomings of general matter-element analysis method. It can not only overcome the fuzziness and randomness of qualitative evaluation index, but also can directly use the original data of evaluation index to combine the advantages of cloud model and matter-element analysis method. It can reduce the subjectivity of evaluation and avoid the possible information loss in the process of normalizing the original data. Therefore, this paper introduces cloud matter-element model in the evaluation of vehicle equipment maintenance support ability, so that the evaluation results of vehicle equipment maintenance support ability are more reasonable, credible, scientific and objective.

Through comprehensive analysis, the first level indexes are determined as information control ability U_1, command and control ability U_2, rapid mobility capability U_3, rescue and repair capability U_4, and comprehensive defense capability U_5.

In view of the research on cloud theory and matter-element analysis theory in academic circles, this paper will not introduce the relevant theories in detail. The specific methods and steps of this model are as follows.

In this paper, the object to be evaluated is the support unit $F_i(i=1, 2,\cdots,m)$, and the matter element x_{ij} to be evaluated is the maintenance support capability of vehicle equipment. The main task of this step is to determine the quantity value of the evaluation index of the maintenance support ability of the support unit and its corresponding vehicle equipment, which represents the value of the first evaluation index of the vehicle equipment maintenance support ability of the support unit. Among them, the quantitative value of qualitative evaluation index can be obtained by expert scoring method, and the quantitative value of quantitative evaluation index can be obtained through on-site observation and analysis of relevant data.

Determining the standard cloud matter-element is to analyze and determine the level cloud of each evaluation index of vehicle equipment maintenance support capability. After transforming the matter-element in traditional matter-element analysis method into cloud matter-element, we can know that the standard cloud is:

$$\mathrm{R}_{0\mathrm{d}}=\begin{bmatrix} F_d & C_1 & (\mathrm{E}_{\mathrm{x}1},\mathrm{E}_{\mathrm{n}1},\mathrm{H}_{\mathrm{e}1}) \\ & \vdots & \vdots \\ & C_{\mathrm{n}} & (\mathrm{E}_{\mathrm{x}n},\mathrm{E}_{\mathrm{n}n},\mathrm{H}_{\mathrm{e}n}) \end{bmatrix} \tag{1}$$

In the formula, $R_{0\mathrm{d}}$ represents the classification level when evaluating the maintenance support capability of vehicle equipment, F_d represents the standard object with level d, C_j represents the evaluation index, and (E_{xj},E_{nj},H_{ej}) represents the cloud representation C_j at time $R_{0\mathrm{d}}$.

In this paper, the maintenance support capability of vehicle equipment is divided into four levels by using excellent, good, medium and poor. On the basis of consulting relevant information and consulting experts, the paper analyzes and gives the values of each evaluation index of vehicle equipment maintenance support capability in different levels of time zone, and then converts the four level interval values of each evaluation index into standard cloud matter-element. The conversion method is that the values of different grades of each evaluation index are regarded as an index $[C_{\min},C_{\max}]$ with double constraints, then the calculation methods of expectation E_x, entropy E_n and super entropy H_e of standard cloud matter-element are as follows:

$$E_{\mathrm{x}}=\frac{C_{\min}+C_{\max}}{2} \tag{2}$$

$$E_{\mathrm{n}}=\frac{C_{\max}-C_{\min}}{6} \tag{3}$$

$$H_e=d \tag{4}$$

In formula (4), d is a constant, and its value should be determined according to the value range of different levels of each evaluation index.

The calculation of single correlation degree refers to the correlation degree between the evaluation index value of vehicle equipment maintenance support capability of the support unit to be evaluated and the standard cloud value of different levels of cloud index.

If the certainty value of each evaluation index of the vehicle equipment maintenance support capability of the support unit to be evaluated is regarded as a cloud drop x_{ij}, the calculation of single correlation degree is to calculate the cloud certainty represented by the cloud drop. If the cloud of the interval value of the evaluation index under the level is expressed as (E_{xj},E_{nj},H_{ej}), then the algorithm of the certainty degree of x_{ij} when the evaluation grade is d is as follows:

(1) A normal random number is generated, whose mean value is E_{nj} and standard deviation is H_{ej};

(2) Let the quantity value of the evaluation index certainty is x_{ij}, and the cloud drop is $\left(x_{ij},\mu_{ij}\right)$;

(3) Calculate the correlation degree

$$\mu_{\mathrm{ij}}=\exp\left[-\frac{\left(\mathrm{x}_{\mathrm{ij}}-\mathrm{E}_{\mathrm{xj}}\right)^2}{2\mathrm{E}_{\mathrm{nj}}^{'2}}\right] \tag{5}$$

In this paper, $k_{ij}\left(F_i\right)$ is used to express the

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correlation degree when the j th evaluation index of the i th support unit is at the level d .

3. Index Weight Calculation

The basic idea of the model is to seek a kind of consistency or compromise between the weights determined by different methods, that is, to minimize the deviation between the possible weights and the basic weights. The specific methods are as follows:

In this paper, the weights of evaluation indexes of vehicle equipment maintenance support capability are calculated respectively by using subjective and objective weighting methods. Among them, $k=1,2,\cdots,L$. Any linear combination of weight vectors w_k is recorded as:

$$w=\sum_{k=1}^{L}\alpha_k\, w_k^T \tag{6}$$

In the above formula, w represents a possible weight vector obtained by crossing and fusing the basic weight vectors, and all of them $\left\{ w \middle| w=\sum_{k=1}^{L}\alpha_k\, w_k^T, \alpha_k>0 \right\}$ represent the set of possible weight vectors.

The integrated weighting model of game theory seeks the most satisfactory weight vector. In fact, it is a multi-person optimization problem, that is, by optimizing linear combination coefficients α_k , the deviation between each weight vector w_k and possible weight vector w is minimized. The game model can be derived as follows:

$$\min\left\| \sum_{j=1}^{L}\alpha_j\, w_j^T \right\| (i=1,2,\cdots,L) \tag{7}$$

According to the differential property of matrix, the first derivative of equation (7) can be obtained

$$\sum_{j=1}^{L}\alpha_j w_i w_j^T = w_i w_i^T \left(i=1,2,\cdots,L\right) \tag{8}$$

By solving equation (8), we can get the integrated weight as follows:

$$w^* = \sum_{k=1}^{L}\alpha_k^*\, w_k^T \tag{9}$$

4. Correlation Degree and Grade Evaluation

To determine the relevance of the things to be evaluated includes two parts: calculating the single dimension correlation degree and calculating the comprehensive correlation degree. The calculation of single dimension correlation degree refers to the calculation of the correlation degree of the first level evaluation index of the support unit to be evaluated, and the calculation of the comprehensive correlation degree refers to the calculation of the correlation degree of the level of the support unit to be evaluated.

(1) Single dimension correlation degree

$$k_m\left(F_i\right)=\sum_{j=1}^{n} w_{mj} k_{ij}\left(F_i\right) \tag{10}$$

Where, w_{mj} is the combination weight of the second level evaluation index and the first level evaluation index.

(2) Comprehensive correlation degree

$$k_d\left(F_i\right)=\sum_{j=1}^{n} w_j k_j\left(F_i\right) \tag{11}$$

Where, w_j is the weight of the first level evaluation index.

If the maintenance level of the vehicle can be evaluated according to the support level of the vehicle support team, that is to say, $k_{md}=\max_{d=1,2,3,4} k_m\left(F_i\right)$, $k_d=\max_{d=1,2,3,4} k_d\left(N_i\right)$, the support level of the vehicle support team can be determined according to the support level of the maximum equipment support level.

5. Conclusions

The maintenance support capability of vehicle equipment is a complex system engineering, which involves many factors. In view of the fact that the current academic research on vehicle equipment maintenance support capability is insufficient, this paper puts forward an evaluation model based on game theory cloud matter-element, and analyzes the model through an example. The evaluation results are scientific and reasonable, in line with the actual situation, which shows that the model is feasible and can provide certain reference for vehicle equipment maintenance support ability.

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